KIRTLAND AIR FORCE BASE
ALBUQUERQUE, NEW MEXICO

Pre-Remedy Monitoring and Soil-Vapor Extraction System Operation and Maintenance Work Plan

Bulk Fuels Facility Spill
Solid Waste Management Units ST-106 and SS-111

February 2011

377 MSG/CEANR
2050 Wyoming Blvd. SE
Kirtland AFB, New Mexico 87117-5270

KIRTLAND AIR FORCE BASE
ALBUQUERQUE, NEW MEXICO

PRE-REMEDY MONITORING AND SOIL-VAPOR EXTRACTION SYSTEM OPERATION AND MAINTENANCE WORK PLAN

BULK FUELS FACILITY SPILL SOLID WASTE MANAGEMENT UNITS ST-106 AND SS-111

February 2011

Prepared for
U.S. Army Corps of Engineers
Albuquerque District
Albuquerque, New Mexico 87109

USACE Contract No. W912DY-10-D-0014
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This work plan describes pre-remedy monitoring activities to be conducted at the Bulk Fuels Facility (BFF) Spill at Kirtland Air Force Base. Quarterly monitoring activities will include collecting samples quarterly from soil-vapor monitoring wells, soil-vapor extraction units, existing groundwater monitoring wells, and four municipal wells. In addition, onsite monitoring will be conducted for the soil-vapor extraction wells and units. Quarterly monitoring will be expanded to include all new wells to be installed as part of concurrent groundwater and vadose-zone investigations at the BFF Spill. In addition, this work plan describes biweekly, monthly, quarterly, semi-annual, and annual operation and maintenance activities that will be performed on the four existing soil-vapor extraction systems as well as for new soil-vapor extraction, soil-vapor monitoring, and injection wells to be installed during vadose-zone investigations. Pre-remedy monitoring will be performed in accordance with sampling, analysis, and reporting requirements specified by the New Mexico Environment Department. Pre-remedy monitoring will occur from 2011 until Remedy In Place is achieved or until an approved change by NMED. New wells will be included in pre-remedy quarterly monitoring as they are installed and become operational.

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40 CFR 270.11
DOCUMENT CERTIFICATION
DECEMBER 2010

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COLONEL ROBERT L. MANESS
Commander

This document has been approved for public release.

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377 ABW Public Affairs

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PREFACE

This Pre-Remedy Monitoring and Soil-Vapor Extraction System Operation and Maintenance Work Plan was prepared by Shaw Environmental & Infrastructure, Inc. (Shaw) for the U.S. Army Corps of Engineers (USACE) under contract W912DY-10-D-0014, Delivery Order 0002. It pertains to Solid Waste Management Units ST-106 and SS-111, collectively known as the Bulk Fuels Facility (BFF) Spill, at Kirtland Air Force Base (AFB), New Mexico. This work plan was prepared in accordance with all applicable federal, state, and local laws and regulations, including the New Mexico Hazardous Waste Act New Mexico Statutes Annotated 1978; New Mexico Hazardous Waste Management Regulations; Resource Conservation and Recovery Act; and regulatory correspondence between the New Mexico Environment Department (NMED) Hazardous Waste Bureau (HWB) and the Air Force, dated April 2, June 4, and August 6, 2010.

This work plan describes activities associated with pre-remedy monitoring at the BFF Spill. Pre-remedy monitoring will be conducted in accordance with sampling, analysis, and reporting requirements specified by the NMED HWB as well as requirements contained in the *Base-Wide Plans for Investigations under the Environmental Restoration Program,* Kirtland AFB, 2004 Update. Pre-remedy monitoring activities include the following: collecting samples from the 15 existing soil-vapor monitoring wells (58 sample points), collecting inlet and exhaust soil-vapor samples from the four existing soil-vapor extraction units, and collecting groundwater samples from the 29 existing BFF groundwater monitoring wells and four municipal wells for offsite laboratory analysis. In addition, onsite monitoring will be conducted for 13 existing soil-vapor extraction (SVE) wells on a quarterly basis. Quarterly sampling and analysis activities will be expanded to include all new wells to be installed at the facility as part of groundwater and vadose-zone investigations being implemented concurrently under this delivery order.

This work plan also describes quarterly monitoring, as well as operation and maintenance (O&M) activities, at four existing SVE systems operating at the BFF Spill site. Quarterly monitoring and biweekly, monthly, quarterly, semi-annual, and annual O&M activities will be expanded to include additional SVE wells to be installed in the deep, intermediate, and shallow zones as part of concurrent groundwater and vadose-zone investigations being implemented under this delivery order.

Pre-remedy monitoring will be conducted from 2011 until Remedy In Place is achieved or until an approved change by NMED. New wells will be included in pre-remedy monitoring activities as they are installed and become operational.

This work is performed under the authority of the USACE, Contract No. W912DY-10-D-0014, Delivery Order 0002. All work was initiated in October 2010. Mr. Walter Migdal is the Project Manager for the USACE Albuquerque District. Mr. Wayne Bitner, Jr. is the Kirtland AFB Restoration Section Chief, and Mr. Tom Cooper is the Shaw Project Manager. This plan was prepared by Ms. Rachel Vavra and Ms. Pam Moss.

Thomas Cooper, PG, PMP
Shaw Environmental & Infrastructure, Inc.
Project Manager

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Attachment 2: June 4, 2010 Correspondence from the NMED HWB to Colonel Robert L. Maness, Base Commander, 377 ABW/CC and Mr. John Pike, Director, Environmental Management Section, 377 MSG/CEANR, Re: Reporting, Sampling, and Analysis Requirements, SWMUs ST-106 AND SS-111, BFF Spill, Kirtland AFB

Attachment 3: August 6, 2010 Correspondence from the NMED HWB to Colonel Robert L. Maness, Base Commander, 377 ABW/CC, Re: SWMUs ST-106 and SS-111, BFF Spill, Kirtland, AFB, Directive for Conducting Interim Measures and Notice of Disapproval, Interim Measures Work Plan, June 2010, Vadose Zone Work Plan, June 2010, Groundwater Investigation Work Plan, June 2010

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ACRONYMS AND ABBREVIATIONS

3D	three-dimensional
^{o}C	degrees Celsius
^{o}F	degrees Fahrenheit
ADR	automated data review
AFB	Air Force Base
AFCEE	Air Force Center for Engineering and Environment
Air Force	U.S. Air Force
APH	air-phase petroleum hydrocarbon
AST	aboveground storage tank
ASTM	ASTM International
AvGas	aviation gasoline
AWWA	American Water Works Association
BFF	Bulk Fuels Facility
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
BWP	*Base-Wide Plans for Investigation under the Environmental Restoration Program, 2004 Update,* Kirtland AFB
cm	centimeter
COPC	contaminant of potential concern
CRP	Community Relations Plan
CSM	conceptual site model
DoD	U.S. Department of Defense
DQCR	daily quality control report
DQO	data quality objective
DTIC	Defense Technical Information Center
EDB	ethylene dibromide
EIMS	Environmental Information Management System
ELAP	Environmental Laboratory Accreditation Program (DoD)
EM	Engineer Manual
EPA	U.S. Environmental Protection Agency
EPH	extractable petroleum hydrocarbon
ERP	Environmental Restoration Program
ERPIMS	Environmental Resources Program Information Management System
FCR	Field Change Request
FFOR	Former Fuel Offloading Rack
ft	foot/feet
ft/day	foot/feet per day
GC/MS	gas chromatography/mass spectrometry
GIS	geographic information system

ACRONYMS AND ABBREVIATIONS (continued)

HWB	Hazardous Waste Bureau (NMED)
ICE	internal-combustion engine
IDW	investigative-derived waste
JP-4	Jet Propellant-4 fuel
JP-8	Jet Propellant-8 fuel
KAFB	Kirtland Air Force Base
LNAPL	light non-aqueous phase liquid
LOQ	limit of quantitation
MA DEP	Massachusetts Department of Environmental Protection
MCL	maximum contaminant level
µmhos	micro mhos
µg/L	microgram(s) per liter
mg/kg	milligram(s) per kilogram
mg/L	milligram(s) per liter
NMED	New Mexico Environment Department
NRC	National Research Council
NTIS	National Technical Information Service
NTU	nephelometric turbidity unit
O&M	operation and maintenance
OSRTI	Office of Superfund Research and Technology Innovation (EPA)
OSWER	Office of Solid Waste and Emergency Response (EPA)
PPE	personal protective equipment
ppm	parts per million
ppmv	parts per million by volume
PSH	phase-separated hydrocarbon
QAPjP	BFF Spill Quality Assurance Project Plan
QC	quality control
RSI	Remediation Services International
SEDD	Staged Electronic Data Deliverable
Shaw	Shaw Environmental & Infrastructure, Inc.
SM	Standard Method
SOP	standard operating procedure
SVE	soil-vapor extraction
SVEW	soil-vapor extraction well
SWMU	Solid Waste Management Unit
SVMW	soil-vapor monitoring well

ACRONYMS AND ABBREVIATIONS (concluded)

TPH	total petroleum hydrocarbons
USACE	U.S. Army Corps of Engineers
USF	Santa Fe Group member
V.A.	Veterans Administration
VOA	volatile organic analysis
VOC	volatile organic compound
VPH	volatile petroleum hydrocarbon
WQCC	Water Quality Control Commission (New Mexico)

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EXECUTIVE SUMMARY

This work plan documents requirements and procedures to be implemented as part of pre-remedy monitoring activities at Solid Waste Management Units ST-106 and SS-111, collectively known as the Bulk Fuels Facility (BFF) Spill, at Kirtland Air Force Base (AFB), New Mexico. This work is being performed under U.S. Army Corps of Engineers contract W912DY-10-D-0014, Delivery Order 0002.

This document was developed in response to regulatory correspondence, dated April 2, June 4, and August 6, 2010, from the New Mexico Environment Department (NMED) Hazardous Waste Bureau (HWB) to the U.S. Air Force (Air Force). In these letters, the NMED HWB required the Air Force to develop and submit work plans to address soil and groundwater contamination at the BFF Spill at Kirtland AFB. Pre-remedy monitoring will be conducted in accordance with sampling, analysis, and reporting requirements specified in the NMED June 4, 2010 letter to Kirtland AFB. Submittal of this work plan demonstrates the Air Force's commitment to addressing fuel contamination resulting from past practices and events at the BFF Spill at Kirtland AFB.

Specific objectives of pre-remedy monitoring are to:

- Obtain immediate, as well as long-term, sampling data on subsurface contaminant distribution in the vadose zone and groundwater at the BFF Spill; and
- Monitor and maintain existing soil-vapor extraction (SVE) systems and planned soil-vapor extraction wells (as they are installed) to keep all systems and infrastructure in good working order and performing as intended.

This work plan describes procedures and requirements for the quarterly monitoring of soil gas and groundwater. Pre-remedy monitoring activities include the following: collecting samples from the 15 existing soil-vapor monitoring wells (58 sample points), collecting inlet and exhaust soil-vapor samples from the four existing SVE units, and groundwater sampling for the existing 29 monitoring wells at the BFF Spill and four municipal wells. Groundwater and soil-vapor samples will be sent to an offsite

U.S. Department of Defense Environmental Laboratory Accreditation Program certified laboratory for analysis. In addition, onsite monitoring will be conducted for the existing 13 SVE wells on a quarterly basis. Quarterly sampling activities will be expanded to include the 78 additional groundwater monitoring wells and 35 additional soil-vapor wells to be installed as part of groundwater and vadose-zone investigations being implemented concurrently with this work plan.

This document also describes quarterly monitoring, as well as operation and maintenance (O&M) activities for the four existing SVE systems operating within the BFF Spill site. Quarterly monitoring and O&M activities will be expanded to include new SVE wells to be installed in the deep, intermediate, and shallow zones as part of concurrent vadose investigations being conducted under this delivery order. Routine maintenance of SVE systems is described, including biweekly, monthly, quarterly, semi-annual, and annual maintenance activities. O&M of new soil-vapor extraction wells will occur as the wells are installed and become operational.

Quarterly monitoring will be conducted from 2011 until Remedy In Place is achieved or an approved change by NMED.

1. INTRODUCTION

1.1 Overview

This Pre-Remedy Monitoring and Soil-Vapor Extraction System Operation and Maintenance Work Plan was prepared by Shaw Environmental and Infrastructure, Inc. (Shaw) for the U.S. Army Corps of Engineers (USACE), under contract W912DY-10-D-0014, Delivery Order 0002. This work plan describes pre-remedy quarterly monitoring activities to be conducted at Solid Waste Management Units (SWMUs) ST-106 and SS-111, collectively known as the Bulk Fuels Facility (BFF) Spill, located at Kirtland Air Force Base (AFB) in Albuquerque, New Mexico (Figure 1-1).

This work plan was prepared in accordance with all applicable federal, state, and local laws and regulations, including the:

- New Mexico Hazardous Waste Act New Mexico Statutes Annotated 1978;
- New Mexico Hazardous Waste Management Regulations;
- Resource Conservation and Recovery Act; and
- April 2, June 4, and August 6, 2010 regulatory correspondence between the New Mexico Environment Department (NMED) Hazardous Waste Bureau (HWB) and the U.S. Air Force (Air Force) regarding the BFF Spill at Kirtland AFB (Appendix A, Attachments 1, 2, and 3).

Specific objectives of pre-remedy monitoring are to:

- Obtain immediate, as well as long-term, sampling data on subsurface contaminant distribution in the vadose zone and groundwater at the BFF Spill, and
- Monitor and maintain existing soil-vapor extraction (SVE) systems and planned soil-vapor extraction wells (SVEWs) (as they are installed) to keep all systems and infrastructure in good working order and performing as intended.

Quarterly monitoring will be conducted in accordance with sampling, analysis, and reporting requirements specified in the NMED June 4, 2010 letter to Kirtland AFB (Appendix A, Attachment 2). In addition to requirements outlined in this work plan, quarterly monitoring will also conform to

requirements described in the *Base-Wide Plans for Investigation under the Environmental Restoration Program for Field Investigation*, 2004 Update, Kirtland AFB, and the BFF Spill Quality Assurance Project Plan (QAPjP) contained in Appendix E of this plan, to ensure that data are of sufficient quality and quantity to achieve the project-specific data quality objectives (DQOs).

This plan contains:

- Field procedures associated with groundwater and vadose-zone sample collection and analysis, including sampling and analysis methods and approaches, field quality control, sampling packaging and shipment, reporting, data management, management of investigation-derived waste, equipment decontamination, and use of personal protective equipment;
- Biweekly, monthly, quarterly, semi-annual, and annual operation and maintenance (O&M) procedures to maintain existing SVE systems as well as planned new SVEWs; and
- A proposed project schedule.

1.2 Scope of Activities

Pre-remedy monitoring activities include collecting samples from the 15 existing soil-vapor monitoring wells (SVMWs) at 58 sample points, collecting soil-vapor samples from the four existing SVE units, and collecting groundwater samples from the 29 existing BFF Spill groundwater monitoring wells and four municipal wells. These samples will be sent to a U.S. Department of Defense (DoD) Environmental Laboratory Accreditation Program (ELAP) certified laboratory for analysis. In addition, onsite monitoring will be conducted for the 13 existing SVEWs on a quarterly basis. Sampling activities will be expanded to include all new wells to be installed during implementation of concurrent groundwater and vadose-zone investigations being conducted at the BFF Spill under this delivery order. Groundwater and soil-gas sampling will provide immediate, as well as long-term data, on subsurface contaminant distribution in the groundwater and vadose zone.

This document also describes quarterly monitoring and O&M activities for four existing internal-combustion engine unit SVE systems operating within the BFF Spill site. Quarterly monitoring and O&M activities will be expanded to include planned new SVEWs to be installed in the deep, intermediate, and

shallow zones as part of concurrent vadose investigations being conducted under this delivery order. Routine maintenance of SVE systems is described, including biweekly, monthly, quarterly, semi-annual, and annual maintenance activities. O&M of new SVEWs will occur as the wells are installed and become operational.

Quarterly monitoring will be conducted for the period of January 2011 until Remedy In Place is achieved or an approved change by NMED.

1.3 Report Organization

The outline for this work plan follows the format required by NMED and is organized into 13 sections as follows:

- Section 1: Introduction
- Section 2: Background Information
- Section 3: Site Conditions
- Section 4: Data Quality Objectives Process
- Section 5: Quarterly Monitoring Methods and Approach
- Section 6: SVE Systems Operation & Maintenance
- Section 7: Project Schedule
- Section 8: Organizational Plan
- Section 9: Data Management Plan
- Section 10: Quality Assurance/Quality Control
- Section 11: Waste Management
- Section 12: Accident Prevention Plan/Site Safety and Health Plan
- Section 13: Community Relations Plan

Figures and tables are provided in separate tabs following the body of the work plan.

Appendices to this work plan include:

- Appendix A: 2010 Regulatory Correspondence between the NMED HWB and the Air Force Regarding the Kirtland AFB BFF Spill
- Appendix B: Project Schedule
- Appendix C: Waste Management Plan
- Appendix D: Field Forms
- Appendix E: BFF Spill QAPjP – to be provided

- Appendix F: Remediation Services International Operations and Maintenance Manual, Version 8.xx
- Appendix G: Standard Operating Procedures (SOPs) for Pre-Remedy Monitoring

2. BACKGROUND INFORMATION

2.1 Site Description

Kirtland AFB is located in Bernalillo County, in central New Mexico, southeast of and adjacent to the City of Albuquerque and the Albuquerque International Sunport (Figure 1-1). The approximate area of the base is 52,287 acres.

2.2 Operational History

The BFF Spill site is located in the northwestern part of Kirtland AFB (Figure 1-1). Historical aerial photography has revealed that the area was used for fuel storage and processing as early as 1951 (CH2M HILL, 2001). At that time, the fueling area was separated into a distinct tank holding area where bulk shipments of fuel were received (near the location of existing well KAFB-1066) and a separate fuel loading area where individual fuels trucks were filled. The truck loading area appears to have been approximately 250 feet (ft) north of the tank area.

Subsequent aerial photographs indicate that construction of the facility and associated infrastructure took place from 1951 until 1953. Once completed, the facility operated until it was removed from service in 1999, as a result of belowground line leakage along the offloading rack (CH2M HILL, 2001). Bulk storage for Jet Propellant-8 fuel (JP-8), diesel fuel, and aviation gasoline (AvGas) was managed in the eastern portion of the facility. A 250-gallon underground storage tank was located near the Pump House, Building 1033 (CH2M HILL, 2001). The three types of fuel handled by the BFF were AvGas, Jet Propellant-4 fuel (JP-4) and JP-8. The use of AvGas and JP-4 at Kirtland AFB was phased out in 1975 and 1993, respectively. JP-8 was handled through the Former Fuel Offloading Rack (FFOR) until the leak was discovered in 1999.

The exact history of releases is unknown. Conceptually, releases could have occurred when fuel was transferred through the FFOR from railcars initially, followed by tanker trucks in later years, to the pump house, and then to the bulk fuel storage containers on the south end of the site (Tanks 2420 and 2422). Probable release points have been investigated and are summarized in subsequent sections. Fuel transfer from the railcars to the pump house was done under vacuum transfers. Transfer of fuel from the pump house to the bulk storage containers was performed under pressurized conditions. Fuel transfer infrastructure for vacuum transfers was exempt from pressure testing, whereas fuel infrastructure for pressurized transfer did undergo regular pressure testing. Only when the vacuum portion of the fuel system underwent pressure testing in 1999 was any problem noted in the fueling system (CH2M HILL, 2001).

At present, jet fuel is stored in two aboveground storage tanks (ASTs) (2.1 and 4.2 million gallons), diesel fuel is stored in two ASTs (one 5,000-gallon and one 10,000-gallon AST), and unleaded gasoline is stored in one 10,000-gallon AST. The site currently has one temporary JP-8 offloading rack located in the southwest corner of the facility, west of the fuel loading structure Building 2404. This rack was placed into service following the piping failure at the FFOR (ST-106). A second small offloading rack (Building 2401) is used for the delivery of diesel and unleaded gasoline motor vehicle fuels.

Fuel delivered to the temporary JP-8 offloading rack is conveyed to the Pump House (Building 1033) via subsurface transfer lines. The fuel is then pumped to the JP-8 ASTs by piping of varying sizes that runs aboveground for approximately 750 ft and runs belowground for approximately 300 ft. Figure 2-1 presents the infrastructure present at the eastern portion of the BFF Spill source area.

3. SITE CONDITIONS

This section describes site conditions, including regional and site-specific geology, hydrogeology, and geochemistry. In addition, it presents the known extent of contamination, summarizes previous investigative results, and describes contaminants of potential concern (COPC) and potential receptors.

3.1 Regional Geology

The geology of the Kirtland AFB area varies in accordance with the regional geology. The eastern portion of the base is mountainous, with elevations reaching 7,900 ft above mean sea level. These mountains are composed of Precambrian metamorphic, igneous (primarily granite), and Paleozoic sedimentary rock (primarily marine carbonates). The western portion of the base (which includes the BFF) lies within the Albuquerque Basin. Geologic features in this area of the basin include travertine and unconsolidated and semi-consolidated piedmont deposits, as well as aeolian, lacustrine, and stream channel deposits.

In general, the surficial geology is characterized by recent deposits (i.e., mixtures of sandy silt and silty sand with minor amounts of clay and gravel), Ortiz gravel (i.e., alluvial piedmont sand and gravel deposits), and the Santa Fe Group (i.e., a mixture of sand, silt, clay, gravel, cobbles, and boulders). Generally, the northern and western portions of Kirtland AFB are dominated by unconsolidated geologic units; consolidated units predominate in the eastern half of the base.

Kirtland AFB lies within the eastern portion of the Albuquerque structural basin, which contains the through-flowing Rio Grande. The basin is approximately 90 miles long and 30 miles wide. The deposits within the Albuquerque Basin consist of interbedded gravel, sand, silt, and clay. The presence of clay has significant implications for bulk hydrocarbon migration in the vadose zone. The thickness of basin-fill deposits in most of the basin exceeds 3,000 ft, though the thickness varies considerably because of the large amount of faulting in the basin. (CH2M HILL, 2008).

Geologic materials of primary importance within the basin are the Santa Fe Group (USF) and the piedmont slope deposits. The USF consists of beds of unconsolidated to loosely consolidated sediments and interbedded volcanic rocks. The materials range from boulders to clay and from well-sorted stream channel deposits to poorly sorted slope wash deposits. Coalescing alluvial fans of eroded materials from the surrounding mountains were deposited unconformably over the USF, extending westward from the base of the Sandia and Manzano mountains to the eastern edge of the Rio Grande floodplain. The fan sediments range from poorly sorted mud flow material to well-sorted stream gravel; the beds consist of channel fill and interchannel deposits. The fan deposits range in thickness from 0 to 200 ft and thicken toward the mountains. The USF under the BFF is further broken down into two depositional facies called the USF-1 and USF-2 (Hawley et al., 1995). USF-1 is present from ground surface to approximately 86 ft below ground surface (bgs), then a transition occurs where USF-1 and USF-2 are interfingered to a depth of 144 ft bgs, under which USF-2 is present to a depth of greater than 500 ft (CH2M HILL, 2008).

3.2 Site-Specific Geology

Soil types at the BFF range from lean clays, silts, and sands to minor silty or sandy gravels. These can be correlated into several litho-stratigraphic zones discussed below.

- From the surface to approximately 86 ft bgs, the soil primarily consists of thick, discontinuous intervals of silt and silty or sandy clays.
- From approximately 86 to 144 ft bgs, two 13- to 25-ft-thick units of poorly graded, fine-grained sands alternate with two silty, sandy, and lean clay units that are up to 25-ft in thickness.
- From approximately 144 to 270 ft bgs, poorly graded, fine-grained sands combine with well-graded, fine-to- coarse-grained sands.
- From approximately 270 to 280 ft bgs is brown, moist to wet, very stiff, lean clay and silty clay.
- From approximately 280 to >517 ft bgs is poorly graded, fine-grained sands combined with buff colored, well-graded, fine to coarsely grained sands with a higher fraction of gravel.

Soil at the BFF ranges from wet to dry. The finer-grained upper soil is generally moist, while the coarser-grained, deeper soil could be moist or dry. Several minor perched water-bearing zones are present in the vadose zone above the regional groundwater table at the BFF. None of these water-bearing zones is substantial enough to merit the installation of a groundwater monitoring well. Some of the water-bearing zones below 400 ft bgs are probably remnants of the regional aquifer left behind as the water table has dropped. The regional water table varies with its location within Kirtland AFB and ranges from approximately 485 to 500 ft bgs (CH2M HILL, 2001).

3.3 Hydrogeology

The groundwater system at Kirtland AFB and in the Albuquerque area lies within the Albuquerque Basin, also referred to as the Middle Rio Grande Basin. The basin is part of the Rio Grande Rift. As the Rio Grande Rift spread, the Albuquerque Basin filled with sediments several miles thick, most of which are referred to as the USF. The unit consists of unconsolidated sediments that thin toward the basin boundary. Edges of the basin are marked by normal faults. Overlying the USF are the Pliocene Ortiz gravel and Rio Grande fluvial deposits.

Generally, the upper unit of the USF contains the most productive portion of the regional aquifer that supplies groundwater to the City of Albuquerque and Kirtland AFB. The unit is characterized by piedmont slope, river, and floodplain deposits. The ancestral Rio Grande formed a large aggradational plain in the central basin, depositing a mix of coarse- to fine-grained sands, silts, and clays with variable bed thickness.

Basin-fill deposits make up the aquifer in the Albuquerque Basin. Hydraulic conductivity values range from 0.25 ft per day (ft/day) to 50.0 ft/day because of large variations in the lithology of the basin-fill deposits. Clay layers have relatively low hydraulic conductivity, whereas gravel and cobble deposits have

relatively high hydraulic conductivity. Deposits of interbedded gravel, sand, silt, and clay have intermediate hydraulic conductivity (Tetra Tech, 2004).

This principal aquifer underlies Kirtland AFB, with the basin fill in this area consisting of unconsolidated and semi-consolidated sands, gravels, silts, and clays of the USF; alluvial fan deposits associated with erosion of upland areas; and valley alluvium associated with stream development. The alluvium varies in thickness from a few feet near the mountains on the east side of the base to greater than 2,100 ft at a location 5 miles southwest of the airfield (Tetra Tech, 2004).

3.4 Geochemistry

Geochemical conditions are one factor that influences the transport and transformation of chemical compounds in the environment. Biodegradation often is a major transformation process for petroleum hydrocarbons and related compounds and, in general, requires sufficient electron acceptors for microbial metabolism of petroleum hydrocarbons. In the presence of a carbon source (including fuel-related aromatic and aliphatic hydrocarbons), naturally occurring bacteria can use the fuel as food for growth and numerous naturally occurring compounds—nitrate, iron, manganese, sulfate, carbon dioxide, etc.—as electron acceptors, producing carbon dioxide, methane, and water (National Research Council [NRC], 2000). Microbial testing of soil performed in 2009 found that significant microbial action was detected at the location with high fuel contamination (CH2M HILL, 2009a).

3.5 Nature and Extent of Contamination

3.5.1 Contaminant Sources

In November 1999, three known discharges occurred as a result of pressure testing of the lines that transfer fuel from the JP-8 offloading rack (Building 2405) to the pump house at the facility (Figure 2-1):

- Failure of one of the 14-inch-diameter belowground transfer pipelines (pipeline #22) during a hydrostatic pressure test,
- Failure of a cam-lock coupling during pressure test of the second belowground transfer pipeline (pipeline #23), and
- Failure of the second belowground transfer pipeline (pipeline #23) during a hydrostatic pressure test after the cam-lock coupling problem had been corrected.

Testing revealed that the primary belowground transfer pipeline (pipeline #22) had been in a state of failure for an unknown duration; therefore, the total amount of fuel released is unknown. The volumes of the second two discharges were estimated to be approximately 200 to 400 gallons and 30 gallons, respectively. For all discharges documented in November 1999, the product released was JP-8. However, because of the presence of multiple types of fuel contamination on the water table and the size of the light non-aqueous phase liquid (LNAPL) plume, it is likely that the primary pipeline had been in a state of failure for many years. The presence of LNAPL fuel hydrocarbons on the water table also indicates that substantial releases have occurred and that a range of fuel types may have been released. Fuel types include AvGas, diesel, JP-4, and JP-8 (Tetra Tech, 2004).

In 1951, the U. S. Government specified JP-4 (for Jet Propellant) as a 50-50 kerosene-unleaded gasoline blend (MIL-J-5624E). JP-4 was the primary Air Force jet fuel between 1951 and 1995 (Tetra Tech, 2004). JP-4 is a mixture of aliphatic and aromatic hydrocarbons with a low flash point (0 degrees Fahrenheit [°F]/-18 degrees Celsius [°C]), if a lit match is dropped into JP-4, ignition does not occur.

JP-8 was specified by the U. S. Government in 1990 as a lower volatility replacement for JP-4. JP-8 is kerosene-based and has been used in nearly all jet aircraft, tactical ground vehicles, and electrical generators since 1996. Based on historical Air Force fuel usage, AvGas would have been in use from approximately the 1940s to 1975. Ethylene dibromide (EDB) was added to the fuel as a lead scavenger

and serves as a useful tracer of time frames. Likewise, the transition from JP-4 to JP-8 in 1993 serves as another potential marker.

Over the past several years, potential sources in addition to the offloading rack were evaluated as possible contributors to LNAPL on the water table. These previously investigated potential sources include the pump house, a fueling island, underground piping, an evaporation pond, and areas where water from the bottom water holding tanks was released. The bulk fuel ASTs will be investigated following demolition of the standing ASTs. Demolition in this area is anticipated to be completed in the second quarter of 2011.

3.5.2 Investigative Results

As previously mentioned, in November 1999, three known discharges occurred as a result of pressure testing of the lines that transfer fuel from the JP-8 offloading rack (Building 2405) to the pump house at the facility. Subsequent investigations were conducted and the results are provided in the following reports:

- *Stage 1 Abatement Plan Report for the Bulk Fuels Facility (ST-106)* (CH2M HILL, 2001),
- *Stage 2 Abatement Plan Report for the Soil Vapor Extraction and Treatment System, Bulk Fuels Facility (ST-106)* (CH2M HILL, 2006a),
- *Stage 1 Abatement Plan Report, East Side of the Kirtland AFB Bulk Fuels Facility* (CH2M HILL, 2006b),
- *Semi-Annual Summary and Performance Report, October 2007 through March 2008, Bulk Fuels Facility* (CH2M HILL, 2008), and
- *Remediation and Site Investigation Report for the Bulk Fuels Facility* (CH2M HILL, 2009a).

Findings of these investigations are summarized below.

Stage 1 Abatement Plan Report (CH2M HILL, 2001)

In the soil investigations initiated immediately after the 1999 discovery of the fuel-line leak, contamination was detected along the JP-8 offloading rack that supplies the 300-ft-long, belowground pipeline. The horizontal extent of shallow contamination less than 40 ft bgs was delineated during the June 2000 direct-push investigation portion of the Stage 1 investigation. This contamination appeared to be limited to within 50 ft lateral to the location where the pipelines went belowground.

Site investigations conducted during 2000 also included soil characterization at depth, extending down to the water table at select locations. Contamination was identified in two deep soil borings (SB-25 and SB 26) installed during July 2000 using hollow-stem auger drilling. These two borings were located on the eastern and western ends of the offloading rack. The maximum concentration detected in soil from boring SB-25 was 81,000 parts per million (ppm) of total petroleum hydrocarbons (TPH) in the sample from 105 ft bgs, which is just below the Transition Zone between USF-1 and USF-2. The maximum concentration detected in boring SB-26 was 114,000 ppm of TPH in the sample from 270 ft bgs, which is just above the clay zone that divides the USF-2 hydrostratigraphic unit.

Additional borings were installed to determine the horizontal extent of the TPH-contaminated soil with concentrations greater than 100 milligrams per kilogram (mg/kg). Based on data from the additional borings, soil contaminated in excess of the NMED *TPH Screening Guidelines* (NMED, 2006) is limited to within approximately 310 ft of the surface; and within the area 65 ft south, 280 ft north, 400 ft east, and 175 ft west of the FFOR. The total area of soil affected by the petroleum-hydrocarbon contamination is estimated to be 6.5 acres, with depths of contamination extending to 310 ft bgs.

Stage 2 Abatement Plan Report (CH2M HILL, 2006a)

Additional borings were advanced in 2003 as part of a pilot test for SVE. All four SVMWs included both soil and vapor sampling activities and were completed to depths of approximately 450 ft bgs. In addition

to the anticipated intervals of petroleum-related contamination, two locations were found to have detections at the lowest sampling depth of 60 ft bgs.

Stage 1 Abatement Plan Report, East Side of the Kirtland AFB Bulk Fuels Facility, (CH2M HILL, 2006b)

In 2005, a shallow soil investigation of potential source areas on the east side of the BFF was conducted. Soil samples were collected from the following areas:

- Former Wash Rack Drainfield
- Three fuel-storage ASTs
- Former Fuel/Water Evaporation Pond
- Recovered Liquid Fuel Collector Tank
- Primary fuel-storage ASTs and tank bottom water-holding tanks

The investigation included excavating test pits (TP-07, TP-08, and TP-09) and advancement of a direct-push borehole (SB-04) to 50 ft bgs. Additionally, a temporary soil-vapor monitoring point was installed in the direct-push borehole and was monitored for hydrocarbon concentrations with field monitoring equipment for several quarters. Based on visual observations, analysis of soil samples from the test pit and shallow soil sampling at this location, and soil-vapor samples, substantial hydrocarbon impacts were not identified in the interval from the ground surface to 50 ft bgs. The only area where the NMED TPH guideline (NMED, 2006) was exceeded was in the vicinity of the primary fuel storage ASTs and tank bottom water-holding tanks. The maximum petroleum-hydrocarbon concentration was 2,400 mg/kg detected in the 15 ft bgs sample. None of the detections suggested the area was a contributor to the soil-vapor profile at the BFF Spill.

Semi-Annual Summary and Performance Report (CH2M HILL, 2008)

In 2007, groundwater monitoring well KAFB-1066 was installed in the general vicinity of the east side of the BFF. This monitoring well was installed between the presumed area of the storage tank associated with the 1951 rack operations and the location of the filling rack itself where tanker trucks would have

been fueled. Well KAFB-1066 is roughly 75 ft north of the storage tank area associated with 1951 operations. Additionally, 15 groundwater monitoring wells were installed between 2007 and 2008. These monitoring well installations are reported in the Semi-Annual Summary and Performance Reports. Soil sampling was conducted at 20-ft intervals during advancement of the KAFB-1066 borehole, from 20 to 480 ft bgs. Soil sample results did not suggest the presence of a large surface release of fuel in this area. However, there were detections of limited petroleum-hydrocarbon concentrations (< 100 mg/kg) throughout much of the borehole length, and isolated, higher concentration detections of other fuel compounds, such as toluene, benzene, xylenes, etc., at individual shallower depths of 40 and 140 ft bgs in the borehole. While the individual fuel-related detections in the borehole were not extremely high, the pattern of detections may be indicative of a predominantly stair-step lateral and vertical migration of near surface releases of fuel through the vadose zone.

Remediation and Site Investigation Report (CH2M HILL, 2009a)

In 2009, soil boring investigations were conducted and four additional groundwater monitoring wells were installed at the BFF Spill to further evaluate other potential source areas. Soil data are consistent with previous sampling results, and the effectiveness of the SVE system was indicated. LNAPL was not detected in samples collected from any of the newly installed wells.

3.5.3 Identification of Contaminants of Potential Concern (COPC)

Petroleum contamination associated with the BFF Spill has been identified in subsurface soil, soil gas, and groundwater. Contamination appears to be a result of various releases that have occurred over the operational history of the facility. Information is available on some of the releases whereas other releases are not well documented and are inferred to have been ongoing for unknown periods of time. All COPCs at the BFF Spill are constituents of refined petroleum products and include, but are not limited to, the following: benzene, toluene, ethylbenzene, and xylene (BTEX); naphthalene; EDB; and lead.

COPCs for the BFF Spill are compared to the New Mexico Water Quality Control Commission (WQCC) water quality standards 20.6.2.3103 and 20.6.2.4103 New Mexico Administrative Code and the drinking water maximum contaminant levels (MCLs) adopted by the U.S. Environmental Protection Agency (EPA) under the federal Safe Drinking Water Act. If both standards have been established for a contaminant then the more stringent of the two standards will be used as the cleanup level for the contaminant. The WQCC and MCL for the COPCs are as follows:

Parameter	New Mexico WQCC	EPA MCL
Benzene	0.01 milligrams/liter (mg/L)	0.005 mg/L
Toluene	0.75 mg/L	1.0 mg/L
Ethylbenzene	0.75 mg/L	0.70 mg/L
Total xylenes	0.62 mg/L	10.0 mg/L
EDB	0.0001 mg/L	0.00005 mg/L

Previous TPH vapor data suggest the movement of LNAPL through the vadose zone was offset to the east and north, presumably by fuel migration along dipping clay layers. Conceptually, TPH vapor results at 450 ft show the effect and correlate well with the distribution and orientation of LNAPL on top of the water table and groundwater contamination.

3.5.4 LNAPL Distribution

The greatest thickness of LNAPL occurs in the area to the east of the FFOR. LNAPL thickness is consistent with vadose-zone migration of bulk LNAPL migration along east dipping clay beds by following the groundwater table toward the north and east. On May 14, 2010, measurements of LNAPL were made in monitoring wells that have historically had or potentially have measurable thickness of LNAPL. Measured LNAPL was detected in the following wells:

- KAFB-1065 3.33-ft SVE
- KAFB-1066 2.45-ft SVE
- KAFB-1068 3.8-ft SVE
- KAFB-1069 0.79-ft
- KAFB-10610 1.18-ft

- KAFB-10614 0.23-ft
- KAFB-10618 (sheen)
- KAFB-10628 (0.5 ft estimated based on surrounding well data)

Measured thicknesses are greater at monitoring wells where active SVE is ongoing, possibly producing a mounding effect. The LNAPL plume extends approximately 2,600-ft long and is approximately 1,000-ft wide trending along the groundwater flow direction.

3.5.5 Dissolved-Phase COPC Distribution

The distribution of dissolved-phased contaminants forms a halo around the LNAPL plume. As expected, high concentrations of dissolved COPCs are detected very close to the LNAPL plume due to the dissolution of petroleum products into the groundwater and lower concentrations further from the LNAPL plume. The dissolved-phase plume as it is currently understood extends approximately 4,500 ft along the axis of the plume, trending along the groundwater flow direction. EDB is the most widely distributed COPC. The footprint of the dissolved-phase plume downgradient is elongated as the more mobile contaminants, such as benzene and EDB, are more quickly transported along with groundwater movement downgradient.

3.5.6 Site-Specific Fate and Transport

In aerobic and anaerobic environments, BTEX can be degraded by microorganisms. Kinetic rates of BTEX degradation are highest under aerobic conditions. The natural abundance of electron acceptors like nitrate, manganese, iron, and sulfate are typically higher than contributions from oxygen and are typically more than sufficient to stabilize the advancement of a dissolved petroleum-hydrocarbon plume (NRC, 2000). Methanogenesis is unique in that carbon dioxide, biodegradation byproduct, is both produced and used as an electron acceptor. Thus, if methanogenesis is occurring at a site, electron acceptor limitations will not be expected to occur until all petroleum hydrocarbons and carbon residuals are fully degraded. EDB can degrade via aerobic and anaerobic biodegradation and abiotic hydrolysis.

In the vadose zone at the BFF Spill, aerobic biodegradation is expected to be a significant transformation mechanism. Natural fluctuations in barometric pressures create pressure differentials between the atmosphere and the subsurface promoting air exchange and oxygen transfer. Biological sampling in the vadose zone has determined that a robust bacterial community is present, which can contribute to degradation of hydrocarbons. In the saturated zone, both aerobic and anaerobic biodegradation are expected to occur (CH2M HILL, 2009a).

The fuel "type" indicates the release started before 1981 due to the presence of AvGas on the water table. EDB is detected on the leading edge of the plume, indicating the source as being AvGas. The presence of EDB and the lack of BTEX compounds is indicative of natural attenuation occurring on the edges of the dissolved plume. EDB is a recalcitrant compound and slow to naturally attenuate by microbial means.

Vertical migration of LNAPL from the source area/release through the vadose zone is the primary mechanism of contaminant transport within the vadose zone at Kirtland AFB. The release of fuels in the source area ceased in 1999. Residual fuel in the vadose zone will be entrapped by capillary forces in the soil. Only that part of the fuel that is present in the vadose zone at greater than residual saturation will continue to migrate.

A secondary transport mechanism within the vadose zone in the source area is within the soil vapor. Vapor-phase contamination occurs as contaminants partition from entrapped LNAPL and soil water into soil gas. Vapor-phase contamination will disperse in an approximately spherical pattern through the vadose zone surrounding the source area. For this reason, additional monitoring points have been located radially around the source area and vertically across the vadose zone to allow delineation of this spherical vapor plume. In addition to vapor migration vertically down to the groundwater table, vapor migration vertically upwards to the ground surface also is a potential.

Groundwater flow and, hence, contaminant transport is affected by both regional groundwater flow and localized effects of induced groundwater flow from pumping. Locally, the effects of pumping can induce increased gradients vertically and laterally. Transport of dissolved contaminants will be affected by both physio-chemical retardation and biodegradation.

3.5.7 Potential Receptors

The Veterans Administration (V.A.) Medical Center water well and Kirtland AFB groundwater production wells KAFB-15 and KAFB-16 are located sidegradient of known areas of petroleum-hydrocarbon contamination. The V.A. Medical Center water well, Kirtland AFB groundwater production wells, and water utility authority well fields will be considered potential pathways of exposure until they can be excluded with defensible data. During the second quarter 2009 sampling, TPH-diesel range organics was the only chemical detected in well KAFB-16 at 0.26 micrograms per liter (µg/L). This detection was attributed to the requirement of the use of lubricating oil in the pump. Water production wells KAFB-3 and Burton Well W-5 are located 3,800 and 3,700 ft, respectively, downgradient of the leading edge of the EDB plume and 5,400 and 4,800 ft, respectively, downgradient of the LNAPL plume. Construction workers who may be exposed to subsurface soil are potential receptors. However, the existing Kirtland AFB digging permit clearance process provides notification and protection against inappropriate exposures to construction workers.

Vapor intrusion may be a concern in any building located near the LNAPL release. Therefore, an investigation of the potential for vapor intrusion was recently completed for two buildings overlying the LNAPL release. Based on the results of this investigation, indoor air quality levels of LNAPL-related compounds are acceptable (AECOM, 2010).

3.5.8 Site-Specific Conceptual Model

The specific conceptual site model (CSM) will be included as Part II to the Groundwater Investigation Work Plan (Shaw, 2010a), which will also address data gaps as applicable. The CSM will include an in-depth discussion of site geology; it will encompass the source areas, fuel percolation area, LNAPL plume floating on groundwater, and dissolved-phase contaminant plume in groundwater. Applicable models will be illustrated through the liberal use of detailed, accurate, scaled geologic cross-sections; maps in plan view; and other figures to clearly and accurately show geologic features, hydrologic features, and contamination levels.

4. DATA QUALITY OBJECTIVES PROCESS

4.1 Data Quality Objectives

DQOs are the basis for design of the data collection plan. DQOs specify the type, quality, and quantity of data to be collected and how the data are to be used to make the appropriate decisions for the project. They are qualitative and quantitative statements that specify the quality of data generated to support decision making. DQOs are scoping and planning tools applicable to every data generation effort, and developing DQOs is a necessary step for project-specific plans. For each data collection task, DQOs are developed during project scoping and include a description of the purpose of the task, the specific activities to be performed, the intermediate and end-uses of the generated data, and the resultant data quality that is required.

The DQO development process includes the following steps:

1. Statement of the problem
2. Identification of a decision that addresses the problem
3. Identification of inputs that affect the decision
4. Specification of the domain of the decision
5. Development of logic statement
6. Establishment of constraints on uncertainty
7. Optimization of design for obtaining data

The DQO process is an iterative process that occurs at every stage throughout the project to ensure that stakeholders obtain sufficient quantity and quality of data to provide the basis for decision making. DQO development is consistent with EPA guidance, *Guidance on Systematic Planning Using the Data Quality Objectives* (EPA, 2006) and the *Uniform Federal Policy for Quality Assurance Project Plans, Final, Version 1,* worksheets 10, 11, and 17 (EPA, 2005a). DQOs specific to the pre-remedy quarterly monitoring work plan are presented in Table 4-1. Details are provided below.

4.1.1 Quarterly Groundwater and Soil-Vapor Sampling

Quarterly groundwater samples will be collected from 29 existing groundwater and 4 municipal wells, and 78 additional wells as well installation is completed for this project. In addition, quarterly soil-vapor samples will be collected from the 15 existing SVMWs and 35 additional wells to be installed, and the current 4 SVE systems. The samples will be sent to a DoD Environmental Laboratory Accreditation Program certified laboratory for analysis per the requirements in the June 4, 2010 NMED letter. In addition, onsite monitoring will be conducted for the 13 SVEWs on a quarterly basis. The DQOs for the quarterly groundwater and soil-vapor sampling and analysis are to ensure that data of sufficient quality and quantity is being collected to continuously monitor the extent of contamination of the groundwater and vadose zone associated with the BFF Spill.

4.1.2 Groundwater and LNAPL Measurement

The DQO to characterize horizontal and vertical groundwater flow will be satisfied by collection of groundwater elevation measurements in the aquifer. Groundwater measurements will be collected from all new and existing monitoring wells on a monthly basis through 2011 and quarterly until Remedy In Place is achieved or an approved change by NMED. The data will then be used to calculate groundwater horizontal and vertical gradients, which determine groundwater flow directions. Groundwater flow direction will be used to refine, as applicable, the locations of proposed groundwater extraction wells to contain the movement of the LNAPL and the dissolved-phase plume and to investigate probable contaminant flow paths.

DQOs associated with collection of LNAPL measurements are to determine the extent of the LNAPL plume. The extent of the thickness of LNAPL will be used to determine if locations of planned SVE and groundwater extraction remediation wells should be revised. Thickness measurements of the LNAPL will assist in determining the persistence of LNAPL in conjunction with proposed remediation efforts.

4.1.3 SVE System O&M

SVE system O&M will be performed on a routine basis in accordance with Section 6 of this work plan and as required per the SVE unit manufacturer's guidelines to ensure appropriate and efficient operation of the systems to effect ongoing removal of volatile organic compounds (VOCs) from contaminated soil at the BFF Spill site. Vapor samples will be collected from the SVE units quarterly for offsite laboratory analysis to support the evaluation of SVE system operations.

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5. QUARTERLY MONITORING METHODS AND APPROACH

5.1 Project Coordination

Before the start of field work, a kickoff meeting will be held at Kirtland AFB. Invitees will include representatives from the USACE, Air Force Center for Engineering and Environment (AFCEE), Kirtland AFB, NMED, and contractors conducting the work. The meeting will outline roles and responsibilities of all participants; review scope, schedule and procedures; and discuss base rules and security requirements. During the field implementation kickoff meeting, a list of critical contacts within the field team, the USACE, Kirtland AFB, and AFCEE will be compiled. This contact list will be used should immediate input be needed to any decision process critically impacting field work. This list will be reviewed and revised, as needed.

During quarterly monitoring activities, daily quality control reports (DQCRs) will be completed by the field lead and provided to the project manager and the USACE. DQCRs summarize field activities and quality control (QC) activities that occur during each day. In compliance with the established *Base-Wide Plans for Investigations under the Environmental Restoration Program*, Kirtland AFB, 2004 Update, Field Change Request (FCR) forms will be filled out if there are any changes to the approved work approach. If the FCR represents a major change, the USACE, AFCEE, and Kirtland AFB will be notified for approval and for submittal to the NMED for approval before commencement.

A monthly status meeting will be held among the field team, the USACE, AFCEE, Kirtland AFB, and NMED to discuss the progress of the field effort, upcoming field work, and consider any problems or issues that require resolution. Meeting minutes and action items will be documented by the project manager or designee, and circulated to the participants. Conference calls will be implemented as deemed necessary.

5.2 Field Activities

Field activities associated with pre-remedy monitoring include groundwater and vadose-zone sampling, collection of field parameter measurements, onsite monitoring of SVEWs, sample packaging and shipment, management of investigation-derived waste (IDW), equipment decontamination, pump installation and maintenance, and use of proper personal protective equipment (PPE). Groundwater sampling activities will include pump installation and maintenance, monitor well purging, pre-monitoring well sampling, sample collection, and groundwater level and LNAPL measurements. Vadose-zone sampling and analysis will include well purging, sample collection, and sample management. Each of these activities is described in the subsections below.

All soil-gas and groundwater information collected during quarterly monitoring will support delineation of the lateral and vertical distribution of LNAPL and dissolved groundwater contaminants, either as residual masses in the soil or from the floating pool at the water table. This information will be used to refine the conceptual site model and to determine the requirements of the shallow/intermediate remediation and LNAPL containment interim measure systems. The scope of quarterly monitoring will include new wells to be installed as described in the Groundwater Investigation and Vadose Zone Investigation Work Plans (Shaw, 2010a,b). Locations of existing groundwater wells are shown on Figure 5-1 and locations of existing soil-gas sample points on Figure 5-2. Figure 5-3 identifies the locations of all new wells proposed to be installed as part of concurrent groundwater and vadose-zone investigations to be conducted at the BFF Spill.

The USACE will notify the NMED no less than 15 days before field sampling or other field activities and will provide the NMED the opportunity to collect split samples upon request.

5.2.1 Groundwater Sampling and Analysis

Groundwater sampling consists of measuring groundwater and LNAPL levels and use of approved purging and sampling to collect representative groundwater samples for field parameters and offsite laboratory analysis. Each groundwater monitoring well, including the existing wells and 78 wells to be installed as outlined in the Groundwater Investigation Work Plan (Shaw, 2010a), will be sampled quarterly under the scope of this work plan. Table 5-1 lists the existing groundwater monitoring wells at the BFF, well construction details, and groundwater elevations. This table will be updated quarterly as new wells are completed and incorporated into the monitoring program.

5.2.1.1 Sampling Pump Installation and Maintenance

Each groundwater monitoring well will be equipped with a dedicated Bennett sampling pump, which will be installed following completion of well development. Use of dedicated sampling pumps improves sample integrity by minimizing the need to decontaminate equipment, thus minimizing cross-contamination often associated with reusable sample pump and tubing. A non-dedicated, sampling pump system will be used to perform quarter 1 sampling in January 2011 at 19 of the existing 29 wells. Subsequent to the 2011 quarter 1 sampling event, Bennett pumps will be purchased for installation at the 19 existing wells and all additional wells as they become completed.

5.2.1.2 General Pre-Monitoring Well Sampling Requirements

1. Monitoring wells will be sampled in order of increasing contamination unless the wells are equipped with dedicated pump systems.
2. Sampling for newly installed wells will be performed subsequent to well development.
3. Appropriate PPE, as outlined in the Site Safety and Health Plan (Shaw, 2011), will be used. In addition, field sampling personnel will don new sampling gloves at each individual well before beginning sampling.
4. The exterior of the monitoring well will be visually examined for signs of damage or tampering and observations recorded on the purge log form.
5. The well cap or outer steel casing lid will be unlocked.

6. Photoionization detector readings will be taken with the appropriate meter(s) at the well head immediately upon opening the cap and information recorded in field logbook. If high concentrations are detected, the appropriate measures, as outlined in the Site Safety and Health Plan (Shaw, 2011), will be implemented.

7. The static water level and the LNAPL depth and thickness in the well will be measured using a oil/water interface probe. Measurements will be recorded on the purge log form prior to sampling, and on the field form for water level measurements only. The "as-built" depth of the well will be measured to verify original construction details and determine if any appreciable fines have entered the well, which may cause problems during sampling and/or potential problems with analytical data. The water-level indicator will be appropriately decontaminated using phosphate-free detergent and rinsed with tap or deionized water in between each well to prevent cross-contamination.

8. The Groundwater Purge and Water Quality Meter Field Calibration forms (Appendix D, Forms 1 and 2) will be used in the field to: 1) calculate the specific purge volume for each well; 2) document the water quality parameters; 3) document the field alkalinity measurement; and 4) maintain the water quality meter calibrations. Appendix D also contains the sample chain of custody record (Form 3) to be used for sample collection and shipment to the offsite laboratory.

5.2.1.3 Low-Flow Purging Requirements

Monitoring wells will be purged using the Kirtland AFB Base-Wide Plan (BWP) Standard Operating Procedure (SOP) B4.1, "Monitoring Well Sampling" (Appendix G). Specifics from this SOP include:

1. Begin purging at a rate of approximately one liter per minute or as slow as the conditions and dedicated system will allow (if greater than one liter per minute).

2. Monitor the following field parameters while purging: dissolved oxygen, pH, oxidation reduction potential, turbidity, specific conductance, and temperature. In addition, alkalinity will be measured in the field using a LaMotte, Hach, or similar type field test kit, after stabilization of parameters.

3. Continuously monitor the water level and potential subsequent drawdown with an electric water-level indicator. If the static water level before purging is within the screened interval, the drawdown will not exceed a distance of 25 percent of the length of the saturated screened interval. If the water level falls below the 25 percent drawdown level, the pumping rate will be decreased to stabilize the water level to prevent cascading and potential loss of volatiles, excessive turbidity, and entrapment of air in the filter pack. If the static water level is above the screened interval, acceptable drawdown is defined as the lowering of the water level to the top of the screened interval. If continued drawdown occurs below the top of the screened interval, the pump rate will be decreased to stabilize the water level to prevent atmospheric contact with the filter pack and formation, which could alter redox chemistry of the well.

   Note: In wells with slow recharge rates, it may be necessary to stop the pump and allow the well to recharge in order to remain at or above the drawdown limit. If this is necessary, field personnel will be certain not to allow any water in the tubing to back flush into the well when purging recommences.

4. Purging will be considered complete when the volume of purge water calculated according to the formula presented in Appendix D, Form 1 has been removed, and groundwater quality parameters have stabilized according to the requirements listed below:

   - Dissolved oxygen ± 3.0 mg/L

- Oxidation reduction potential ± 10 millivolts
- Turbidity < 10 nephelometric turbidity unit (NTUs) or ± 10% when < 10 NTUs cannot be achieved
- Specific conductance ± 3 % micro mhos (µmhos)/centimeter (cm)
- pH ± 0.1 units
- Temperature ± 10 % °C or °F

5. In the event that the pump seizes and locks up during purging or sampling activities and it is necessary to jiggle or move the pump within the well, purging will be re-initiated beginning with the first step of this procedure.

5.2.1.4 Groundwater Sample Collection

All groundwater samples will be collected using the dedicated, low-flow, submersible pump installed in the sample well, or portable submersible pump until dedicated pumps can be installed. Samples will be collected for field parameters and laboratory analysis. Collection of groundwater samples will follow the following procedures:

1. Flow rates for sampling with low-flow pumps will be maintained at 1-2 liters per minute pending drawdown.

2. Sample labels will be affixed to each container after sample collection, so that they do not become illegible.

3. Samples for volatile organic analysis (VOA) will be collected first. The samples will be carefully filled to avoid overflow and potential loss of preservative and tapped so entrapment of air is minimized and no head space exists. If bubbles appear, the vial will be refilled or a new vial will be used if a sample preservative (i.e., hydrochloric acid) is used.

4. Samples for non-volatile organic analysis will be collected following the volatile organic sample collection. Samples for dissolved metals analysis may be field-filtered according to procedures presented below. If field filtration is not performed, the sample container must be clearly marked to state “laboratory filtration required.”

5. Field parameters (pH, specific conductance, temperature, dissolved oxygen, turbidity and oxidation reduction potential) will be measured using a flow cell with a water-quality meter prior to sample collection. Field alkalinity will be measured after the environmental samples are collected from the well.

6. Analytical samples will be placed in a cooler and chilled to 4°C. Samples will be shipped to the appropriate laboratory within 24 hours. The sample cooler will be shaded from direct sunlight immediately after collection.

7. The well will be closed and the well cap re-locked.

8. The Daily Field Activity Log sheets, sample log sheet, custody seals, and chain-of-custody form (Appendix D, Form 3) will be completed prior to leaving the well location.

Each monitoring well will be sampled for the following field and laboratory parameters:

- Field Parameters/Analysis:
  - Dissolved oxygen - meter
  - Oxidation reduction potential - meter
  - Specific conductance - meter
  - Turbidity - meter
  - pH - meter
  - Temperature - meter
  - Alkalinity – field test kit

- Offsite Laboratory Analysis:
  - VOCs - SW846 8260B (EPA, 2007)
  - EDB – SW846 8011 (EPA, 2007)
  - TPH gasoline/diesel range organics - SW846 8015C [modified] (EPA, 2007)
  - Volatile petroleum hydrocarbon (VPH) /extractable petroleum hydrocarbon (EPH) – Massachusetts Department of Environmental Protection (MA DEP) (4 quarters only for risk assessment purposes) (MA DEP, 2004a,b)
  - Cations (calcium, potassium, magnesium, sodium) - SW846 6010C (EPA, 2007)
  - Lead - SW846 6010C (EPA, 2007)
  - Dissolved iron and manganese - SW846 6010C (EPA, 2007)
  - Anions (chloride, sulfate, nitrate) - EPA 300.0 (EPA, 1993)
  - Ammonia nitrogen - SM 4500NH (American Water Works Association [AWWA], 2005)
  - Alkalinity (carbonate and bicarbonate) - SM 2320B (AWWA, 2005)
  - Total sulfide - SM 4500 S2CF (AWWA, 2005)

Groundwater sampling meets requirements set forth in the NMED correspondence (Appendix A, Attachment 2). Table 5-2 lists sample container, preservation, and holding time for each parameter. Table 5-3 specifies the number of field and QC samples to be collected and the appropriate analytical methods to be used.

Field filtration of groundwater samples will be conducted in accordance with Kirtland AFB BWP SOP B4.4, “Field Filtration” (Appendix G). Filtering of groundwater field samples for dissolved iron and manganese analysis will employ a 0.45-micron cellulose-based membrane filter. The filters are designed for single use in-line water filtration in the field. Use of these filters will eliminate cross-contamination. The sample will be filtered immediately after collection to minimize changes in the concentration of the metals of interest. Samples will only be passed through the filtration apparatus once. Samples will then be

preserved immediately, as required. All paperwork accompanying samples to the laboratory will clearly state that the samples have been field-filtered.

Field filtering of groundwater samples will be conducted as follows:

1. The filter apparatus will be decontaminated and cleaned.
2. The sample will be poured into the filter apparatus and filtered through a cellulose-based membrane filter of 0.45-micron, nominal size. To condition the filter, ½ of the sample volume will be passed through the filter apparatus and filter paper and then discarded. The full sample volume will then be filtered and collected in the appropriate sample container. Samples are only passed through the filter once.
3. Samples will be preserved immediately, as required.
4. Analytical samples will be placed in a cooler and chilled to 4°C. Samples will be shipped to the appropriate laboratory within 24 hours.
5. The field logbook, sample log sheet, labels, custody seals, and chain-of-custody forms will be completed during sample collection.

5.2.1.5 Measuring Groundwater and LNAPL Levels

Water/LNAPL level measurements should be conducted in accordance with Kirtland AFB BWP SOP B5.6, “Water Levels,” and Shaw SOP EI-FS108, “Measurement of Water and LNAPL in Monitoring Wells” (Appendix G). Water and LNAPL measurements will be documented on the Groundwater Level Data Form (Appendix D, Form 4). Depth to water and LNAPL thickness will be measured in each groundwater monitoring well using an electronic, oil-water interface probe, or similar device, immediately before purging and sampling. Measurements will be performed monthly for 2011 and then on a quarterly basis for 2012 until Remedy In Place is achieved or until an approved change by NMED. Although wells located within the LNAPL plume (NMED well locations 11, 12, 13, 17, and 18) are anticipated to contain LNAPL, measurements of LNAPL will be performed at all newly installed monitoring wells, including wells outside of the known LNAPL plume. These measurements will be used to help delineate the extent of the LNAPL. Standard procedures when conducting depth to LNAPL, depth to water, and LNAPL thickness are, as follows:

1. Arrange the sequence of measurements from the well with the least amount of LNAPL contamination to the well with the greatest measurable LNAPL concentration in order to minimize cross-contamination.

2. Check operation of measurement equipment aboveground. Before opening the well, don PPE as required by the Site Safety and Health Plan (Shaw, 2011).

3. Lower the interface probe into the well and note the depth to LNAPL, the depth to groundwater, and total well depth. Take all measurements from the surveyed reference mark located on the top edge of the well casing. Record all measurements to the nearest 0.01 ft (0.3 cm).

4. Record all information on the field form (well sampling form) and/or in the field logbook.

5. Record well number, top of casing elevation, well diameter, and ground surface elevation if available.

6. Record the time and day of the measurement.

7. Clean all oil/water level measurement devices before and after each use to prevent cross-contamination of wells. Use a standard brand of phosphate-free detergent (Alconox or Liquinox brands) and tap water from any municipal water treatment system or deionized water to rinse equipment free of detergent. Rub detergent over the surface of the equipment, using a brush or paper towels, to appropriately remove any residues. Rinse surfaces off with water and dry with paper towels or air dry. Inspect equipment before use to ensure that no residue remains.

5.2.2 Vadose-Zone Sampling and Analysis

Quarterly vadose-zone monitoring of soil gas will be conducted starting in 2011 until Remedy In Place is achieved or an approved change by NMED. Samples will be collected from the 15 existing SVMWs (58 sample points). These samples will be sent for laboratory analysis. Field measurement parameters will be collected for hydrocarbon concentration, percent oxygen, carbon monoxide, and carbon dioxide in the 13 existing SVEWs, using the Horiba emissions analyzer. The scope of quarterly monitoring will be expanded to include the 35 additional SVM wells upon completion. To maximize efficiency, vadose-zone monitoring will be conducted in conjunction with groundwater monitoring. Table 5-4 summarizes the existing soil-vapor monitoring wells, the soil-vapor extraction wells, and the existing SVE units. Existing SVMWs are depicted on Figure 5-2 and proposed wells are depicted on Figure 5-3.

5.2.2.1 Well Purging

Soil-vapor well purging and sampling will be conducted in accordance with RTI Laboratories, Inc.'s SOP for air sample collection (Appendix G). To collect a representative sample, each well will be purged

before sampling to remove stagnant air from the well casing and any associated piping. Purging and sampling of a well will be conducted after the well pressure has been measured and recorded. Exceptions will be made for vapor extraction wells that are actively open to the treatment unit as the treatment engines continuously purge the well and associated piping during operation. For each well, the volume (in cubic feet) of casing and any associated piping will be calculated, and the purge pump will be operated long enough to remove three casing/piping volumes before sampling the well.

5.2.2.2 Soil-Gas Sample Collection

Per NMED requirements a total of 58 soil-gas monitoring points will be sampled during 2011 quarter 1, and a total of 215 additional vapor points will be sampled during subsequent quarters pending installation of the 35 additional SVMWs. Samples will be collected using passive Bottle-Vac™ canisters with a controlled-flow pump system. The Bottle-Vac™ canisters will be obtained from the specialty air laboratory that will ensure that they are certified clean for use. Soil-vapor sampling will be performed in accordance with approved EPA methodologies, MA DEP methodologies, the BWP SOPs (Tetra Tech, 2004), and the BFF Spill QAPjP.

Vadose-zone sampling and monitoring documentation will be recorded in field logbooks and on field forms as specified in the BWP SOPs. Sample information will be recorded on chain-of custody forms (Appendix D, Form 3), and samples will be packaged for shipment to the offsite laboratory in accordance with the BWP SOPs, the BFF Spill QAPjP (Appendix E), and manufacturer's recommendations.

Vapor samples will be collected from all monitoring intervals (all depths) for each SVMW. The soil concentration of soil vapor will be continually monitored with an appropriate field instrument (e.g., photoionization detector of appropriate lamp energy) while purging. Samples will be collected after field instrument readings have stabilized within ±10 percent for three consecutive measurements and after the sampling tubing and the soil-gas monitoring well have been purged to remove all stagnant vapor. Soil-gas

measurements taken in the field during purging, the data and time of each measurement, and the type and serial number of field instrument used will be recorded in a logbook.

Samples from the SVEWs will be analyzed quarterly in the field using a Horiba Mexa 554J emissions analyzer for the following parameters:

- Petroleum-hydrocarbon concentration in parts per million by volume (ppmv)
- Percent oxygen
- Carbon monoxide
- Carbon dioxide
- Pressure measurements with a Magnehelic® gauges in units of inches of water

Quarterly vapor samples will be analyzed by an offsite specialty analytical laboratory that maintains a current DoD ELAP certification or equivalent for performing the required vapor analyses. Sample analysis will be performed for this program in accordance with the *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition, Compendium Method TO-15* (EPA, 1999); the *Method for the Determination of Air-Phase Petroleum Hydrocarbons (APH), Final, Revision 1* (MA DEP, 2009); and ASTM International (ASTM) approved methodologies.

Vapor samples will be analyzed for the following list of parameters:

- Volatile organics – EPA TO-15 (EPA, 1999)
- APH – Method MA DEP (2009)
- TPH/ gasoline range organics – EPA TO-15 (EPA, 1999) (after 4 quarters of APH data are collected)
- Fixed gases (oxygen, nitrogen, carbon monoxide, carbon dioxide, methane) – ASTM D2504

5.2.3 Field Quality Control

Field QC samples will be collected throughout quarterly monitoring activities to ensure the integrity and reproducibility of groundwater and soil vapor monitoring data. Field QC samples for pre-remedy monitoring activities include field duplicate samples, matrix spike samples, trip and field blanks for VOC analysis, equipment rinse blanks for non-dedicated sampling equipment, and temperature blanks. Field QC samples for quarterly groundwater monitoring will be collected at the following frequency:

- Field duplicate samples (water/vapor) - 10 percent of total number of environmental samples per event.

- Matrix spike/matrix spike duplicate samples (water) – 5 percent of total number of environmental samples per event.

- Equipment rinse blank samples (water) – 5 percent of total number of environmental samples per event, collected using non-dedicated sampling equipment.

- Field blank samples (water) – 5 percent of total number of environmental samples per event for VOCs only.

- Trip blank samples (water/vapor) – one per each shipment of groundwater and vapor samples per event for VOCs only.

- Temperature blank (water) – 1 per each shipment of environmental samples.

5.2.4 Sample Packaging and Shipping

Sample packaging and shipping requirements are designed to maintain sample integrity from the time a sample is collected until it is received at the analytical laboratory. All chain-of-custody forms, sample labels, custody seals, and other sample documents will be completed as specified in BFF Spill QAPjP (Appendix E). Specific procedures for packaging and shipping of environmental samples are presented below.

1. A sample label, completed with indelible ink, will be attached to the sample bottle.

2. A picnic cooler (e.g., Coleman or other sturdy cooler) will typically be used as a shipping container. In preparation for shipping samples, the drain plug will be taped shut so that no fluids, such as melted ice, will drain out of the cooler during shipment. A large plastic bag may be used as a liner for the cooler. Packing material, such as bubble wrap, or Styrofoam beads, will be placed in the bottom of the liner.

3. The containers will be placed in the lined picnic cooler. Cardboard separators may be placed between the containers at the discretion of the shipper.

4. All samples for chemical analysis must be shipped cooled to 4°C with ice. All samples will require icing before shipment. A temperature blank will be included in each shipment of water and soil samples.

5. The liner will be taped closed, if used, and sufficient packing material will be used to prevent sample containers from making contact or rolling around during shipment.

6. A copy of the chain-of-custody form will be placed inside the cooler.

7. The cooler will be closed and taped shut with strapping tape (filament-type).

8. Custody seals will be placed on the cooler. Clear tape will be placed over the custody seals to help prevent them from being accidentally torn or ripped off.

9. The cooler of samples will be shipped via an overnight carrier. A standard air bill is necessary for shipping environmental samples.

5.2.5 Reporting

A quarterly monitoring report will be submitted within 60 days after the end of each quarterly period or other NMED agreed submittal date. The quarterly periods will extend from January – March, April – June, July – September, and October – December for years 2011 through 2014. Quarterly reports will be provided to Kirtland AFB, USACE, and AFCEE for review and approval prior to submittal to NMED.

The report will document the pre-remedy monitoring, investigation, and remediation activities performed during the period and will provide the following detailed information:

- Summary of all BFF Spill site-wide field activities;
- Descriptions of installed groundwater and soil-gas monitoring wells and surveyed locations;
- Geologic and geophysical logs of wells and boreholes installed;
- Water levels and water-level maps;
- LNAPL measurements;
- Plume contaminant maps and cross-sections;

- Field and analytical laboratory data for groundwater, soil, soil gas, and trend graphs;
- Data validation summary of laboratory data and discussion of data quality;
- Summary of operation, maintenance, and performance of the SVE and groundwater systems; and
- Certification page signed by the Kirtland AFB Environmental Restoration Section Chief or Base designee.

Groundwater flow will be assessed in three dimensions (3D) using standard geographical information systems (GIS) gridding techniques to interpolate groundwater head (elevation) data into a 3D grid. Once this head grid is developed, associated GIS methods will be used to generate conventional plan-view hydraulic head maps and vertical cross-sections for the quarterly reports. The same 3D grid will be used to generate particle tracking maps for assessment of capture by the LNAPL containment system. Consistent plan-view maps and sections will be provided in the quarterly reports with adjustments as warranted as additional data become available.

Vadose-zone soil gas and dissolved-groundwater concentration data will be evaluated in a similar manner using 3D GIS methods to interpolate concentration grids for the various compounds of concern. Separate grids will be developed for the vadose-zone soil gas and dissolved-groundwater plumes because they represent separate environmental media. Associated GIS methods will be utilized with the 3D grids to generate conventional plan-view plume concentration maps and vertical cross-sections for the quarterly reports. For consistency in data evaluation, the same plan-view maps elevations and vertical section locations used for the groundwater head data will be used for the dissolved groundwater plumes. Vadose-zone soil gas maps and sections will be consistent between the quarterly reports to allow for efficient data analysis.

5.3 Investigation-Derived Waste

All IDW will be handled in accordance with the project-specific Waste Management Plan, which is provided as Appendix C to this work plan. Water produced from groundwater purging and sampling will be containerized and characterized for proper disposal. All PPE equipment (e.g., sampling gloves) will be disposed of with municipal waste.

5.4 Equipment Decontamination

The objective of field decontamination is to remove contaminants of concerns from sampling and other field equipment to concentrations that will not impact study objectives. Kirtland AFB BWP SOP B1.11, "Equipment Decontamination" (Appendix G) will be used by field personnel responsible for cleaning sampling or other equipment in the field.

Specification for Decontamination Materials:

- Use a standard brand of phosphate-free detergent such as liquid Liquinox® or powder, Alconox®. These surfactant type detergents are used industry-wide and have proven to be effective in cleaning oily residue from field equipment.
- Detergent solution will be rubbed over the surface of the equipment to appropriately remove any residues, using a brush or sponge, paper towel, etc.
- Use tap water from any municipal water treatment system or deionized water for rinsing off detergent. Dry equipment with paper towel or allow to air dry.
- Inspect before use to ensure that no residue remains.

5.4.1 Handling and Containers for Cleaning Solutions

Improperly handled cleaning solutions may easily become contaminated, thereby jeopardizing the validity of sample data. Containers will be constructed of proper materials to ensure their integrity. The following containers will be used for storing specified cleaning materials:

- Soap—Keep in clean containers until use. It will be poured directly from the container into the wash bucket or tub.
- Tap water—Keep in clean tanks, hand-pressure sprayers, or squeeze bottles, or apply directly from a hose.
- Deionized water—Store in clean containers that can be closed when not in use. It may be applied from squeeze bottles.

5.4.2 Decontamination of Sampling Equipment

The following procedure will be used to decontaminate devices, such as bailers, sample trays, spatulas, and spoons that come in direct contact with the sample media:

- Wash and scrub equipment using tap water and a standard brand of phosphate-free laboratory detergent (Liquinox® or Alconox®). Wire or plastic bristle brushes can be used.
- Rinse with tap water, removing all visible dirt and soap residue.
- Rinse with deionized water.
- Place on clean plastic sheeting and allow to completely air dry.
- If not used immediately, wrap in aluminum foil.

Decontamination of sampling equipment will be kept to a minimum in the field and, whenever possible, dedicated sampling equipment will be used. Decontamination fluids will be disposed as required by the project-specific Waste Management Plan (Appendix C). Personnel directly involved in equipment decontamination will wear appropriate PPE as specified in the Site Safety and Health Plan (Shaw, 2011).

5.5 Personal Protective Equipment

Personnel directly involved in equipment decontamination will wear appropriate PPE as specified in the Site Safety and Health Plan (Shaw, 2011). Appropriate PPE will be selected based on the level of contamination present or suspected at a site. Care will be taken to ensure that the selected PPE will protect decontamination workers from unnecessary contact with soil or decontamination fluids. The following minimum PPE will be required to perform decontamination activities:

- Safety glasses with splash shields or goggles and latex gloves will be worn during all cleaning operations. For decontamination activities involving large amounts of water, rain suits or aprons and rubber over-boots also will be worn.
- No eating, smoking, drinking, chewing, or any hand-to-mouth contact will be permitted during cleaning operations.

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6. SVE SYSTEMS OPERATION AND MAINTENANCE

6.1 SVE System Overview

Each of the existing SVE treatment units associated with the BFF Spill consists of a trailer-mounted pair of computer-controlled, 460-cubic-inch, displacement Ford Model LSG-875 internal-combustion engines (ICEs). These ICEs have been modified and remanufactured to the specifications of Remediation Services International (RSI). The complete, trailer-mounted, SVE systems were supplied by RSI. Within each SVE system, the engines act both as a vacuum pump and as a means to destroy hydrocarbon vapors removed from the vadose zone. The engine manifold vacuum is applied to the subsurface via extraction wells and piping. The vacuum is used to extract soil vapor from SVEWs in the vadose zone or to volatilize phase-separated hydrocarbons (PSHs) directly from the water table surface in groundwater monitoring wells and extract the vapor-phase hydrocarbons. Hydrocarbon vapors are mixed with ambient dilution air to achieve the proper combustion ratio and processed through the engine intakes and combustion chambers, where the hydrocarbon vapors are burned as fuel to run the engines. The exhaust stream of each engine is fitted with a post-combustion catalytic converter to destroy unburned hydrocarbons remaining in the exhaust.

At ST-106, the FFOR, the SVE and treatment system is connected to nine SVEWs. Each of the nine SVEWs is plumbed via buried piping to a central manifold located adjacent to the SVE treatment unit. The manifold allows the flow of soil vapor from each well to be regulated and the soil vapor to then be uniformly mixed before entering the treatment unit. In addition, the manifold provides a central location from which to collect soil-vapor samples and monitor pressures within individual extraction wells.

The SVE and treatment systems installed at groundwater monitoring wells KAFB-1065, KAFB-1066, and KAFB-1068 are directly connected to PSH-containing wells with no need for a manifold system or mixing with other hydrocarbon vapor sources. The application of the vacuum at the wellheads induces volatilization of fuel from the PSH surface and the volatilized fuel stream is extracted via the well casing

to the ground surface to directly operate the ICEs of the interim remedial system. The KAFB-1065 system was installed in August 2008 and the KAFB-1066 and KAFB-1068 systems were installed in March 2009. The SVE systems installed at KAFB-1065, KAFB-1066, and KAFB-1068 have some differences from the SVE unit in place at the FFOR. These SVE units are fitted with adjustable hydraulic loading modules that apply resistance to the engines, allowing the engines to do more work and subsequently allowing for greater hydrocarbon mass recovery from the subsurface (CH2M HILL, 2010).

6.2 Operation and Maintenance

The SVE systems will be operated and maintained in accordance with the maintenance interval recommended by the manufacturer, RSI. RSI will be provided a maintenance agreement to support maintenance and repairs as needed for the SVE units. Presently, four ICE SVE systems operate at the BFF Spill. O&M will expand to include additional SVEWs installed in the deep, intermediate, and shallow zones as they are installed and become operational. Onsite monitoring will be conducted for the 13 SVEWs on a quarterly basis.

Samples will be analyzed in the field for the following parameters:

- Petroleum hydrocarbon concentration in ppmv
- Percent oxygen
- Carbon monoxide
- Carbon dioxide

Pressure measurements will be collected with Magnehelic® gauges in units of inches of water. Vapor monitoring data will be used for decision-making purposes to determine optimization and effectiveness of the operating systems.

Samples will be collected from the four SVE units for offsite laboratory analysis on a quarterly basis. Samples will be collected in the Bottle-Vac™ canisters and shipped to the offsite DoD ELAP air laboratory for analysis.

Soil-gas samples will be analyzed for the following list of parameters:

- Volatile organics – EPA TO-15 (EPA, 1999)
- APH – Method MA DEP (2009)
- TPH/ gasoline range organics – EPA TO-15 (EPA, 1999) (after 4 quarters of APH data is collected)
- Gases (oxygen, nitrogen, carbon monoxide, carbon dioxide, methane) – ASTM D2504

Biweekly, monthly, and quarterly routine system maintenance will be performed in accordance with the *Operations and Maintenance Manual for the Soil Vapor Extraction Systems, Bulk Fuels Facility* (CH2M HILL, 2009b) and as identified in the sections below. Emergency maintenance or repairs will be completed as expeditiously as practicable, and the unit returned to service immediately after maintenance or repairs are completed. Any maintenance or repairs that will take more than 3 calendar days will be reported in writing to the NMED within 24 hours of notification from RSI. One complete SVE unit and inventory of spare parts will be maintained onsite for emergency replacement, if needed, to minimize unit down time. All maintenance and repair activities will be documented in the quarterly report. A copy of RSI's Operations and Maintenance manual is included as Appendix F.

Since the four SVE units consist of the same primary ICE components, routine maintenance will be conducted for all of the units at the same intervals specified in the existing Operations and Maintenance Manual. The primary maintenance interval for the SVE systems ICEs is every 360 hours (approximately 2 weeks), as recommended by the system manufacturer. Since the SVE systems consist of ICEs that operate continuously, they require the same type of regular maintenance as an engine in any motor vehicle, such as changing the oil, oil filter, spark plugs, air filter, and coolant, and other general maintenance items. Service maintenance will be provided by RSI to ensure the SVE units are operable, operate at peak efficiency, and minimize fuel usage. Routine maintenance will be conducted on the unit within the same day so as not to impact system operation.

6.2.1 Biweekly Maintenance

SVE engines require a typical automotive tune-up for every 360 hours of operation (15 days). The maintenance to be conducted on a biweekly basis includes the items listed below:

- Change oil and replace oil filter.
- Replace spark plugs.
- Inspect fresh intake air filter and replace, as necessary.
- Check coolant level and refill, as necessary.
- Check belts and hoses.
- Check battery connections.
- Check level of condensate in 55-gallon drum (winter months only).

It is anticipated that biweekly maintenance activities will be conducted within a one-day timeframe to minimize impact to system operation.

6.2.2 Monthly and Quarterly Maintenance

The following maintenance activities will be performed either monthly or quarterly (every 3 months), as specified below:

- Replace engine fan and water pump belt (monthly).
- Inspect/replace positive crankcase ventilation valve (quarterly).
- Pressure wash and degrease radiator (quarterly).
- Replace distributor cap and rotor (quarterly).

It is anticipated that monthly and quarterly maintenance activities each will be conducted within a one-day timeframe to minimize impact to system operation.

6.2.3 Semi-Annual and Annual Maintenance

The following maintenance activities will be performed either semi-annually (every 6 months) or annually, as specified below:

- Replace spark plug wires (semi-annually).
- Flush and refill radiator (semi-annually).
- Inspect and/or replace spark arrester (semi-annually).
- Clean or replace flame arrester (semi-annually).
- Test and/or replace catalytic converters (semi-annually).
- Check emergency contact switches (semi-annually).
- Inspect and clean automatic fire extinguisher system (annually).

It is anticipated that semi-annual and annual maintenance activities will each be conducted within a one-day timeframe to minimize impact to system operation.

6.2.4 Reporting

All maintenance and service activities performed on the SVE units, in addition to analytical monitoring data collected for each quarter, will be documented in the quarterly monitoring report. The quarterly report will include an overview of the remediation system including any operational issues, extraction due to natural attenuation and active extraction, mass recovery rates, and cumulative recovery rates. The report will contain vadose-zone monitoring descriptions and a soil-vapor data summary for each interval. A discussion of vadose-zone conditions and conclusions will be included in the report and summarizes the following: the magnitude, extent and nature of the soil-vapor plume; the effects of the SVE systems on the vadose zone; and an analysis of soil-vapor trends. This information will be used to evaluate the effectiveness of the treatment systems and address system optimization: recommendations will be provided, as needed, in each report. The goal of optimization efforts will be to extract the maximum amount of required combustion constituents (fuel and oxygen) from the subsurface, thereby maximizing overall mass recovery rates, and achieving the highest possible total mass removal from the four combined SVE systems in their current configurations.

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7. PROJECT SCHEDULE

The project schedule is provided in Appendix B to this work plan.

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8. ORGANIZATIONAL PLAN

8.1 Overall Project Organization

The organizational structure of our team is shown in Figure 8-1.

8.2 Responsibilities, Qualifications, and Authority of Key Personnel

Table 8-1 summarizes roles and responsibilities, qualifications, and authorities of project team members.

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9. DATA MANAGEMENT PLAN

Environmental laboratory services will be provided only by laboratories compliant with the *DoD Quality Systems Manual for Environmental Laboratories, Version 4.1* (DoD, 2009) or a most recent version and that hold current DoD ELAP accreditation for all appropriate analytical methods. Two laboratories will provide analytical results in support of pre-remedy monitoring at the BFF Spill. Each laboratory will provide electronic data in the Staged Electronic Data Deliverable (SEDD) format and in the ShawView™ format. The SEDD deliverable will be used for applying the electronic data review process. The ShawView™ data deliverable will be uploaded into the project database for use in generating reports and figures, and for use in generating the Environmental Resources Program Information Management System (ERPIMS) deliverable. All analytical data generated in support of the BFF Spill remediation will be uploaded to the Air Force data repository.

9.1 EPA Level III Data Review

Analytical data generated in support of Kirtland BFF Spill pre-remedy monitoring will undergo an EPA Level III data review by a project chemist. An automated data review (ADR) software, developed by Laboratory Data Consultants, Inc., will be used to perform 100-percent, EPA Level III data review. The data review will be performed for groundwater and soil-vapor analytical data obtained from each of the pre-remedy quarterly monitoring events. Data review will be performed using the QC procedures specified the following documents:

- BFF Spill QAPjP (Appendix E);
- *DoD Quality Systems Manual for Environmental Laboratories, Version 4.1* (DoD, 2009);
- *Test Methods for Evaluating Solids Waste, Physical/Chemical/Methods (SW-846)* (EPA, 2007 and updates);
- USACE, *Guidance for Evaluating Performance-Based Chemical Data, Engineer Manual (EM) 200-1-10* (2005);

- *USEPA Contract Laboratory Program, National Functional Guidelines for Superfund Organic Methods Data Review* (EPA, 2008); and

- *USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Superfund Data Review* (EPA, 2010).

The following QC elements will be included in the EPA Level III data review:

- Laboratory method blanks
- Sample extraction and analysis holding times
- Surrogate spike recoveries
- Laboratory control sample/laboratory control sample duplicate recoveries
- Matrix spike/matrix spike duplicate recoveries
- Relative percent difference for duplicate samples
- Initial calibrations
- Continuing calibrations
- Trip and field blank data (water samples for volatiles only)
- Field duplicate samples

Note that because of laboratory information system limitations, laboratories may not be able to provide initial and continuing calibration results in SEDDs. In this case, the project chemist will manually review the calibration data and document review findings in a database and data review worksheets.

Data will be validated and flagged with the following data qualifiers as applicable:

- ***J+ qualifier*** denotes the analyte was positively identified, but the associated numerical value is estimated with a potential high bias.

- ***J- qualifier*** denotes the analyte was positively identified, but the associated numerical value is estimated with a potential low bias.

- ***U qualifier*** denotes the analyte was analyzed for, but was not detected.

- ***R qualifier*** denotes the data are unusable due to deficiencies in the ability to analyze the sample and meet QC criteria and DQOs.

- ***UJ qualifier*** denotes that the analyte was not detected above the reported sample limit of quantitation (LOQ). However, the reported LOQ is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

As a result of the ADR process, EPA qualifiers will be electronically generated and assigned to the sample results that were outside of established control criteria. Qualified data will then be exported to a contractor database for data users and for report tables and figure preparations. EPA Level III data review

findings will be summarized and documented with each Quarterly Monitoring Report and in other reports containing analytical data.

ShawView™ is an Oracle-based Environmental Information Management System (EIMS), which will be used for sample planning, data loading, data management, and data reporting. This system supports all aspects of the project from the planning stages throughout the project lifecycle and ultimately data archiving, and thus maintains the integrity of all project-related data. Each step of the data management process will be performed in accordance with the BFF Spill QAPjP (Appendix E) and applicable BWP SOPs. All quarterly monitoring field data, including but not limited to water-level data, survey data, boring logs, and well construction logs, will be uploaded into the contractor EIMS and will be linked with validated analytical results in order to generate output files that will be used to populate Environmental Restoration Program Tools and generate ERPIMS Version 5.0 submittals. ERPIMS data submittals will be reviewed for accuracy and completeness before submittal. ERPIMS submittals will be provided to the Air Force, at a minimum, every six months or as appropriate for data generation for uploading to the Air Force data repository. ERPIMS submittals will be deemed complete upon receipt of the insertion letter from the Air Force.

Site characterization data will be mapped using a GIS. The GIS dataset will be accompanied by metadata conforming to the Federal Geographic Data Committee's Content Standard for Digital Geospatial Metadata and the Army Installation Geospatial Information and Services Metadata Standard, v1, which is compliant with Spatial Data Standards for Facilities, Infrastructure, and Environment v2.6. The horizontal accuracy of GIS data will be tested in accordance with the National Standard for Spatial Data Accuracy and results will be recorded in the metadata. All data will be provided in the Universal Transverse Mercator projection in the appropriate zone, and will have a datum of North Atlantic Datum 83. The GIS effort will involve preparation, analysis, processing, and interpretation of data acquired from sampling and analysis, geophysical surveys, and intrusive investigations. The GIS coordinator will register and

process all survey and intrusive field data such that it can easily be incorporated into the Kirtland AFB and Army Mapper database. Contractor GIS analysts will prepare maps depicting site-specific attributes for continuous updates to be provided to project stakeholders. No data will be released to project stakeholders without the approval of the USACE.

All project-related data will be maintained and archived in the electronic project files on the corporate server and will be made available to the government as necessary. All data generated in support of this contract will be maintained in accordance with contract requirements.

10. QUALITY ASSURANCE/QUALITY CONTROL

A comprehensive QAPjP document in support of sampling and analysis activities for the BFF Spill is presented in Appendix E.

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11. WASTE MANAGEMENT

All wastes generated during implementation of this work plan will be handled and disposed of according to the requirements presented in the Waste Management Plan (Appendix C).

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12. ACCIDENT PREVENTION PLAN/SITE SAFETY AND HEALTH PLAN

The Accident Prevention Plan, including the Site Safety and Health Plan (Attachment 10) for the Kirtland AFB BFF Spill investigation work, was submitted under separate cover (Shaw, 2011).

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13. COMMUNITY RELATIONS PLAN

A Community Relations Plan (CRP) is being developed and submitted under separate cover (Shaw, 2010c) in accordance with contract No. W912DY-10-D-0014, Delivery Order 0002 and the Kirtland AFB Base-Wide Community Relations Plan. Community information meetings, including community outreach as well as presentations at neighborhood association meetings, are ongoing. Below is a general approach to supporting community relations. For details, see the CRP submitted under separate cover.

The CRP Update will designate activities designed to aid people working on the project in understanding community issues and concerns related to bulk fuels contamination associated with the Kirtland AFB BFF Spill. The CRP Update also will outline the types of information to be provided and how that information will be distributed to surrounding communities and other interested stakeholders. The CRP Update will include the following activities:

- Conduct in-person interviews with community representatives that reflect the spectrum of the impacted community;
- Analyze interview, local demographic, site historical, and technical data; and
- Develop appropriate and proactive communication strategies based on the compiled data.

An outreach strategy will be developed to meet current regulatory standards and Air Force communication needs and requirements. This strategy will also respond to community's needs and desire for information about the on going remediation field activities associated with the BFF Spill. Community relations work will be conducted in accordance with the appropriate regulatory guidance, including EPA's *RCRA Public Participation Manual, 1996 Edition, EPA530-R-96-007* (EPA, 1996), and *Superfund Community Involvement Handbook, EPA 540-K-05-003* (EPA, 2005b).

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FIGURES

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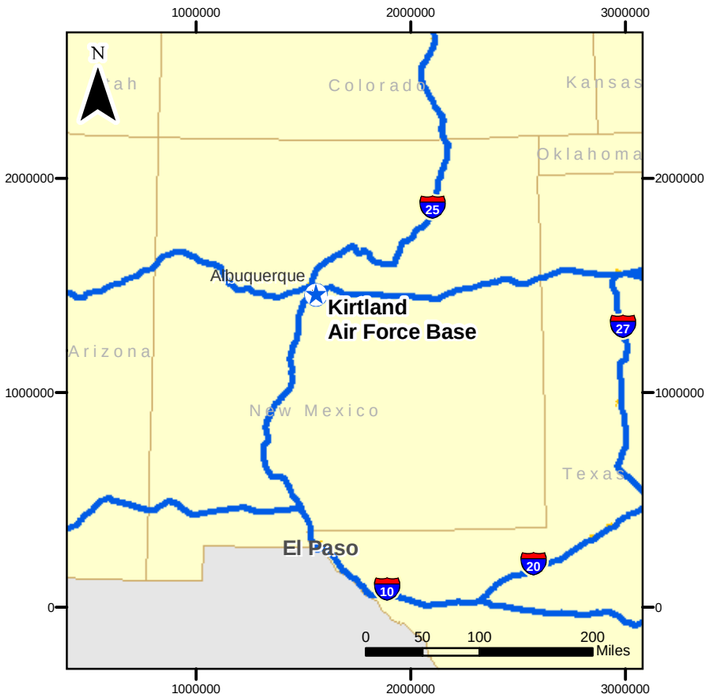

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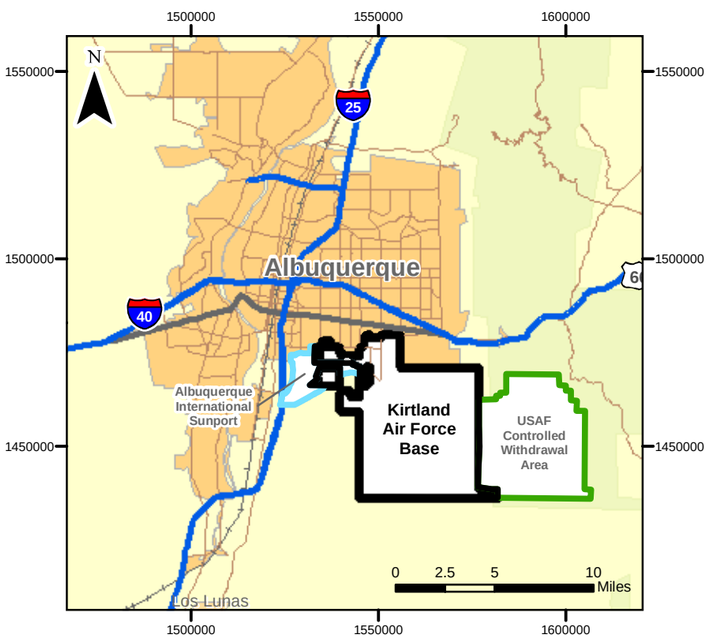
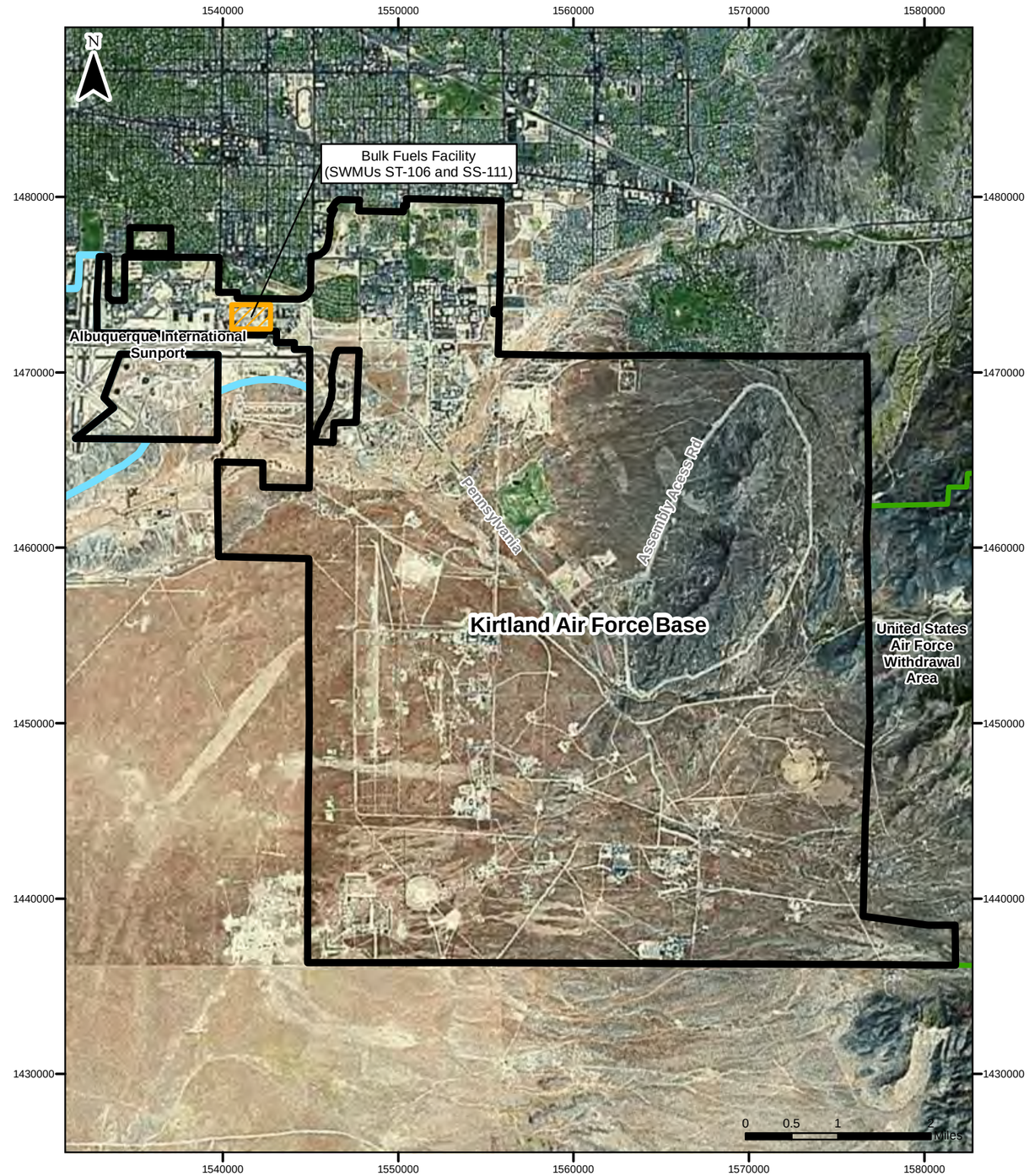


Local Area Map



Kirtland AFB Area Map

- Bulk Fuels Facility (SWMUs ST-106 and SS-111)
- State Boundary
- Urban Area
- Installation Location
- Kirtland Air Force Base Installation Boundary
- Albuquerque_Intl_Sunport
- United States Air Force Withdrawal Area
- Limited Access
- Highway
- Major Road

Projection : NAD_1983_StatePlane_New_Mexico_Central_FIPS_3002_Feet

BULK FUELS FACILITY
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 1-1

SITE LOCATION MAP

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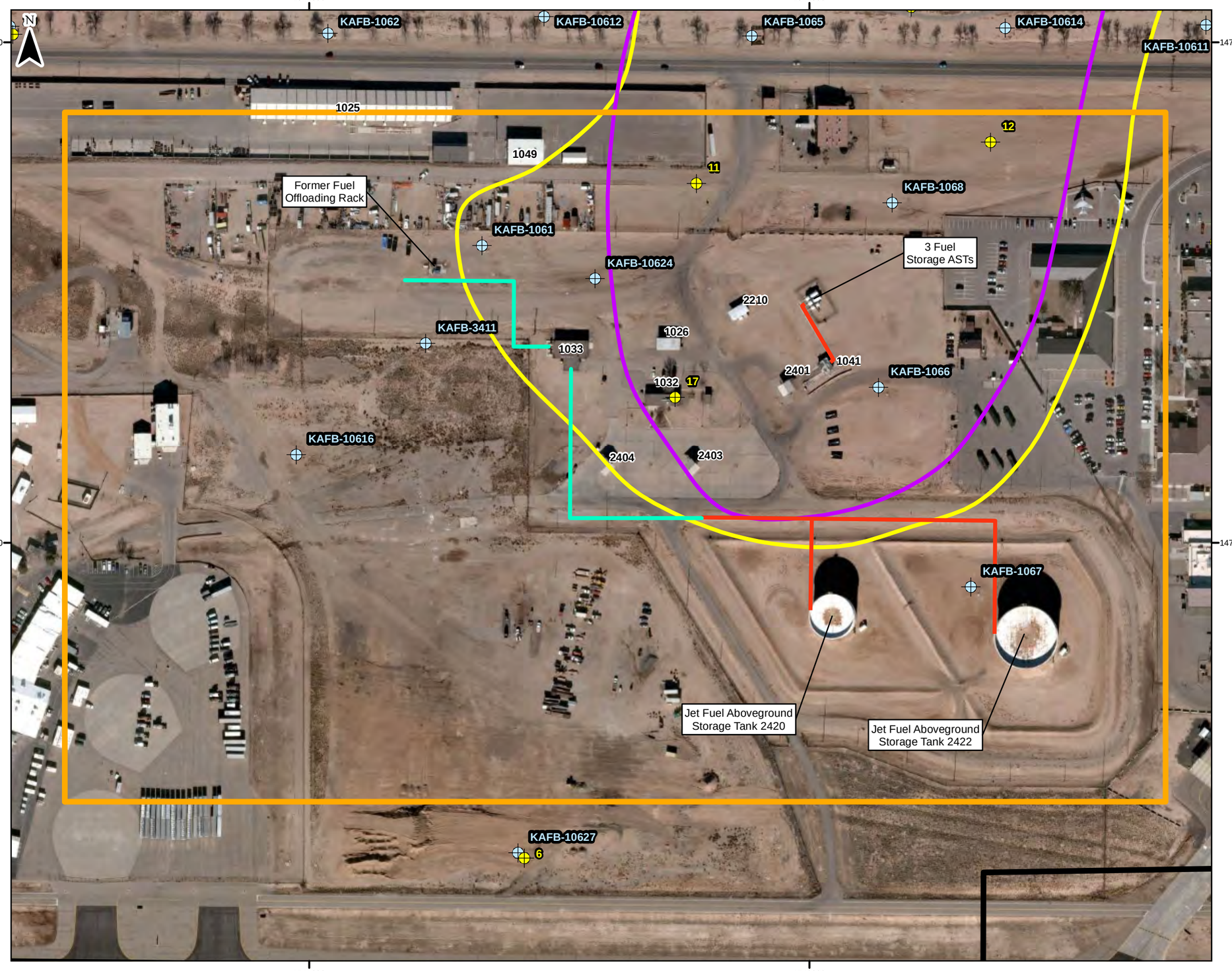

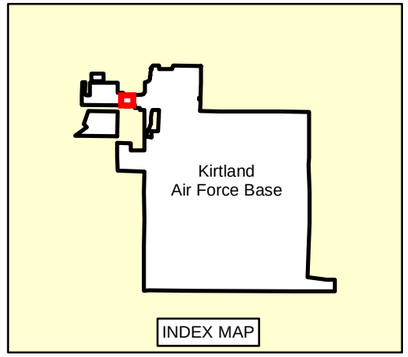

- Proposed Monitoring Well Cluster (Labeled with ID provided by NMED)
- Existing Monitoring Well
- Aboveground Fuel Transfer Lines
- Underground Fuel Transfer Lines
- Bulk Fuels Facility (SWMUs ST-106 and SS-111)
- Estimated Extent of LNAPL
- Estimated Extent of Dissolved Phase Contaminant Plume
- Installation Boundary

0 100 200 Feet

1 Inch = 200 ft

Projection : NAD_1983_StatePlane_New_Mexico_Central_FIPS_3002_Feet

BULK FUELS FACILITY
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 2-1

SOURCE AREA AND INFRASTRUCTURE

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Project Number: 140705

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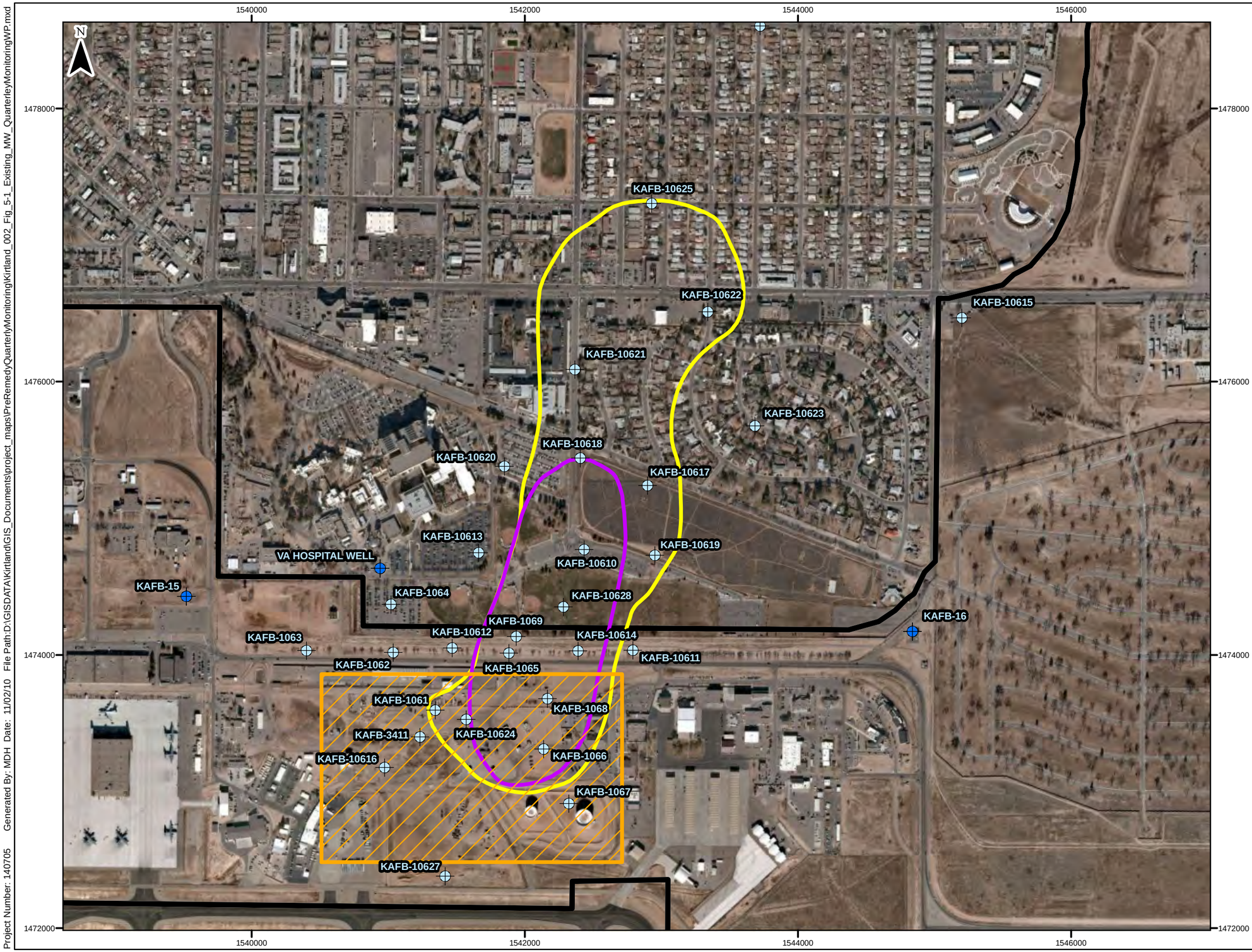

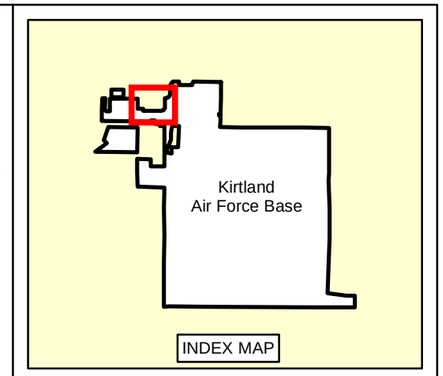

Water Well/Monitoring Well

Existing Monitoring Well

Bulk Fuels Facility (SWMUs ST-106 and SS-111)

Estimated Extent of LNAPL

Estimated Extent of Dissolved Phase Contaminant Plume

Installation Boundary

0 500 1,000 Feet

1 Inch = 700 ft

Projection : NAD_1983_StatePlane_New_Mexico_Central_FIPS_3002_Feet

BULK FUELS FACILITY
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 5-1

GROUNDWATER PLUME EXTENT
AND EXISTING MONITORING WELLS

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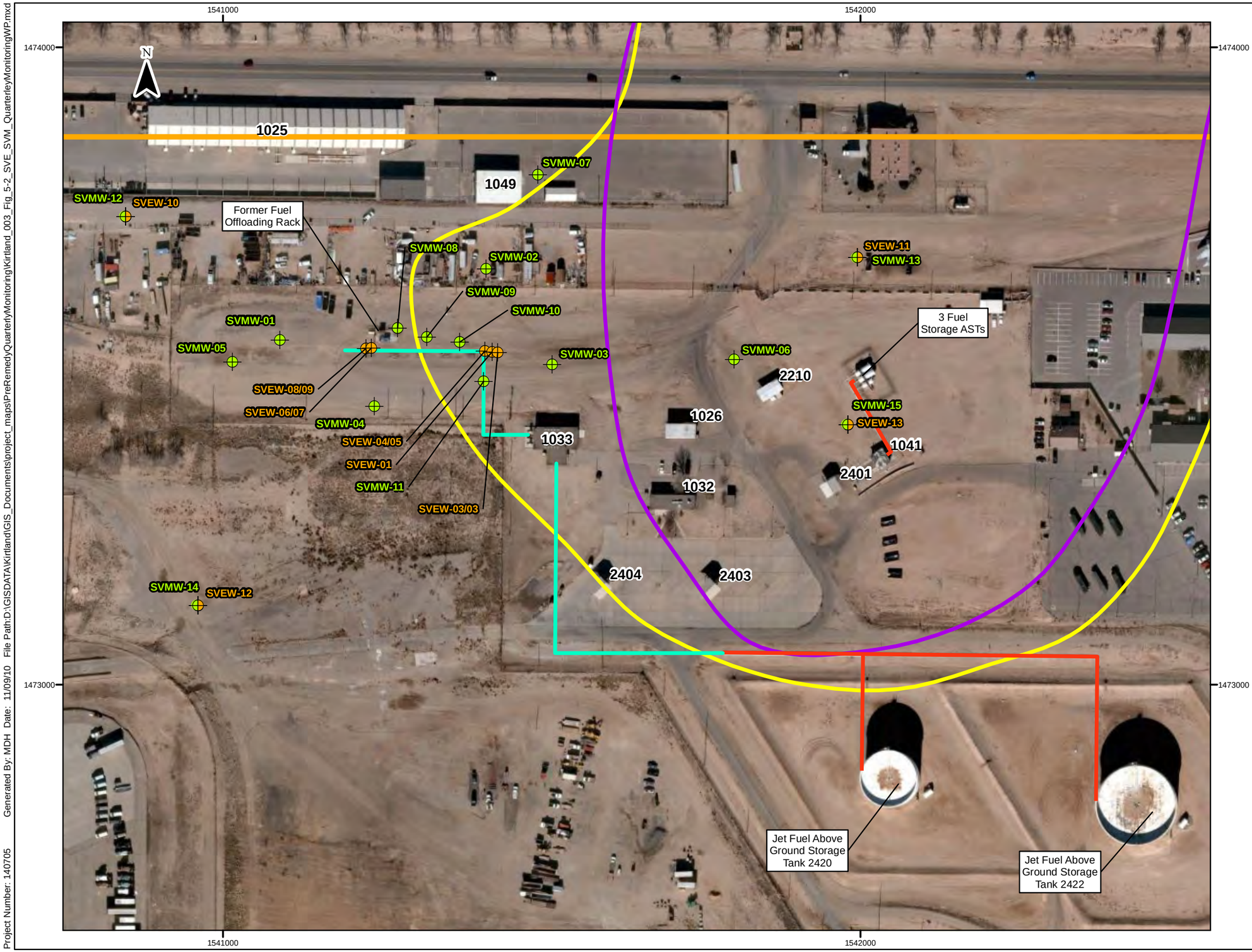

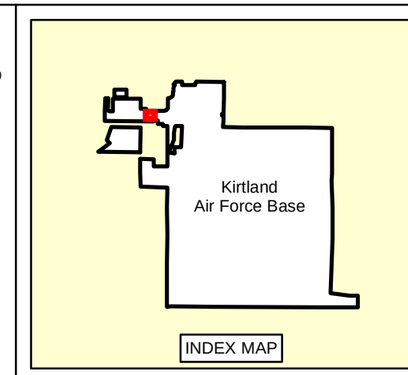

Soil Vapor Monitoring Well

Soil Vapor Extraction Well

Soil Vapor Monitoring/Extraction Well

Aboveground Fuel Transfer Lines

Underground Fuel Transfer Lines

Estimated Extent of LNAPL

Estimated Extent of Dissolved Phase Contaminant Plume

Bulk Fuels Facility (SWMUs ST-106 and SS-111)

Installation Boundary

0 100 200 Feet

1 Inch = 200 ft

Projection : NAD_1983_StatePlane_New_Mexico_Central_FIPS_3002_Feet

BULK FUELS FACILITY SPILL
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 5-2

EXISTING SOIL-GAS WELLS AND SVE SYSTEMS

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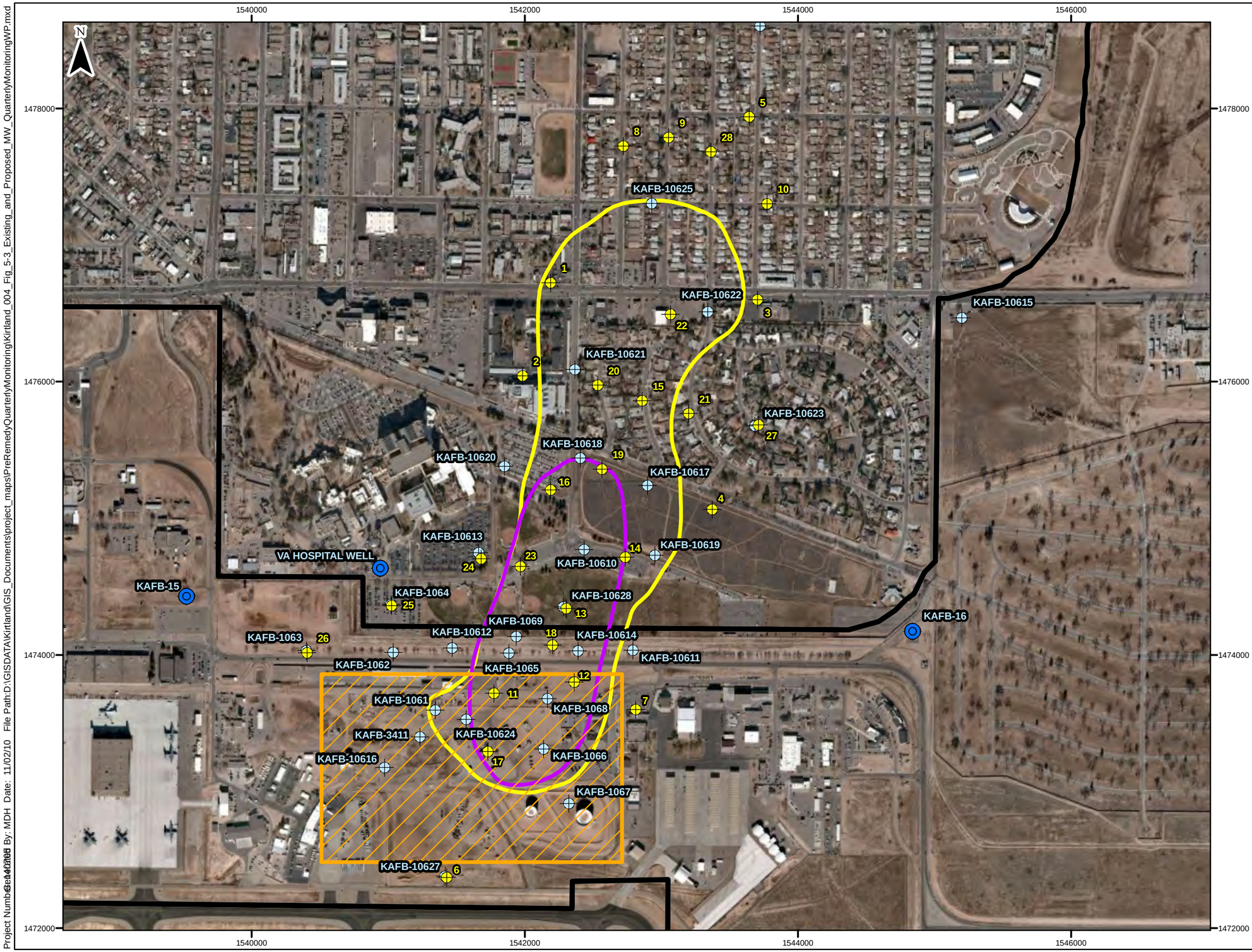

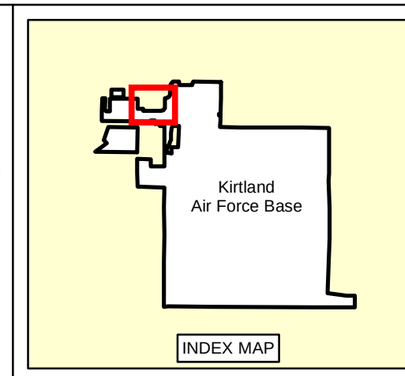

Proposed Monitoring Well Cluster (Labeled with ID provided by NMED)

Water Well/Monitoring Well

Existing Monitoring Well

Bulk Fuels Facility (SWMUs ST-106 and SS-111)

Estimated Extent of LNAPL

Estimated Extent of Dissolved Phase Contaminant Plume

Installation Boundary

0 500 1,000 Feet

1 Inch = 700 ft

Projection : NAD_1983_StatePlane_New_Mexico_Central_FIPS_3002_Feet

BULK FUELS FACILITY
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 5-3

PROPOSED WELL LOCATIONS

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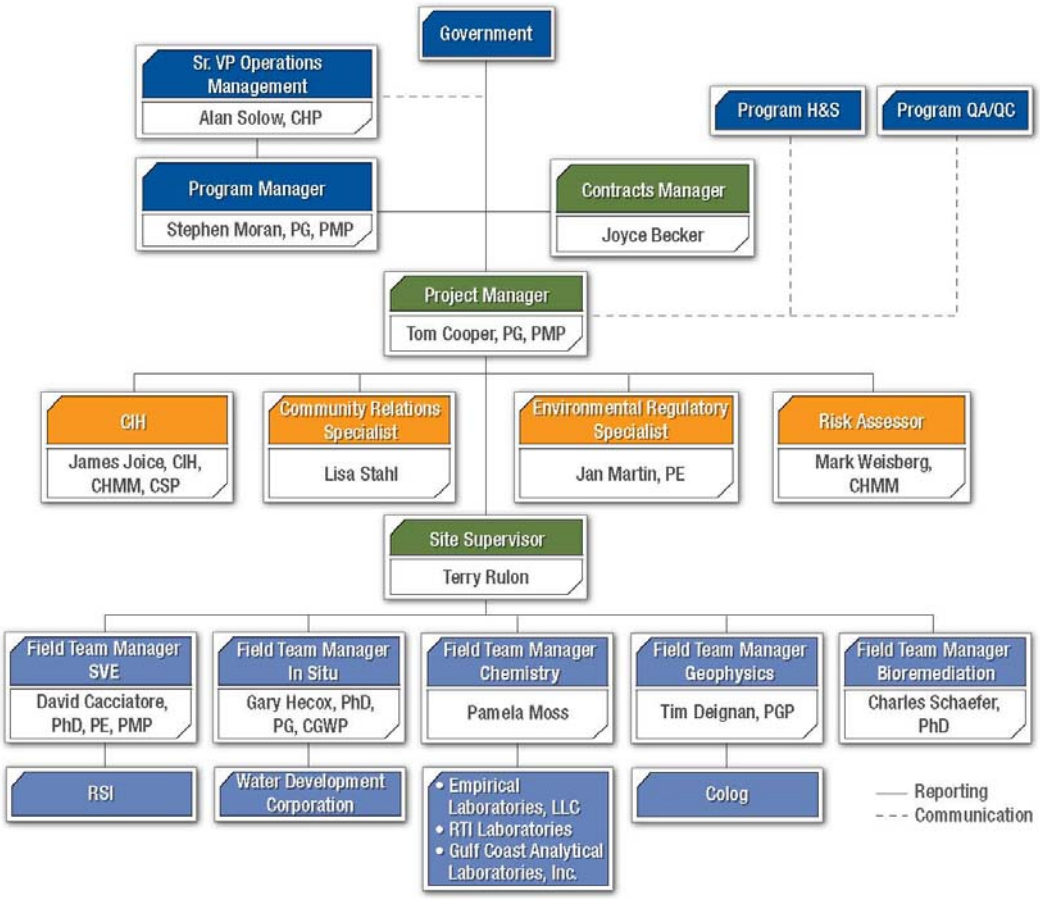
Figure 8-1. Project Organization



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TABLES

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Table 4-1. Data Quality Objectives Summary Table

DQO Step	Details of DQO Step per EPA DQO Guidance (2006)	BFF Spill Pre-Remedy Monitoring Work Plan Topic 1	BFF Spill Pre-Remedy Monitoring Work Plan Topic 2	BFF Spill Pre-Remedy Monitoring Work Plan Topic 3
1) State the Problem	Summarize the contamination problem requiring new data, resources available, and conceptual site model.	Requirements to collect groundwater and soil-vapor data to monitor movement of groundwater and vadose zone contamination at the BFF.	Determine the extent of the light, non-aqueous phase liquid (LNAPL) plume.	Ensure the soil-vapor extraction (SVE) systems are functioning efficiently and appropriately to optimize extraction and recovery.
2) Identify the Decision	Identify the decision that requires new environmental data to address the contamination problem.	Collect additional data of sufficient quantity and quality to further evaluate site contamination in groundwater and the vadose zone (i.e., moving, spreading, or stagnant).	Collect LNAPL measurements from all new and existing monitoring wells monthly for 2011. These measurements will be used to support delineation of LNAPL plume.	Perform operation and maintenance (O&M) activities as required by manufacturer's specifications to optimize systems.
3) Identify Inputs to the Decision	Identify the information needed to support the decision and specify which inputs require new environmental measurements.	Groundwater and LNAPL measurements, groundwater sample data, soil-vapor measurements, and sample information.	LNAPL measurements from new and existing wells.	Bi-weekly, monthly, quarterly, semi-annual, and annual maintenance activities required as part of the O&M schedule. Vapor samples will be collected from the SVE units to determine efficiency.
4) Define the Study Boundaries	Specify the spatial and temporal aspects of the environmental media that the data must represent to support the decision.	The study boundaries included the existing 29 monitoring wells, 4 municipal wells, soil-vapor wells, and soil extraction wells. The boundary is expected to expand to include all newly installed wells.	The study boundary includes all new and existing monitoring wells.	The study boundary includes new SVE systems and will expand to include additional SVE wells installed in the deep, intermediate, and shallow zones as they are installed and become operational.

Table 4-1. Data Quality Objectives Summary Table (concluded)

DQO Step	Details of DQO Step per EPA DQO Guidance (2006)	BFF Spill Pre-Remedy Monitoring Work Plan Topic 1	BFF Spill Pre-Remedy Monitoring Work Plan Topic 2	BFF Spill Pre-Remedy Monitoring Work Plan Topic 3
5) Develop a Decision Rule	Develop a logical "if…then" statement that defined the conditions that would cause the decision maker to choose among alternative actions.	Per New Mexico Environmental Department (NMED) requirements, data will be collected from 2011 through 2014 (the duration of this delivery order), or until Remedy In Place is achieved, whichever comes first.	Measurements will be made quarterly, immediately before purging and sampling, and for a period of one year.	O&M activities will be conducted from 2011 through 2014 (the duration of this delivery order), or until Remedy In Place is achieved, whichever comes first.
6) Specify Limits on Decision Errors	Specify the decision maker's acceptable limits on decision errors, which are used to establish performance goals for limiting uncertainty in the data.	Samples will be collected in accordance with NMED requirements and the approved BFF Spill Quality Assurance Project Plan (QAPjP).	Samples will be collected in accordance with NMED requirements and the QAPjP.	O&M activities will be performed in accordance with the manufacturer's specification and in accordance with the O&M Work Plan.
7) Optimized Design	Identify the most resource-effective sampling and analysis design for generating data that are expected to satisfy the DQOs.	Installing strategically located monitoring wells and soil vapor wells.	Installing strategically located monitoring wells to accurately measure the LNAPL plume.	A service maintenance contract will be awarded to Remediation Services International to ensure the SVE units are operable, operate at peak efficiency, and minimize fuel usage.

BFF = Bulk Fuels Facility
DQO = data quality objective
EPA = U.S. Environmental Protection Agency

Table 5-1. BFF Groundwater Monitoring Well Construction Details and Elevations

Well Number	Location	Total Well Depth (ft bgs)	Screened Interval (ft)	TIC Elevation (ft msl)	Depth to Groundwater (ft below TIC)	Groundwater Elevation (ft msl)
KAFB-1061	Along north fence line in northwest portion of facility. South of contractor's storage yards.	508.5	482-508	5344.41	488.77	4855.64
KAFB-1062	North side of Randolph Ave. North of DRMO office.	505	479-504	5342.00	486.44	4855.56
KAFB-1063	North side of Randolph Ave. North of DRMO's western yard.	503	476-501	5339.71	484.05	4855.66
KAFB-1064	Parking lot south of VA Hospital.	510	484-509	5345.68	490.54	4855.14
KAFB-1065	North of Fuels Dr. and Randolph Ave. intersection.	507	479-506	5346.59	495.75	4854.75
KAFB-1066	1951 Offloading Rack.	511	483.5-508.5	5353.14	499.68	4855.35
KAFB-1067	Inside tank berm.	511	484-509	6349.41	494.41	4856.13
KAFB-1068	South of the 90-Day Storage.	513.5	486-511	5353.45	501.00	4855.38
KAFB-1069	Base Fence Line.	507.5	480-505	5344.34	489.79	4855.16
KAFB-10610	Bullhead Park.	510.5	483-508	5343.20	489.90	4854.21
KAFB-10611	North of Randolph Ave. West of Super Sabre Dr.	516	511-486	5353.01	498.16	4854.85
KAFB-10612	North side of Randolph Ave. North of former DRMO's eastern yard.	510.5	505.5-480.5	5345.31	490.07	4855.24
KAFB-10613	Parking lot southeast of VA Clinic.	516.5	511.5-486.5	5350.45	495.71	4854.74
KAFB-10614	North of Randolph Ave. Between Fuel Dr. and Super Saber Dr.	516	511-486	5350.08	495.07	4855.19

Table 5-1. BFF Groundwater Monitoring Well Construction Details and Elevations (continued)

Well Number	Location	Total Well Depth (ft bgs)	Screened Interval (ft)	TIC Elevation (ft msl)	Depth to Groundwater (ft below TIC)	Groundwater Elevation (ft msl)
KAFB-10615	Southeast of the intersection of Gibson Blvd. and Lousiana Blvd.	515	510-485	5342.31	490.22	4852.09
KAFB-10616	In the western portion of the facility, southeast of Bldg 1039.	505	500-475	5342.34	487.5	4854.84
KAFB-10617	In the dirt field south of intersection of Ridegcrest and Dakota.	512	507-482	5342.51	488.83	4853.68
KAFB-10618	Southeast of the intersection of San Pedro Dr. and Ridgecrest Dr.	506	501-476	5335.97	482.22	4853.75
KAFB-10619	In the dirt field, north of Bullhead Park parking lot.	523	518-493	5354.67	500.70	4853.97
KAFB-10620	In the southwest corner of VA hospital staff parking lot.	512	507-482	5340.75	486.82	4853.93
KAFB-10621	East side of San Pedro Dr., between Gibson and Ridegecrest.	488	458-483	5314.31	461.05	4853.26
KAFB-10622	East side of Dakota St., south of Gibson Blvd.	492	462-487	5318.02	465.15	4852.87
KAFB-10623	1300 block of Hertz Dr. SE.	503	473-498	5328.43	475.32	4853.11
KAFB-10624	In the facility, east of the east end of the Former Fuel Offloading Rack.	511	481-506	5343.35	487.46	4855.89
KAFB-10625	South side of Eastern Ave., west of California St.	495	465-490	5317.05	465.03	4851.99

Table 5-1. BFF Groundwater Monitoring Well Construction Details and Elevations (concluded)

Well Number	Location	Total Well Depth (ft bgs)	Screened Interval (ft)	TIC Elevation (ft msl)	Depth to Groundwater (ft below TIC)	Groundwater Elevation (ft msl)
KAFB-10626	North side of Anderson Ave., east of Florida St.	491	466-486	5322.39	471.44	4850.95
KAFB-10627	South of the facility, along flight line fence.	506	481-501	5348.36	488.01	4860.35
KAFB-10628	Bullhead Park.	516	491-511	5348.75	NA	NA
KAFB-3411	South of southern fence line around western portion of the facility.	503	477-502	5343.49	487.47	4856.02

DRMO = Defense Reutilization and Marketing Office
ft = feet
ft bgs = feet below ground surface
ft msl = feet above mean sea level
KAFB = Kirtland Air Force Base
NA = not available.
TIC = top of inner casing
VA = Veterans Administration

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Table 5-2. Sample Preservation and Container Requirements for Pre-Remedy Monitoring

Matrix	Parameter[1,2]	Container[3,4]	Preservation[5]	Maximum Holding Times[6]	
				Extraction	Analysis
Water	Volatiles	3 x 40-mL G, Septa Vial	Ice to 4°C 4 drops conc. Hydrochloric acid (HCl) or sodium bisulfate ($NaHSO_4$) to pH<2	N/A	7 days (unpreserved) 14 days (preserved)
Water	Ethylene dibromide	3 x 40-mL G, Septa Vial	Ice to 4°C	N/A	7 days
Water	Total and dissolved metals	1 x 1-L P	Nitric acid (HNO_3) to pH<2	N/A	6 months
Water	TPH – gas/VPH[1] TPH – diesel / EPH[1]	2 x 40-mL G, Septa Vial/ 2 x 1-L G	Ice to 4°C 4 drops conc. Hydrochloric acid Ice to 4°C	N/A 7 days	14 days 40 days
Water	Anions (Cl, NO3, SO4)[2] Alkalinity	1 x 1-L P	Ice to 4°C	N/A	48 hours, 28 days[2] 14 days
Water	Ammonia nitrogen	1 x 1-L P	Ice to 4°C Sulfuric acid (H2SO4) to pH<2	N/A	28 days
Water	Total sulfide	1 x 1-L P	Ice to 4°C Zinc acetate	N/A	14 days
Vapor	VOCs/ TPH gas/ APH[1]	1 x 1-L Bottle Vac	None	N/A	30 days
Vapor	Fixed gases	1 x 1-L Tedlar bag	None	N/A	30 days

NOTES:

1 TPH = total petroleum hydrocarbon; VPH = volatile petroleum hydrocarbon; EPH = extractable petroleum hydrocarbon; APH = air phase petroleum hydrocarbon.

2 Chloride (Cl), nitrate (NO_3), sulfate (SO_4); holding time for extraction is 48 hours for nitrate.

3 All containers must have Teflon-lined seals (Teflon-lined septa for volatile organic analysis [VOA] vials).

4 G = glass; L = liter; mL = milliliter; P = high-density polyethylene. Sample preservation will be done in the field immediately upon sample collection. If water samples are filtered in the field, differential pressure methods using 45-micron filters will be used, and preservatives added after filtration.

5 Samples with residual chlorine present will be dechlorinated with sodium thiosulfate as specified in SW-846 (third edition).

6 When N/A is specified, it implies total holding time from sampling until analysis.

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Table 5-3. Kirtland AFB Pre-Remedy Monitoring - Field and Quality Control Sample Summary per Quarter

Matrix	Analytical Group	No. of Primary Sampling Locations	No. of Field Samples	No. of Field Duplicates	No. of MS/MSDs	No. of Field Blanks	No. of Equipment Rinsates	No. of Trip Blanks	Total No. of Samples to Laboratory
Soil-Vapor Well/Soil-Vapor Extraction Unit Samples (Existing and Proposed)									
Soil Gas	VOCs – EPA TO-15	54[1]	285	29	0	0	0	1 per shipping container	314 & blanks
Soil Gas	TPH gasoline – EPA TO-15	54	285	29	0	0	0	0	314
Soil Gas	APH – MA DEP (4 events)	54	285	29	0	0	0	0	314
Soil Gas	Fixed gases – ASTM 2504	54	285	29	0	0	0	0	314
Groundwater Well Samples (Existing and Proposed)									
Water	VOCs – SW-846 8260B	111[2]	111	12	12	6	6	1 per cooler	135 & blanks
Water	EDB – SW-846 8011	111	111	12	12	0	0	0	135
Water	TPH as Gasoline – SW-846 8015B	111	111	12	12	0	1 per day if needed	0	135 & blanks
Water	TPH as Diesel – SW-846 8015B	111	111	12	12	0	1 per day if needed	0	135 & blanks
Water	VPH/EPH – MA DEP	111	111	12	12	0	1 per day if needed	0	135 & blanks
Water	Cations and Lead – SW-846 6010C	111	111	12	12	0	1 per day if needed	0	135 & blanks
Water	Anions – EPA 300.0	111	111	12	12	0	0	0	135
Water	Dissolved Iron/Manganese – SW-846 6010C	111	111	12	12	0	1 per day if needed	0	135 & blanks

Table 5-3. Kirtland AFB Pre-Remedy Monitoring - Field and Quality Control Sample Summary per Quarter (concluded)

Matrix	Analytical Group	No. of Primary Sampling Locations	No. of Field Samples	No. of Field Duplicates	No. of MS/MSDs	No. of Field Blanks	No. of Equipment Rinsates	No. of Trip Blanks	Total No. of Samples to Laboratory
Groundwater Well Samples (Existing and Proposed, continued)									
Water	Ammonia Nitrogen – SM4500NH BD/BG	111	111	12	12	0	0	0	135
Water	Total Sulfide – SM 4500 S2CF	111	111	12	12	0	0	0	135
Water	Alkalinity – SM 2320B	111	111	12	12	0	0	0	135

NOTES:

1 Sampling locations include 15 existing soil-vapor monitoring wells (58 ports), 35 new soil-vapor monitoring wells (215 ports), and 4 soil-vapor extraction units - inlet, exhaust 1, 2 (12 samples).

2 Sampling locations include 29 existing wells, 4 municipal wells, and 78 new wells.

APH = air-phase petroleum hydrocarbon
ASTM = ASTM International
EDB = ethylene dibromide
EPA = U.S. Environmental Protection Agency
EPH = extractable petroleum hydrocarbon
MA DEP = Massachusetts Department of Environmental Protection
MS/MSD = matrix spike/matrix spike duplicate
TPH – total petroleum hydrocarbon
VOC = volatile organic compound
VPH – volatile petroleum hydrocarbon

Table 5-4. Soil-Vapor Monitoring Wells, Extractions Wells, and Existing SVE Systems

Soil-Vapor Monitoring Wells		
Well Location	**Screened Depth (ft bgs)**	**Total Sampling Ports**
SVMW-01	50-52.5	4
	100-102.5	
	250.7-253.2	
	308.5-310	
SVMW-02	50-52.5	3
	97-99.5	
	150-152.5	
SVMW-03	50-52.5	4
	100-102.5	
	250-252.5	
	300-302.5	
SVMW-04	50-52.5	4
	98-100.5	
	250.252.5	
	297.5*300	
SVMW-05	50-52.5	4
	100-102.5	
	229.5-231	
	287-290	
SVMW-06	50-52.5	4
	99.5-102	
	252-254.5	
	302.5-305	
SVMW-07	49.5-52	3
	95.5-98	
	147.5-150	
SVMW-08	50-52.5	4
	100-102.5	
	250-252.5	
	266-268.5	
SVMW-09	50-52.5	4
	100-102.5	
	250-252.5	
	266-268.5	
SVMW-10	50-52.5	4
	100-102.5	
	150-152.5	
	250-252.5	
SVMW-11	50-52.5	4
	100-102.5	
	250-252.5	
	260-262.5	
SVMW-12	150-152.5	4
	250-252.5	
	350-352.5	
	450-452.5	
SVMW-13	150-152.5	4
	250-252.5	
	350-352.5	
	450-452.5	

Table 5-4. Soil-Vapor Monitoring Wells, Extractions Wells, and Existing SVE Systems (continued)

Soil-Vapor Monitoring Wells (continued)		
Well Location	**Screened Depth (ft bgs)**	**Total Sampling Ports**
SVMW-14	150-152.5	4
	250-252.5	
	350-352.5	
	450-452.5	
SVMW-15	150-152.5	4
	250-252.5	
	350-352.5	
	450-152.5	
Soil-Vapor Extraction Wells		
Well Location	**Screened Depth (ft bgs)**	**Total Sampling Ports**
SVEW-01	245-260	1
SVEW-02	45-60	1
SVEW-03	145-160	1
SVEW-04	298-313	1
SVEW-05	445-460	1
SVEW-06	45-60	1
SVEW-07	145-160	1
SVEW-08	245-260	1
SVEW-09	435-450	1
SVEW-10	400-410	1
SVEW-11	400-410	1

Table 5-4. Soil-Vapor Monitoring Wells, Extractions Wells, and Existing SVE Systems (concluded)

Soil-Vapor Extraction Wells (continued)		
Well Location	**Screened Depth (ft bgs)**	**Total Sampling Ports**
SVEW-12	400-410	1
SVEW-13	400-410	1
Soil-Vapor Extraction Units		
Well Location	**Screened Depth (ft bgs)**	**Total Sampling Ports**
ST-106	NA	3
KAFB-1065	NA	3
KAFB-1068	NA	3
KAFB-1066	NA	3

ft bgs = feet below ground surface
KAFB = Kirtland Air Force Base
SVEW = soil-vapor extraction well
SVMW = soil-vapor monitoring well

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Table 8-1. Project Team Roles and Responsibilities

Position	Qualifications	Duties and Responsibilities	Authority Level
Project Manager	• Tom Cooper, PG, PMP • Mr. Cooper is a Professional Geologist (PG) and Project Management Professional (PMP) with 11 years of experience as a hydrogeologist on complex groundwater remediation projects and 5 years of experience as a project manager for firm-fixed-price, performance-based acquisition (PBA) projects, including hybrid PBAs with options. He has expert knowledge of groundwater and soil sample collection/data evaluation and has extensive experience working proactively with clients and regulators to determine the best technologies to reach remedial performance objectives. • Mr. Cooper has served as the project manager for DoD projects at Former Air Force Plant PJKS (PJKS), Pueblo Chemical Depot, and Vandenberg AFB. For these projects, he established strong and cooperative working relationship with his clients as well as state and EPA regulators. At PJKS, he successfully negotiated with regulators to implement an environmental covenant and technical impracticability waiver as opposed to a pump-and-treat system. The environmental covenant saved the Air Force millions of dollars. At Pueblo, Mr. Cooper developed ten remedy-specific work plans that were approved within the first year of the project. He and his team then completed installation of eight in situ bioremediation systems within the second year of the project.	• Manages task order (TO) deliverables, schedules, and budgets • Implements procedures to eliminate conflicts, errors, and omissions and ensure the accuracy of all output • Establishes and maintains close communication and coordination with the USACE for the duration of the project • Assigns scientists, engineers, and select subcontractors • Procures services, equipment, and supplies as needed • Ensures personnel follow approved work plans/specs • Tracks materials and resources and justify change orders • Coordinates subcontractors' work to ensure compliance with safety and health, quality, and contract procedures	• Full responsibility and authority to execute TOs • Approves subcontractor invoices, project charges, and deliverables • Implements corrective action • Stops work for non-compliance/safety violation
Site Supervisor	• Terry Rulon • Mr. Rulon has over 22 years as a site supervisor on restoration, remediation, demolition, and hazardous waste sites. His role has been primarily bid preparation, estimating, overall site management, and field work on numerous complex environmental projects throughout the U.S. • Mr. Rulon's experience includes, but is not limited to, management of contaminated soil remediation, in situ bioremediation of groundwater for chlorinated compounds, shock-sensitive chemical packaging, and emergency response actions.	• Tracks progress of daily well installation production and soil excavation • Schedules manpower and balancing project resources • Schedules use of equipment • Manages sampling of environmental media and IDW, handling of IDW, and coordination of IDW disposal. • Manages operation and maintenance of all equipment • Addresses field issues to keep project on schedule • Communicates daily with project manager to keep project on schedule	• Supervises field TO engineering and design staff • Manages subcontractors • Implements corrective action • Stops work for non-compliance/safety violation

Table 8-1. Project Team Roles and Responsibilities (continued)

Position	Qualifications	Duties and Responsibilities	Authority Level
Field Team Manager – Soil-Vapor Extraction (SVE)	• David Cacciatore, PhD, PE, PMP • Dr. Cacciatore is a registered Professional Engineer (PE) and PMP with 7 years of experience designing and implementing SVE/bioremediation systems for environmental remediation projects. He has designed and implemented a wide range of bioremediation technologies, including monitored natural attenuation (MNA). Dr. Cacciatore has served as the Designer of Record on plans and reports for several high-profile projects at sites including Hunters Point Naval Shipyard and Treasure Island in California. He has played an integral role in supporting negotiations with regulators to gain approval of the remedies and cleanup goals for these projects. Dr. Cacciatore has authored/co-authored 11 technical papers/ presentations at industry conferences on the design and implementation of bioremediation and other remedial methods.	• Identifies, trains, mentors, and assigns qualified engineering staff to tasks/projects • Ensures compliance and consistency of engineering and technical program execution across all TOs • Provides professional engineering certification of drawings, specifications, and documents as necessary • Ensures compliance with all applicable engineering and design codes, standards, and guidance	• Supervises field TO engineering and design staff • Defines qualifications and requirements of engineering and technical staff at TO level • Evaluates performance of engineering staff and provides feedback, including recommendations, to project manager • Stops work for non-compliance/safety violation
Field Team Manager – In Situ	• Gary Hecox, PhD, PG, CGWP • Dr. Hecox is a PG and Certified Groundwater Professional (CGWP) with 32 years of experience in hydrogeology, GIS development and application, contaminant investigations, risk analysis, and remediation. He is a technical expert in non-aqueous phase liquid (NAPL) assessment and remediation, groundwater modeling, geostatistics, statistics, and error analysis. • Dr. Hecox has served as Shaw's senior scientist/engineer for federal remediation projects dealing with in excess of 5 million gallons of light, non-aqueous phase liquid (LNAPL) contamination. He specializes in designing and implementing process treatment systems such as for the chemical stabilization of soils and groundwater. He has provided technical input and strategy support in Resource Conservation and Recovery Act (RCRA) site remediation negotiations and technical impracticability waivers for various federal sites. Dr. Hecox also developed and deployed new technologies and applications of geographical information system (GIS) for hydrogeologic assessments.	• Prepares groundwater modeling to assist with the design of remediation systems • Executes the MNA evaluation study • Evaluates and documents all hydrogeologic data to confirm LNAPL and plume containment	• Supervises field TO design staff • Defines qualifications and requirements of technical staff at TO level • Evaluates performance of technical staff and provides feedback, including recommendations, to project manager • Stops work for non-compliance/safety violation

Table 8-1. Project Team Roles and Responsibilities (continued)

Position	Qualifications	Duties and Responsibilities	Authority Level
Field Team Manager – Bioremediation	• Charles Schaefer, PhD • Dr. Schaefer has 14 years of experience with assessing the fate and transport of organic contaminants in soil and groundwater systems. His work has included design and performance of laboratory scale experiments, mathematical and numerical modeling, and conceptual design and evaluation of field-scale bioremediation systems. He has taught graduate-level courses in contaminant hydrogeology, and has been successful in attaining research funding from the EPA, DoD, and the U.S. Department of Energy (DOE). Dr. Schaefer's research has included development of experimental methods to evaluate new and emerging technologies including ethylene dibromide degradation in Shaw's treatability study laboratories located in Lawrenceville, New Jersey and Knoxville, Tennessee. As a result of his research, he has developed and published several conceptual and mathematical models that have been used to better understand, interpret, and predict contaminant fate and transport. • Dr. Schaefer has been the lead engineer and/or technical manager on several field projects, many of which have used innovative investigation and treatment technologies. His key contributions include the conceptual design and performance evaluation of an air sparging/soil vapor extraction Superfund site in New Jersey; development of a transport model to evaluate contaminant biodegradation in an engineered biocell at a Superfund site in Delaware; and development and implementation of an innovative cosolvent technology for investigation of dense, non-aqueous phase liquid (DNAPL) in bedrock.	• Identifies, trains, mentors, and assigns qualified engineering staff to tasks/projects • Ensures compliance and consistency of engineering and technical program execution across all TOs • Provides professional engineering certification of drawings, specifications, and documents as necessary • Ensures compliance with all applicable engineering and design codes, standards, and guidance	• Supervises field TO engineering and design staff • Defines qualifications and requirements of engineering and technical staff at TO level • Evaluates performance of engineering staff and provides feedback, including recommendations, to project manager • Stops work for non-compliance/safety violation

Table 8-1. Project Team Roles and Responsibilities (continued)

Position	Qualifications	Duties and Responsibilities	Authority Level
Field Team Manager – Chemistry	• Pamela Moss • Ms. Moss has 32 years of experience in chemical quality control, analytical chemistry, and project management in support of federal contracts. Ms. Moss supported projects at Kirtland AFB from 1996 to 2010. During this time, she managed in excess of $5 million in analytical laboratory services. She has also participated in RCRA site investigations, remedial actions, long-term groundwater monitoring, compliance monitoring and sampling programs, which included hazardous wastes and routine and non-routine analytical parameters for groundwater, drinking water, soil, and air. • Ms. Moss has 14 years of experience at Kirtland AFB participating in regular communications and negotiating with the New Mexico Environmental Department (NMED) to ensure compliance with all applicable regulations. Ms. Moss also has extensive knowledge and experience implementing federal programs in accordance with the USACE; DoD Quality Systems Manual for Environmental Laboratories (QSM); and EPA requirements, protocols, and analytical methodologies.	• Approves project-specific data quality objectives (DQOs) that will meet the project-specific performance standards • Determines appropriateness of sampling procedures, analytical methods, and laboratory quality systems • Approves the final QAPP • Verifies the selection of appropriately qualified laboratories • Coordinates field and laboratory quality assurance surveillance per contract specifications • Notifies the project manager of any problems or nonconformance issues • Directs the performance of data review per contract specifications • Oversees data management and ERPIMS submittals	• Supervises field scientists and technical staff • Defines qualifications, requirements, and assigns engineering and technical staff at TO level • Evaluates performance of technical staff and provides feedback, including recommendations, to project manager • Stops work for non-compliance/safety violation
Field Team Manager – Geophysics	• Tim Deignan, PGP • Mr. Deignan is a registered PGP with more than 21 years of experience, which include executing multiple projects at Kirtland AFB. As a recognized subject matter expert, Mr. Deignan has also donated his time to serve as an archeological expert for efforts at Kirtland AFB. His experience includes design and management of integrated geophysical programs to investigate and assess sites and geotechnical, geologic, hydrogeologic, and cultural resource features. He specializes in high-resolution, integrated geophysical programs for environmental remediation and munitions investigations. • Mr. Deignan works with numerous state and federal agencies to increase the usability of results for geophysical and statistical sampling data, and is integral in developing more adequate and innovative sampling approaches. He is a two-time recipient of the Industry Recognition Award from the Interstate Technology and Regulatory Council.	• Functions in lead technical role for efforts requiring expert level support • Identifies, trains, mentors, and assigns qualified technical staff to tasks/projects • Ensures compliance and consistency of technical program execution • Ensures compliance with all applicable federal, state, and local regulations • Serves as the project geophysicist of record	• Supervises field scientists and technical staff • Defines qualifications, requirements, and assigns engineering and technical staff • Evaluates performance of technical staff and provides feedback, including recommendations, to project manager • Stops work for non-compliance/safety violation

Table 8-1. Project Team Roles and Responsibilities (continued)

Position	Qualifications	Duties and Responsibilities	Authority Level
Environmental Regulatory Specialist	• Jan Martin, PE • Ms. Martin is a New Mexico-registered PE with more than 24 years of experience ensuring compliance on complex environmental investigation and remediation projects. Located in Shaw's Albuquerque office, Ms. Martin has executed a number of environmental remediation projects for DoD in New Mexico and other states, including active installations under the Installation Restoration Program at Wright-Patterson AFB, and Formerly Used Defense Sites (FUDS) at the Former Walker AFB in Roswell, New Mexico and at a FUDS adjacent to Kirtland. • She has worked with DoD clients, EPA regulators, and private and tribal stakeholders to ensure compliance on projects conducted under RCRA as well as various DoD programs, state statutes, and regulations. Ms. Martin has prepared remedial investigation, engineering evaluation/cost analyses, and feasibility study reports, various decision documents, land use control plans, Operating Properly and Successfully (OPS) documents, RCRA closure and corrective action documents, and design analysis documents including plans and specifications.	• Identifies regulatory requirements and oversees implementation of environmental regulatory requirements • Supports project manager in regulatory interaction • Works closely with the installation representatives to ensure that environmental policies and procedures are implemented • Stops work for non-compliance/safety violation	• Reports regulatory updates to project manager • Coordinates regulatory meeting in concert with project manager • Maintains list of team personnel who have authority to contact regulatory agencies • Stop-work authority
Risk Assessor	• Mark Weisberg, CHMM • Mr. Weisberg, a Certified Hazardous Materials Manager (CHMM), has prepared hundreds of risk assessments at more than 25 Army/DoD facilities, including Former Walker AFB in Roswell, New Mexico. At Walker, he prepared NMED-approved screening-level environmental risk assessments for sites throughout the base. He has more than 20 years of experience in ecology and environmental assessment, where he has been responsible for supervising and conducting risk assessments and RCRA facility investigations at numerous hazardous, toxic, and radioactive waste sites for the Army, Air Force, and Navy. His areas of expertise include ecological and human health risk assessment; toxicology; statistical analysis; water quality; site assessment; and federal, state, and local permit preparation.	• Functions in lead technical role for efforts requiring expert level support • Identifies, trains, mentors, and assigns qualified technical staff to tasks/projects • Ensures compliance and consistency of technical program execution • Ensures compliance with all applicable federal, state, and local regulations	• Supervises field scientists and technical staff • Defines qualifications, requirements, and assigns engineering and technical staff • Evaluates performance of technical staff and provides feedback, including recommendations, to project manager • Stops work for non-compliance/safety violation

Table 8-1. Project Team Roles and Responsibilities (continued)

Position	Qualifications	Duties and Responsibilities	Authority Level
Certified Industrial Hygienist (CIH)	• James Joice, CIH, Certified Safety Professional (CSP), CHMM • Mr. Joice, Shaw's CIH for the Huntsville Worldwide Environmental Remediation contract, has 30 years of experience managing the health and safety for projects and programs at hundreds of environmental remediation sites. He has extensive experience establishing and maintaining health and safety plans and procedures where EPA Levels A, B, and C personal protective equipment (PPE) were required. • He regularly supervises project safety personnel; monitors subcontractor activities; develops, implements, and enforces site-specific accident prevention plans (APPs) and site safety and health plans (SSHPs); audits sites for compliance with health and safety (H&S) program requirements; conducts personnel training, and verifies regulatory compliance. He has also prepared and implemented H&S programs for several PBA and firm-fixed-price contracts.	• Implements and oversees H&S program and plans • Develops, implements, and oversees APPs inclusive of SSHPs and directs/approves any changes • Notifies Contracting Officer of changes in the approved plan within 48 hours • Interfaces with the USACE on H&S program requirements • Assesses risk and ensures engineering controls and/or appropriate PPE are used for worker and public protection	• Approves APPs/SSHPs and all modifications before issuance to the USACE • Manages H&S Program and directs training and required attendance • Investigates safety concerns raised by staff • Investigates any accidents • Stops work for non-compliance/safety violation
Community Relations Specialist	• Lisa Stahl • Ms. Stahl is a senior community relations specialist/anthropologist with 17 years professional experience that includes active participation on projects in New Mexico. Ms. Stahl provided public involvement and social science support for efforts at both the Los Alamos National Laboratory as well as Pueblo of Isleta. • She has 17 years of experience working with a variety of assessment tools and information; establishing positive working relationships with multiple stakeholders; and preparing and distributing various bilingual outreach materials to a variety of end-users. • Ms. Stahl specializes in identifying and facilitating community perspectives into program and policy processes through active involvement and regular communication with members of the community. She is also skilled at writing innovative public participation strategies tailored and targeted to the specific needs and concerns of the community. • Her various experiences have included liaison activities between project staff and communities, conducting community assessments, evaluating various public programs, and providing community involvement support to a variety of government clients.	• Performs community outreach to facilitate offsite drilling program • Establishes and maintains regular communication regarding project and field efforts with all members of the community • Plans, organizes, and participates in public meetings regarding the project, including working with all applicable parties to prepare for public meetings • Prepares and advertises public notices as necessary • Prepares project fact sheets and facilitates distribution of fact sheets and other presentation materials • Performs research and community interviews to gather needed information	• Reports updates to project manager • Coordinates public meetings in concert with project manager • Maintains list of team personnel who have authority to conduct community interviews • Stops work for non-compliance/safety violation

Table 8-1. Project Team Roles and Responsibilities (concluded)

Role	Subcontractor	Duties and Responsibilities	Authority Level
Driller	Water Development Corporation	• Installs groundwater, soil-vapor monitoring, and soil-vapor extraction wells • Uses direct-push methods to advance soil borings • Collects continuous soil samples • Collects soil-vapor samples	• Stops work for non-compliance/safety violation
Laboratory	Empirical Laboratories, LLC – groundwater sample analysis Gulf Coast Analytical Laboratories, Inc. – soil sample analysis RTI Laboratories – soil-vapor sample analysis	• Conducts analytical services in accordance with the Uniform Federal Policy – Quality Assurance Project Plan and DoD QSM • Provides analytical data in electronic PDF format • Provides ERPIMS-formatted deliverables	• Stops work for non-compliance/safety violation
Transportation and Disposal	Rhino	• Furnishes trucks, drivers, and all associated services required for transporting hazardous waste oil mixtures from Kirtland AFB to an offsite disposal facility • Ensures compliance with federal, state, and local environmental regulations • Provides all equipment and materials required for performing work at the disposal site	• Stops work for non-compliance/safety violation
SVE Unit Service Maintenance Provider	Remediation Services Int'l	• Provides support maintenance and repairs as needed for the SVE units	• Stops work for non-compliance/safety violation associated with the systems

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APPENDIX A

2010 Regulatory Correspondence between the NMED HWB and the Air Force regarding the Kirtland AFB, BFF Spill

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ATTACHMENT 1

April 2, 2010 Correspondence from the NMED HWB to Colonel Michael S. Duvall, Base Commander, 377 ABW/CC Re: SWMUs ST-106 and SS-111, BFF Spill, Kirtland, AFB

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AR Doc # 3451

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CERTIFIED MAIL - RETURN RECEIPT REQUESTED

April 2, 2010

APR 19 2010

Colonel Michael S. Duvall
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Kirtland AFB, NM 87117-5606

Mr. John Pike
Director, Environmental Management Section
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RE: SOLID WASTE MANAGEMENT UNITS ST-106 AND SS-111, BULK FUELS FACILITY SPILL
KIRTLAND AIR FORCE BASE
EPA ID# NMD9570024423, HWB-KAFB-10-004

Dear Colonel Duvall and Mr. Pike:

As you are aware, the U. S. Department of Defense Kirtland Air Force Base ("Permittee") is conducting an investigation of contaminated groundwater at the Bulk Fuels Facility Former Fuel Offloading Rack (Solid Waste Management Unit ["SWMU"] ST-106) and the associated Light Non-Aqueous Phase Liquid ("LNAPL") plume (SWMU SS-111, or Phase-Separated Hydrocarbon Bulk Fuels Facility Remediation) (collectively, the "Bulk Fuels Facility Spill"). Data submitted by the Permittee show that the contamination caused by the Bulk Fuels Facility Spill represents a significant threat to human health and the environment, particularly to well water in urban neighborhoods adjacent to Kirtland Air Force Base ("KAFB"). Despite the fact that this release of hazardous constituents was first discovered 10 years ago, the Permittee has not completely characterized the Bulk Fuels Facility Spill, nor conducted adequate remediation.

As stated in the New Mexico Environment Department ("Department") Ground Water Quality Bureau ("GWQB") letter enclosed with this letter, the GWQB has transferred oversight of the Bulk Fuels Facility Spill to the Hazardous Waste Bureau ("HWB"),

which will direct corrective action at the Bulk Fuels Facility Spill pursuant to the New Mexico Hazardous Waste Act ("HWA") NMSA 1978, §74-4-1 to 74-4-14 and the Hazardous Waste Management Regulations ("HWMR", 20.4.1 NMAC).

Releases of hazardous waste or hazardous constituents are subject to corrective action under Sections 3004(u) and (v) and 3008(h) of the Resource and Conservation Recovery Act "RCRA"; 42 U.S.C. §§ 6924(u) and (v) and 6928(h); Sections 74-4-4(A)(5)(h) and (i), 74-4-4.2(B), and 74-4-10(E) of the HWA; and the HWMR at 40 C.F.R. Part 264, Subpart F (incorporated by 20.4.1.500 NMAC).

Pursuant to 20.4.1 NMAC incorporating 40 CFR § 264.101(a), the Permittee must institute corrective action as necessary to protect human health and the environment for all releases of hazardous waste or constituents from any SWMU. Additionally, in accordance with 20.4.1 NMAC incorporating 40 CFR § 264.101(c), the Permittee must implement corrective actions beyond the facility boundary.

Section R.5 of the Hazardous and Solid Waste Amendments ("HSWA") Module IV of the Permittee's RCRA Permit states:

> The Permittee shall conduct those investigations of SWMUs previously identified with known or suspected releases of contamination as necessary to protect human health and the environment to: characterize the facility (Environmental Setting); define the source (Source Characterization); define the degree and extent of contamination (Contamination Characterization); and to identify actual or potential receptors.

Additionally, pursuant to Section R.5(b):

> The Permittee shall collect analytical data to completely characterize the waste and areas where waste have been placed, including: type, quantity, physical form, disposition (containment or nature of deposits), and the facility characteristics affecting releases.

And, in accordance with Section R.5(c):

> The Permittee shall collect analytical data on groundwater, soils, surface water, sediment, and subsurface gas contamination when necessary to characterize contamination from a SWMU. The data shall be sufficient to define the extent, origin, direction and rate of movement of the contaminant plumes.

Therefore, in accordance with Section K.1 of the HSWA Module IV of the Permittee's RCRA Permit, the Permittee is directed to immediately implement interim measures to remediate the LNAPL plume, to excavate and remove structures and contaminated soil in

the vadose zone at and in the vicinity of the Former Fuel Offloading Rack, to install additional wells, and continue operation of the existing soil-vapor extraction units as directed below. Additionally, pursuant to Section R.5 of Module IV of the Permit, the Permittee is directed to immediately complete characterization of contaminated soil and soil-gas in the vadose zone, and to immediately complete characterization of the dissolved-phase contamination in groundwater. Furthermore, in accordance with Section M.1 of Module IV of the Permit, the Permittee will be directed by NMED to conduct one or more Corrective Measures Evaluations. The Permittee shall comply with the detailed instructions specified below by the indicated deadlines.

A. REQUIREMENT FOR COMPLETING CHARACTERIZATION OF CONTAMINATION IN THE VADOSE ZONE

The Department finds that contaminant characterization is inadequate at the tank farm, the piping extending from the tank farm to the Former Fuel Offloading Rack, and areas in the vicinity of the Former Fuel Offloading Rack. More specific details on this finding are presented in the next two paragraphs.

Based on information provided by the Permittee, only four soil borings have been completed at the fuel tanks and no borings have been completed along the ancillary piping leading from the fuel tanks to the Former Fuel Offloading Rack. The four soil borings at the tanks were completed to shallow depths ranging from 25-48 feet. Diesel Range Organics ("DRO") contamination was detected in all four boreholes, with the highest concentrations (1800-2400 mg/kg) found in borehole SB-09. A number of hazardous constituents were also detected in soil samples from SB-09 and SB-06. Despite these findings, the Permittee did not determine the extent of contamination near the tanks. The latter is particularly notable given that the Permittee's *Stage 1 Abatement Plan Report* (February 8, 2006) contains the following recommendation (in Section 4.4):

> It is recommended that additional field investigation at the east side of the Bulk Fuels Facility be conducted to determine the full extent of petroleum hydrocarbons in soil and soil vapor beneath Tank 2422...Additional investigation will also determine whether release(s) associated with this tank are the source of sorbed-phase and vapor-phase petroleum hydrocarbons previously indentified in distal monitoring wells SVMW-13 and SVMW-15.

To date, the Permittee has not conducted the additional field investigation to determine the full extent of petroleum hydrocarbons and hazardous constituents in soil and soil vapor around the Bulk Fuels Facility.

The Permittee has also not completed characterization of the contaminated soil in the vicinity of the Former Fuel Offloading Rack, as previous investigative efforts seem to have been arbitrarily terminated once Total Petroleum Hydrocarbons ("TPH") concentrations in soil were found to be less than 100 mg/kg. Additional soil borings should have been completed to investigate the full

extent of soil contamination above background levels regardless of the concentration levels of the contaminants. Similarly, characterization of soil-gas contamination near the Former Fuel Offloading Rack is inadequate; investigative efforts appear to have been terminated once TPH concentrations were found to be below 1000 ppmv in the area. Additional soil-gas monitoring wells should have been installed to investigate the full extent of soil-gas contamination from the surface to groundwater, even in areas where the contamination is less than 1000 ppmv.

Thus, the Permittee has not adequately characterized LNAPL contamination in the vadose zone. Characterization must be complete to design and implement an appropriate final remedy. Accordingly, pursuant to the deadlines established below, the Permittee must:

1. Determine the amount of fuel that exists within the vadose zone as sorbed or residual liquid, or as soil gas.
2. Identify the source of the LNAPL fuel plume.
3. Describe the vadose zone hydrology, its relationship to observed and potential to-be-discovered groundwater contamination, and the potential for continuing contamination of groundwater by vadose zone contamination sources.
4. Characterize the geology and extent of contamination in the soil and soil gas to determine distribution, fate, and migration of contaminants.

Therefore, on or before **June 7, 2010**, the Permittee must submit to the Department for its review and approval a Vadose Zone Investigation Plan that describes the additional actions the Permittee will take to investigate the vadose zone hydrology and geology of the affected area, to identify and characterize the source of the releases at the Bulk Fuel Facility, and to identify the extent of soil and soil-gas contamination in the vadose zone from the surface to groundwater. The area covered under this Vadose Zone Investigation Plan must include the tank farm and the ancillary piping between the farm and the Former Fuel Offloading Rack. The Vadose Zone Investigation Plan must describe in detail all research, locations, depths and methods of exploration, field procedures, sampling and analysis of soil and soil gas and related quality control procedures. The Vadose Zone Investigation Plan shall also describe the results and the means (for example, cross-sections, plan views) by which these results will be reported after the investigation is completed, and a schedule for implementation of the work that complies with the compliance schedule in Table 1 of this letter.

Table 1. Compliance Schedule for Vadose Zone Investigation

Task	Date Due
Submit Vadose Zone Investigation Plan to the Department	June 7, 2010
Complete all subsurface-soil sampling and installation of all soil-gas monitor wells	Within 12 months after Department approval of Vadose Zone Investigation Plan

Report results for subsurface-soil sampling	Within 15 months after Department approval of Vadose Zone Investigation Plan
Complete first four quarters of soil-gas sampling and analysis	Within 24 months after Department approval of Vadose Zone Investigation Plan
Soil-gas sampling	Quarterly after well installations completed
Submit quarterly soil-gas monitoring reports to the Department	60 days after the quarter during which sampling occurred

Furthermore, in addition to any other locations the Permittee identifies, the locations listed in Table 2 of this letter shall be included in the Vadose Zone Investigation Plan and must be sampled for contaminants in soil and soil gas (all coordinates in this table are State Plane Coordinates in feet, NAD83). Soil samples shall be collected at a frequency of at least one sample every 10 feet for the first 50 feet, and at least one sample thereafter every 50 feet to total depth, and at least one sample at total depth in each boring. Each boring at each location shall be drilled from the surface to the water table, and each boring shall be completed as a permanent soil-gas monitoring well. All of the soil-gas monitoring wells shall be capable of yielding discrete samples of soil gas recovered from depths of 25, 50, 150, 250, 350, and 450 feet below the ground surface. While the Permittee shall continue to analyze samples for TPH and hazardous constituents, the investigation shall not be limited to only those areas containing or suspected to contain TPH at concentrations of greater than 100 mg/kg (100 ppm) in soil or 1000 ppmv in soil gas. Instead, investigation of the Bulk Fuels Facility Spill shall be designed to determine the full extent of contamination above background levels regardless of contaminant concentration levels.

Table 2. Borehole locations for soil sampling and for conversion to soil-gas monitoring wells.

Location #	Easting	Northing	Characterization Purpose
1	1541119	1473793	Step out from Fuel Offloading Rack beyond 100 mg/kg contaminated zone
2	1540808	1473503	Step out from Fuel Offloading Rack
3	1541123	1473310	Step out from Fuel Offloading Rack
4	1541425	1473313	Step out from Fuel Offloading Rack
5	1541961	1473492	Path from Fuel Offloading Rack to LNAPL Plume
6	1542002	1473057	Piping
7	1541794	1473061	Piping
8	1542370	1473058	Piping
9	1541898	1473276	Path from Fuel Offloading Rack to LNAPL Plume
10	1541720	1473369	Step out from Fuel Offloading Rack

11	1541776	1473740	Step out from Fuel Offloading Rack
12	1541658	1473505	Path from Fuel Offloading Rack to LNAPL Plume
13	1542061	1472928	Fuel tanks
14	1542063	1472775	Fuel tanks
15	1542142	1472847	Fuel tanks
16	1541982	1472845	Fuel tanks
17	1542330	1472796	Fuel tanks
18	1542430	1472897	Fuel tanks
19	1542516	1472810	Fuel tanks
20	1542428	1472716	Fuel tanks
21	1541611	1473238	Piping

In addition to any other location identified by the Permittee, the locations listed in Table 3 of this letter shall also be included in the Vadose Zone Investigation Plan to be sampled for contaminants in soil gas (all coordinates in this table are State Plane Coordinates in feet, NAD83). Each boring at each location listed in Table 3 shall be completed as a permanent soil-gas monitoring well. All of the soil-gas monitoring wells shall be capable of yielding discrete samples of soil gas recovered from depths of 25, 50, 150, 250, 350, and 450 feet below the ground surface.

Table 3. Locations for soil-gas monitoring wells.

Location #	Easting	Northing	Characterization Purpose
1	1543058	1474093	Characterize outside of LNAPL Plume
2	1543194	1474680	Characterize outside of LNAPL Plume
3	1542306	1474093	Characterize within LNAPL Plume
4	1541555	1475049	Characterize outside of LNAPL Plume
5	1541248	1474141	Characterize outside of LNAPL Plume
6	1542259	1472591	Characterize outside of LNAPL Plume
7	1540667	1472823	Characterize outside of LNAPL Plume
8	1542525	1475459	Characterize within LNAPL Plume
9	1542436	1474878	Characterize within LNAPL Plume

B. REQUIREMENT FOR COMPLETING CHARACTERIZATION OF DISSOLVED-PHASED CONTAMINANTS IN GROUNDWATER

The Permittee has not adequately characterized the dissolved-phase contamination in the groundwater and has not analyzed groundwater samples from wells located in the LNAPL plume area. The final remedy for the Bulk Fuels Facility Spill cannot be determined until this characterization work has been completed. Additionally, the Permittee has not installed any groundwater monitoring wells to investigate the vertical extent of the dissolved-phase groundwater contamination, the effects of vertical gradients, and the geology of the aquifer at any appreciable depth below the water table. The dissolved-phase plume is approaching one or more

Water Utility Authority well fields. Given that the pumping of water supply wells is known to induce vertical gradients in groundwater and can cause significant components of vertical flow in the vicinity of such wells, vertical characterization of groundwater quality and geology is required.

The leading edge and the eastern and western margins of the plume are undefined, and the nature and concentrations of contaminants in the core of the plume are poorly characterized because existing wells are located too far apart (generally at distances greater than 500 feet). Additionally, only one upgradient well has been installed that may yield groundwater samples that are free from contamination. Given the magnitude of this spill, several upgradient wells should be installed that are screened at different depths at and below the water table to ensure that all areas of contaminated groundwater have been located, and that the background wells are truly monitoring background water quality.

Therefore, on or before **July 7, 2010**, the Permittee must submit to the Department for its review and approval a Groundwater Investigation Plan that describes the additional actions the Permittee will take to characterize the nature, horizontal and vertical extent, and the fate and rate of migration of the groundwater contamination. The Groundwater Investigation Plan shall include construction details and the locations and depths of the groundwater monitoring wells to be installed, actions to characterize the geology and hydrogeology at and below the water table, and the groundwater flow direction and velocity. The plan shall also present details on field procedures, and the sampling and analysis of groundwater and related quality control. The Groundwater Investigation Plan shall describe the results, the means (*e.g.*, cross-sections, plan views) by which these results will be reported after the investigation is completed, and a schedule for implementation of the work that complies with the compliance schedule in Table 4 of this letter.

Table 4. Compliance Schedule for Groundwater Investigation

Task	Date Due
Submit Groundwater Investigation Plan to the Department	July 7, 2010
Complete installation of all wells	Within 12 months after Department approval of Groundwater Investigation Plan
Submit well installation report to the Department	Within 15 months after Department approval of Groundwater Investigation Plan
Complete first eight quarters of groundwater sampling and analysis	Within 36 months after Department approval of Groundwater Investigation Plan

Groundwater Sampling	Quarterly after well installations completed
Submit quarterly groundwater monitoring reports to the Department	60 days after the quarter during which sampling occurred

In addition to any locations the Permittee identifies, the Groundwater Investigation Plan shall also include a description of the installation of groundwater monitoring wells at the locations listed in Table 5 of this letter (all coordinates in this table are State Plane Coordinates in feet, NAD83). Three groundwater monitoring wells shall be installed at each of the cluster well locations listed in Table 5. The screen depths shown in Table 5 are distances (in feet) that the top of the screens shall be set below the water table. Screen lengths for wells shall not exceed 15 feet, with the exception that wells screened across the water table (those with screen depths of zero in Table 5) shall have screens 20 feet long, with no more than 15 feet of said screen length situated below the water table.

In addition to any other tools the Permittee identifies, the Groundwater Investigation Plan shall also include details describing the geophysical logging of all existing and new wells using induction (deep), neutron, and gamma (large crystal) tools. Geophysical logging at the cluster well locations listed in Table 5 is required in only the well at each location having the deepest screened interval.

Table 5. Cluster well locations and screen depths relative to the water table.

Location #	Easting	Northing	Screen Depths	Characterization Purpose
1	1542189	1476725	0, 15, 40	Plume margin
2	1541984	1476042	0, 15, 40	Plume margin
3	1543703	1476600	0, 15, 40	Plume margin
4	1543372	1475065	0, 15, 40	Plume margin
5	1543643	1477939	0, 15, 85	Leading edge and deep characterization
6	1541430	1472370	0, 15, 40	Background water quality
7	1542812	1473601	0, 15, 40	Plume margin
8	1542722	1477726	0, 15, 40	Leading edge
9	1543054	1477788	0, 15, 40	Leading edge
10	1543774	1477304	0, 15, 40	Leading edge
11	1541774	1473718	0, 15, 85	Plume core, deep delineation
12	1542362	1473801	0, 15, 85	Plume core, deep characterization
13	1542305	1474340	0, 15, 85	Plume core, deep characterization
14	1542736	1474715	0, 15, 85	Plume core, deep characterization
15	1542860	1475860	0, 15, 85	Plume core, deep characterization
16	1542189	1475207	0, 15, 85	Plume core, deep characterization
17	1541891	1473151	0, 15, 85	Plume core, deep characterization
18	1542203	1474071	0, 15, 85	Plume core, deep

				characterization
19	1542653	1475338	0, 15, 85	Plume core, deep characterization
20	1542535	1475975	0, 15, 85	Plume core, deep characterization
21	1543199	1475767	0, 15, 85	Plume core, deep characterization
22	1543068	1476494	0, 15, 85	Plume core, deep characterization

C. REQUIREMENT FOR INTERIM MEASURES

In its October 28, 2009 letter, the GWQB wrote:

> The New Mexico Environment Department (NMED) has determined, based on information generated by Kirtland Air Force Base (KAFB) during its investigations, that the scale and observed impact of the Light Non-Aqueous Phase Liquid (LNLAP) hydrocarbon contamination of groundwater associated with the SS-111 Bulk Fuels Facility constituting the majority of the KAFB ST-106 LNAPL plume has been largely defined. This plume of LNAPL hydrocarbons has been found to have contaminated groundwater over a substantial area that is the source of drinking water supplies for the City of Albuquerque and is also located in the vicinity of several public water supply wells. The volume of LNAPL hydrocarbons on groundwater, which has been estimated by KAFB to be in the millions of gallons, will take a substantial period of time to remediate. Currently, the majority of the LNAPL hydrocarbon plume is located off of KAFB property and is not being actively remediated.

The Permittee's records indicate that the LNAPL and dissolved-phase plumes have migrated horizontally a distance of about 0.5 mile and 0.9 miles, respectively, from the area of the Former Fuel Offloading Rack.

Interim measures are required to reduce or prevent the migration of contaminants, or to reduce or prevent human or environmental exposure to contaminants while long-term corrective action remedies are evaluated and implemented. Section K.1 of the HSWA Module IV of the Permit states:

> If during the course of any activity initiated under this module, the Administrative Authority determines that a release or potential release of hazardous constituents from a SWMU poses a threat to human health and the environment, the Administrative Authority may specify interim measures. The Administrative Authority will determine the specific measure, including potential permit modifications, and the schedule for implementing the required measures.

Additionally, Section K.2 of Module IV of the Permit states:

The following factors may be considered by the Administrative Authority in determining the need for interim measures.

1. Time required to develop and implement a final remedy;
2. Actual and potential exposure to human and environmental receptors; and
3. The potential for the further degradation of the medium absent interim measures.

The Department has determined that the Bulk Fuel Facility Spill poses a threat to human health and the environment, and furthermore, endangers the groundwater resource – including water supply wells – relied upon by the Albuquerque Bernalillo County Water Utility Authority for delivery of safe drinking water to its customers. The contamination also threatens KAFB water supply wells, and those that supply the Veterans Administration ("VA") Hospital. The large size of the LNAPL plume and its proximity to these water supply wells requires that urgent action be taken to prevent the LNAPL plume from contaminating more of Albuquerque's drinking-water supply.

The Permittee has estimated the volume of fuel released from the Bulk Fuels Facility to range from about 1-2 million gallons, but the actual volume could be considerably larger because characterization of the vadose zone is inadequate. For example, the Department has estimated the volume of sorbed fuel at or greater than 100 ppm in soil to be about 4.8 million gallons; this does not include fuel in soil gas, fuel dissolved in groundwater, and floating fuel forming the LNAPL plume. The Department has estimated the fuel included in the LNAPL plume to be approximately 3 million gallons, giving a total volume of fuel sorbed to soil and that contained within the LNAPL plume at nearly 8 million gallons. The Permittee's records indicate that it has installed and is operating "interim ICE SVE" units on the Permittee's property; however, these four soil-vapor extraction (SVE) units are not an adequate interim measure to address the existing ground water contamination, including the LNAPL plume that has migrated beyond the facility boundary. From April 2003 to September 2009, these SVE units have extracted an estimated 286,600 gallons of fuel. From April through September 2009, the average extraction rate has declined by 25 per cent. The average extraction rate for each SVE unit is about 2,975 gallons per month.

At the rate of extraction achieved so far by the existing SVE units, the operation of these units would take over 14 years to remove 2 million gallons of fuel. This length of time is unacceptable because additional groundwater within the capture zone of Water Utility Authority water supply wells could become contaminated before the remediation could be completed. Furthermore, should the Department's calculations prove to be more accurate than the Permittee's estimated volume of fuel, it would take over 56 years for the remediation of the fuel to be completed.

Additionally, although the Permittee knows that considerable volumes of fuel have leaked from the Former Fuel Offloading Rack, the Permittee has not removed all of the

structures associated with the Former Fuel Offloading Rack (mostly the underground portions of the original structures), and has not excavated and removed contaminated soil around the Former Fuel Offloading Rack. The Permittee has instead abandoned the structures and contaminated soil in place. Soil containing considerable amounts of sorbed fuel, thus containing high concentrations of hazardous constituents, must exist at the Former Fuel Offloading Rack at shallow depths, posing a continuing source of contamination and threat to the groundwater resource.

Therefore, on or before **June 7, 2010,** the Permittee must submit to the Department for its review and approval an Interim Measures ("IM") Plan that describes what immediate actions it will take to remediate and stop the migration of the LNAPL plume. The IM Plan must also describe excavation and removal of all structures of the Former Fuel Offloading Rack, including the underground components, and the excavation and removal of contaminated soil at and in the vicinity of the Former Fuel Offloading Rack to a depth of at least 20 feet. The IM Plan must also include an implementation schedule showing that remediation of the LNAPL plume will be completed within five years of the Department's approval of the IM Plan, and that excavation and removal of structures and contaminated soil at and in the vicinity of the Former Fuel Offloading Rack will be completed within one year of the Department's approval.

Furthermore, on March 16, 2010, the Permittee sent a *Stage 2 Abatement Plan Modification Addendum* (dated March 16, 2010) concerning the proposed installation of three additional offsite groundwater monitoring wells. The March 16 submittal does not address the deficiencies identified by the GWQB in its letters of June 23 and October 28, 2009. This plan would not adequately characterize the LNAPL plume, the dissolved-phase groundwater contamination, or contaminated soil and soil gas at the Bulk Fuels Facility. However, given the urgency to complete characterization and implement an effective remedy, the NMED nevertheless approves the March 16, 2010, submittal as a second and separate interim measure, subject to the modifications described herein:

1. The March 16 plan proposes that well screens are to be constructed with lengths of 25 feet or more. Screen lengths for the wells shall not exceed 20 feet, with 15 feet of screen situated below the water table, and 5 feet of screen constructed above the water table.
2. The March 16 plan proposes that wells completed in the area of the LNAPL plume will not be developed after installation, and proposes that groundwater samples will not be acquired for laboratory analysis from wells located within the area of the LNAPL plume. Although existing wells within the area of LNAPL plume have in the past served only as sampling points to measure LNAPL thickness and as soil-vapor extraction points, these wells must now also be available to sample groundwater below the floating LNAPL so that concentrations of dissolved-phase contaminants can be assessed in this area. This same requirement will also apply to all future wells installed to address the Bulk Fuels Facility Spill, including the wells required under this letter. Thus, all wells that address the Bulk Fuels Facility Spill, including those located within the LNAPL

plume area, shall be properly developed to reduce turbidity and to remove residual drilling fluids (if any).

3. Groundwater at all wells within the LNAPL plume shall be sampled for laboratory analysis of hazardous constituents (volatile and semi-volatile organic compounds) and TPH after the wells are developed.
4. Proposed wells KAFB-10626 and KAFB-10628 shall be installed across the water table at the locations proposed in the March 16 plan. These two wells correspond to locations #5 and 13, respectively, in Table 5 above.
5. Proposed well KAFB-10627 shall be installed at location #6 listed in Table 5 above, which is a different location than that proposed by the Permittee in the March 16 submittal.
6. A tremie pipe shall be used to install the filter pack and seal for each well, and to place grout.
7. Grout shall be placed in lifts, with the first lift no greater than 100 feet in length and subsequent lifts no greater than approximately 200 feet. All lifts shall be allowed to dry until stable before the next lift is placed.
8. The March 16 plan does not contain a schedule for implementation. The March 16, 2010, plan shall be implemented **within two weeks** of approval from the City of Albuquerque to access the City property (e.g., Bullhead Park), to the extent access from the City is required for well installation. The Permittee shall otherwise implement the submittal **immediately**. All work shall be completed no later than **July 6, 2010**, or **90 days** after required access from the City is granted, whichever is later. Completion includes development of all new and existing wells that have not been previously developed, and the sampling of all wells within the LNAPL plume.
9. Sampling results (from item #3) above shall be reported to the NMED in writing on October 5, 2010, or 120 days after required access from the City is granted, whichever is later.

Table 6. Compliance Schedule for Interim Measures

Task	Date Due
Submit Interim Measures Plan to the Department	June 7, 2010
Complete excavation and removal of structures and soil at Former Fuel Offloading Rack	Within one year of approval of Interim Measures Plan
Complete remediation of LNAPL plume	Within five years of approval of Interim Measures Plan

Implement March 16, 2010 Stage 2 Abatement Plan Modification Addendum with required modifications	Immediately, except within two weeks of gaining permission for that portion of the March 16 Plan that requires access to City property.
Submit report to the Department on well installations conducted under March 16 Plan	July 6, 2010, or 90 days after required access from the City is granted, whichever is later
Submit report to the Department on groundwater sampling results conducted under March 16 Plan	October 5, 2010, or 120 days after required access from the City is granted, whichever is later

Until such time that the IM Plan is approved by the NMED, the Permittee shall continue to operate the four SVE units already in service 24 hours per day, 7 days a week, except when necessary to perform maintenance or repairs. If maintenance or repairs are necessary, the maintenance or repairs shall be completed as quickly as practicable, and the unit returned to service immediately after maintenance or repairs are completed. Any maintenance or repairs that will take more than 3 calendar days shall be reported in writing to the Department within 24 hours of discovery that the maintenance or repairs will take more than 3 days. The Permittee shall explain in the report why the maintenance or repairs will take more than 3 calendar days and why the delay is beyond the control of the Permittee.

D. REQUIREMENT TO CONDUCT A CORRECTIVE MEASURES EVALUATION

In accordance with Section M.1 of HSWA Module IV of the Permit, if the Administrative Authority has reason to believe that a SWMU has released concentrations of hazardous constituents, or if the Administrative Authority determines that contaminants present a threat to human health and the environment given site-specific exposure conditions, the Administrative Authority may require a Corrective Measures Study (herein referred to a Corrective Measures Evaluation, or "CME"). With this letter, the Department hereby notifies the Permittee that it is required to conduct a CME for the Bulk Fuels Facility Spill. The CME shall be conducted to develop remedial alternatives that, if implemented, would be appropriate to effectively arrest and remediate contamination in the vadose zone, the LNAPL plume, and the dissolved-phase groundwater contamination in a reasonable period of time. A CME Report shall be prepared that describes in detail the results of the CME. The CME Report shall be submitted to the Department within 180 days after the Department notifies the Permittee that characterization of the Bulk Fuels Facility Spill has been completed and approved by the Department. The CME and CME Report shall also be completed in accordance with Sections O and S of HSWA Module IV of the Permit.

E. REPORTING REQUIREMENTS

The investigation plans required under this letter shall include relevant maps and cross-sections that show concentration data for contaminants and other relevant information with supporting data posted on the maps and cross-sections in a legible manner, and clearly showing which borings/wells contributed data towards construction of the maps and cross-sections and which did not. Tables including all existing soil borings, soil-gas monitoring wells, and groundwater monitoring wells, listing their surveyed location, sampling points and maximum depth of exploration shall also be included in the reports and plans. For soil-gas monitoring wells, tables and graphs shall also be included providing trends of TPH concentrations versus time for the depths below ground surface of 25, 50, 150, 250, 350, and 450 feet.

F. CONCLUSIONS

The requirements in this letter to conduct corrective action at the Bulk Fuel Facility Spill are mandatory. If the Permittee fails to comply with the directives of this letter, the Department may take the following actions, or some combination of the following actions, to enforce these requirements: 1) issue a compliance order under section 74-4-10 of the HWA seeking injunctive relief or civil penalties for noncompliance; 2) file a civil action under sections 74-4-10 and 74-4-10.1(E) of the HWA or section 7002(a) of RCRA, 42 U.S.C. § 6972(a), seeking injunctive relief or civil penalties; or 3) file an action seeking criminal penalties under section 74-4-11 of the HWA. This list of authorities is not exhaustive and NMED reserves its rights to take any action authorized by law to enforce the requirements of the HWA and the HWMR.

The Permittee shall respond directly to my attention, with copy to Mr. Bill Olson of the GWQB, and Mr. William Moats (NMED HWB, 5500 San Antonio NE, Albuquerque, NM 87109), on all correspondence and required plans and reports related to the Bulk Fuels Facility Spill upon receipt of this letter, unless otherwise directed by HWB. All submittals and correspondence must be submitted in hardcopy and electronic format. Assessment of fees for the submittal of corrective action documents pursuant to 20.4.2. NMAC shall be made under separate cover.

If you have any questions or comments concerning the technical matters in this letter, you may contact William McDonald or Sid Brandwein of my staff at (505) 222-9582 and (505) 222-9504, respectively. If you have other questions or comments, I may be contacted directly at 505-476-6000.

Sincerely,

James P. Bearzi
Chief
Hazardous Waste Bureau

cc: M. Leavitt, Director, NMED WWMD
J. Kieling, NMED HWB
W. Moats, NMED HWB
B. McDonald, NMED HWB
S. Brandwein, NMED HWB
B. Olson, Chief, NMED GWQB
A. Puglisi, NMED GWQB
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L. Barnhart, NMED OGC
B. Gallegos, AEHD
B. Gastian, ABCWUA
L. King, EPA-Region 6

File: Reading and KAFB 2010

APR 19 2010

ATTACHMENT 2

June 4, 2010 Correspondence from the NMED HWB
to Colonel Robert L. Maness, Base Commander, 377 ABW/CC and Mr. John Pike,
Director, Environmental Management Section, 377 MSG/CEANR
Re: Reporting, Sampling, and Analysis Requirements
SWMUs ST-106 AND SS-111 BFF Spill, Kirtland AFB

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AR Doc # 3459

CEANR

NEW MEXICO ENVIRONMENT DEPARTMENT

Hazardous Waste Bureau

BILL RICHARDSON
Governor

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RON CURRY
Secretary

SARAH COTTRELL
Deputy Secretary

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

June 4, 2010

Colonel Robert L. Maness
Base Commander
377 ABW/CC
2000 Wyoming Blvd. SE
Kirtland AFB, NM 87117-5606

Mr. John Pike
Director, Environmental Management Section
377 MSG/CEANR
2050 Wyoming Blvd., Suite 116
Kirtland AFB, NM 87117-5270

RE: REPORTING, SAMPLING, AND ANALYSIS REQUIREMENTS SOLID WASTE MANAGEMENT UNITS ST-106 AND SS-111
BULK FUELS FACILITY SPILL
KIRTLAND AIR FORCE BASE, EPA ID# NM9570024423
HWB-KAFB-10-004

Dear Colonel Maness and Mr. Pike:

This letter sets forth reporting, sampling, and analysis requirements related to the characterization and remediation of contaminated groundwater at the U. S. Air Force Kirtland Air Force Base ("Permittee") Solid Waste Management Units ST-106 and SS-111, collectively known as the Bulk Fuels Facility Spill. In the past, the Permittee has submitted semiannual reports concerning the Bulk Fuels Facility Spill to the New Mexico Environment Department (NMED) Groundwater Quality Bureau. However, due to the severity and urgency of this matter, NMED directs that reporting occur on a more frequent basis. This letter describes how the Permittee must submit reports to the NMED from this time forward. In addition, this letter also sets forth general sampling and analysis requirements to ensure that groundwater and soil-gas data are of high quality and representative of the conditions present in the field.

Reporting Requirements

All characterization and remediation activities and data concerning the Bulk Fuels Facility Spill that have been completed or acquired during the last semiannual reporting period (October 2009 through March 31, 2010) are to be reported to the NMED no later

than June 30, 2010.

After June 30, 2010, quarterly reports must be submitted by the Permittee to the NMED for its review and approval. Quarterly reporting shall continue until such time that corrective action is deemed complete for the Bulk Fuels Facility Spill by the NMED, or until NMED approves in writing a different schedule.

Quarterly periods for each year and the due dates for corresponding quarterly reports are summarized in the following table.

Quarter	**Period**	**Due Date of Quarterly Report**
1	January 1 through March 31	May 30
2	April 1 through June 30	August 29
3	July 1 through September 30	November 29
4	October 1 through December 31	February 28 of the following year

Each quarterly report shall provide detailed information on all characterization and remediation activities that took place during the period covered by the report, including, but not limited to, as applicable for the reporting period, field and laboratory analytical results for groundwater, soil, and soil gas; graphs showing trends of major contaminants versus time, a table of surveyed well locations; descriptions of the installation of groundwater and soil-gas monitoring wells; measurements of light non-aqueous phase liquid (LNAPL); table of water levels; water-level map; plume contaminant maps and cross-sections; and geologic and geophysical logs of wells and boreholes. Each quarterly report shall also describe the operation, maintenance, and performance of the four soil-vapor extraction (SVE) systems. Each quarterly report shall also include all field and laboratory quality control data for the reporting period and a discussion of data quality as it relates to accuracy, precision, representativeness, and completeness for each analytical parameter that is to be reported.

In addition to the above reporting requirements, the NMED may require submission of data at any time. The Permittee will be notified in writing of any such required submissions and their associated submission due dates.

Also, pursuant to 20.4.1.900 NMAC (incorporating 40 C.F.R. § 270.11(d)(1)), all quarterly reports shall include a certification, signed by a chief or senior executive officer of the Facility, stating:

> 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.

General Sampling and Analysis Requirements

Groundwater and soil-gas monitoring shall be conducted on a quarterly basis with all groundwater and soil-gas monitoring wells sampled each quarter. Sample collection and analysis must be conducted in manner that yields results of high quality and are representative of the conditions of their respective media in the field. Field quality control samples, including duplicates, field blanks, equipment rinsate blanks, and trip blanks shall be collected or prepared as appropriate and analyzed for quality control purposes. Chain-of-custody and proper shipping and handling procedures shall be followed to ensure the integrity of samples.

At a minimum, groundwater shall be sampled and analyzed in a laboratory for volatile organic compounds (VOCs), total petroleum hydrocarbons (TPH), lead, major ions (calcium, magnesium, potassium, sodium, sulfate, carbonate, bicarbonate, chloride), nitrate, ammonia, sulfide, dissolved iron, and dissolved manganese. Except for sample fractions taken for dissolved iron and manganese, groundwater samples shall not be filtered. Groundwater shall also be sampled and analyzed in the field for temperature, pH, specific conductance, alkalinity, turbidity, dissolved oxygen, and Eh.

Groundwater samples shall be obtained from a well only after temperature, pH, and specific conductance measurements have stabilized within ±10% for three consecutive measurements and after purging at least one well-bore volume of stagnant water. A well-bore volume is herein defined as the volume of water in the saturated filter pack plus the volume of all standing water within the well screen and casing, including the sump. Field measurements taken during purging, including purge volumes and the date and time of each measurement, and the type and serial number of each field instrument used shall be recorded in a log book. The thickness of LNAPL shall be measured and recorded for every well location where LNAPL is present.

The detection limit for each groundwater constituent shall not exceed 50% of the constituent's U. S. Environmental Protection Agency's Maximum Concentration Level or its New Mexico Water Quality Control Commission standard (20.6.2.3103 NMAC), whichever is more stringent. For naturally occurring groundwater constituents, the detection limit for a given constituent shall also not exceed the constituent's background concentration as approved by the NMED for the KAFB area.

Soil-gas samples shall be collected from all monitoring intervals (all depths) for each soil-gas monitoring well. At a minimum, soil gas shall be sampled and analyzed in a laboratory for VOCs. The Permittee shall continually monitor the concentrations of soil vapor with an appropriate field instrument (e.g., photoionization detector of appropriate lamp energy) while purging. The Permittee shall collect soil-gas samples only after field instrument readings have stabilized within ±10% for three consecutive measurements and after the sampling tubing and the soil-gas monitoring well have been purged to remove all stagnant vapor. Soil-gas measurements taken in the field during purging, the date and time of each measurement, and the type and serial number of field instrument used shall be recorded in a log book.

The reporting and sampling and analysis requirements set forth in this letter are in effect, until and unless superseded by subsequent direction in an approved work plan or implementation plan.

If you have any questions concerning the technical matters in this letter, you may contact William McDonald or Sid Brandwein of my staff at (505) 222-9582 and (505) 222-9504, respectively. If you have other questions, you may contact me directly at 505-476-6000.

Sincerely,

James P. Bearzi
Chief
Hazardous Waste Bureau

cc: M. Leavitt, Director, NMED WWMD
J. Kieling, NMED HWB
W. Moats, NMED HWB
B. McDonald, NMED HWB
S. Brandwein, NMED HWB
B. Olsen, HWB GWQB
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L. Barnhart, NMED OGC
B. Gallegos, AEHD
B. Gastian, ABCWUA
L. King, EPA-Region 6
File: Reading and KAFB 2010
KAFB-10-004

ATTACHMENT 3

August 6, 2010 Correspondence from the NMED HWB to Colonel Robert L. Maness, Base Commander, 377 ABW/CC Re: SWMUs ST-106 and SS-111, BFF Spill, Kirtland, AFB

Directive for Conducting Interim Measures and Notice of Disapproval Interim Measures Work Plan, June 2010 Vadose Zone Work Plan, June 2010 Groundwater Investigation Work Plan, June 2010

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NEW MEXICO ENVIRONMENT DEPARTMENT

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Secretary

SARAH COTTRELL
Deputy Secretary

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

August 6, 2010

Colonel Robert L. Maness
Base Commander
377 ABW/CC
2000 Wyoming Blvd. SE
Kirtland AFB, NM 87117-5606

Mr. John Pike
Director, Environmental Management Section
377 MSG/CEANR
2050 Wyoming Blvd., Suite 116
Kirtland AFB, NM 87117-5270

RE: BULK FUELS FACILITY SPILL, SWMUS ST-106 AND SS-111
DIRECTIVE FOR CONDUCTING INTERIM MEASURES AND NOTICE OF DISAPPROVAL
INTERIM MEASURES WORK PLAN, JUNE 2010;
VADOSE ZONE WORK PLAN, JUNE 2010;
GROUNDWATER INVESTIGATION WORK PLAN, JUNE 2010
KIRTLAND AIR FORCE BASE, EPA ID# NM9570024423
HWB-KAFB-10-015, HWB-KAFB-10-016, HWB-KAFB-10-019

Dear Col. Maness and Mr. Pike:

The contamination caused by the Bulk Fuels Facility Spill at Kirtland Air Force Base (KAFB) represents a significant threat to human health and the environment, particularly to well water that supplies drinking water to portions of Albuquerque, KAFB, and the Veterans' Administration Hospital. Even though this release was first discovered 10 years ago, the U. S. Air Force (Permittee) has not characterized the nature and extent of Bulk Fuels Facility Spill, nor conducted adequate remediation. The threat posed by this release demands immediate and aggressive action as called for in the New Mexico Environment Department's (NMED's) April 2, 2010 letter.

The NMED has reviewed the Interim Measures Work Plan (June 2010), Vadose Zone Work Plan (June 2010), and Groundwater Investigation Work Plan (June 2010) regarding the KAFB Bulk Fuels Facility Spill, Solid Waste Management Units (SWMUs) ST-106 and SS-111. The plans were submitted in response to the NMED's letter of April 2, 2010, which concerned the need for

additional site characterization and interim measures to remediate contamination in groundwater, source areas, and fuel floating on the water table.

NMED finds that all three plans are deficient. This Notice of Disapproval (NOD) is issued to the Permittee with the intent that the Permittee correct the deficiencies identified herein. This NOD includes general comments that apply to all three documents, and general and specific comments concerning deficiencies found in each of the individual plans. These comments comprise Part 1 of this letter.

Due to the urgent need to accelerate certain aspects of remediation and characterization, the Permittee is also directed herein to implement interim measures in the form of additional soil vapor extraction and to take various other actions including establishing sentry groundwater monitoring wells and providing NMED certain critical information. This direction comprises Part 2 of this letter, and also sets forth requirements related to well construction, sampling of environmental media, field and laboratory quality assurance, and reporting.

PART 1

A. Deficiencies Common to All Three Plans

1. Appendix A of the Vadose Zone and Interim Measures Work Plans and Appendix D of the Groundwater Investigation Work Plan – Appendix A and Appendix D are exactly the same plan (about 500 pages, dated April 2004), appended to and occupying 80% or more (by number of pages) of the Vadose Zone, Interim Measures, and Groundwater Investigation Work Plans. Although the plan presented in Appendices A and D is voluminous, it is only a general plan that lays out the Permittee's internal requirements for conducting corrective action for the entire base. Furthermore, the copies of this plan provided to the NMED are missing figures (Figure 3-4), have their own appendices that are noted as "to be provided at a later date", and, in places, have outdated information (Table B7.2-1, page B-177 of Appendix B of Appendix A).

Because Appendices A and D are not specific to the Bulk Fuels Facility Spill, they do not describe in sufficient detail how, for example, project organization, data management, and quality assurance will be implemented under the Vadose Zone, Groundwater Investigation, and Interim Measures Work Plans. For example, under the project management plan, the organizational chart only shows KAFB management. The field sampling plan discusses the various types of field quality control (QC) samples that could be utilized during an investigation, but does not set forth the specific types of QC samples that should be prepared or collected for the Bulk Fuels Facility Project. Furthermore, because it is only a general plan for the entire base, the plan does not commit to the collection of QC samples for any project.

Appendices A and D must be deleted from the Vadose Zone, Groundwater Investigation, and Interim Measures Work Plans. They have little value because they do not contain the appropriate level of detail for characterization and clean up of the Bulk Fuels Facility Spill and do not

commit the Permittee to do anything. The Permittee shall revise the Vadose Zone, Groundwater Investigation, and Interim Measures Work Plans to include the appropriate level of detail and commitment on project organization, data management, and field and laboratory quality assurance.

2. Appendix B of the Vadose Zone and Interim Measures Work Plans and Appendix A of the Groundwater Investigation Work Plan – These appendices include only a 2006 NMED guidance document. The guidance is outdated and adds little, if any, value to the Vadose Zone, Interim Measures, and Groundwater Investigation Work Plans, and thus, must be deleted from all three plans. NMED guidance documents may be cited, if necessary, in future submittals.
3. Community Relations - The community relations plan is not included in Appendix A of the Vadose Zone and Interim Measures Work Plans and Appendix D of the Groundwater Investigation Work Plan. Instead, the appendices state "*Appendix I, Community Relations Plan, (to be provided at a later date)*". The Permittee shall revise the Vadose Zone, Interim Measures, and Groundwater Investigation Work Plans to include a community relations plan specific to the Bulk Fuels Facility spill. The plan must specify how the Permittee will inform the public, including the Albuquerque Bernalillo County Water Utility Authority (WUA), the City of Albuquerque, and the Veterans Administration of progress made on characterization and clean up of the Bulk Fuels Facility spill.

4. Schedules – Characterization and clean up of the Bulk Fuels Facility Spill is expected to be a large, complex, and interactive project with many deadlines that will have to be met by the Permittee. The Gantt charts provided in the Interim Measures, Groundwater Investigation, and Vadose Zone Work Plans do not contain sufficient detail and are unacceptable because they over simplify field work on the schedules as only a few tasks. A Gantt chart showing all major tasks, their dependency if any on other tasks, and their early/late starts, early/late completions and critical paths must be provided in each of the plans. NMED expects that charts of sufficient detail would likely require presentation on sheets larger than 11" x 17".

The Permittee must also submit to the NMED a Gantt chart that integrates all of the work to be done under the three plans. This Gantt chart must be submitted with the Vadose Zone Work Plan.

5. Organization - The organization plans in the Interim Measures, Groundwater Investigation, and Vadose Zone Work Plans only include mention of a project manager and a field team manager, and again reference the general site plan under Appendix A of the Vadose Zone and Interim Measures Work Plans and Appendix D of the Groundwater Investigation Work Plan. NMED notes that there are personnel mentioned by name under the Project Management Plan of Appendix A and Appendix D that have not worked for the Permittee at KAFB for the last several years.

It is likely that more than a project manager and a field team manager will be required to manage and execute a project of this size and complexity. Furthermore, it is unclear if there will be a separate field team manager for different tasks, such as conducting geophysical logging, drilling

and installation of wells, operating and maintaining soil vapor extraction (SVE) units, and sampling of environmental media. Also, the plans do not include details on the responsibilities and the qualifications of the personnel (by position) that will be involved.

Simply stating that a kick off meeting " ...will outline roles and responsibilities of all participants..." is not acceptable. It must be clearly understood in writing prior to project start who (by position) will be responsible for overseeing and conducting the myriad of events that need to happen such as field work, interpretation and management of various data, data validation, updating of the conceptual site model, communicating and reporting, and so forth. The Permittee must revise the Interim Measures, Groundwater Investigation, and Vadose Zone Work Plans to correct these deficiencies.

6. Data Management - The Data Management Plan provided in Appendix D of Appendix A of the Vadose Zone and Interim Measures Work Plans and Appendix D of Appendix D in the Groundwater Investigation Work Plan is a general plan for entire base (see Comment #1 of Section A, Part 1) and, thus, is not specific to the Bulk Fuels Facility Spill. The plan specifically fails to provide detail concerning the types of data that are to be managed, schedules for data submittals and entries into the database, how accuracy and completeness of the data will be ensured, and data availability to the NMED. The Permittee must revise the Interim Measures, Groundwater Investigation, and Vadose Zone Work Plans to correct these deficiencies.

7. Identification of and Approach to Addressing Data Gaps - Section 1.2 of each of the plans states "following previous investigations at the BFF, data gaps were identified...". Because these work plans are meant at a minimum to address data gaps identified in NMED's letter of April 2, 1010, the Permittee must list the data gaps that apply to each of the three plans, as appropriate for the topic of the plan, and indicate where in each of the plans the data gaps are addressed. The Permittee must revise the Interim Measures, Groundwater Investigation, and Vadose Zone Work Plans to include a description of the data gaps identified by the NMED and point specifically to where in each the document these data gaps are addressed.

8. Extent of Contamination and Clean Up Criteria – The extent of contamination in the various media (soil, soil vapor, groundwater) shall be based upon determining at what locations hazardous constituents occur at levels that exceed approved background concentrations. This was stated in the NMED's letter of April 2, 2010, and applies to all RCRA facilities in New Mexico that must conduct correction action.

Regarding clean up criteria, any soil contamination left in place within 20 feet of the surface must meet NMED's risk requirements for an acceptable level of risk for all hazardous constituents (10^{-5} for carcinogens and Hazards Index < 1 for noncarcinogens under a residential land-use scenario). Any soil contamination left in place at any depth must also have sufficiently low concentrations of hazardous constituents to be protective of groundwater. The Permittee may use the NMED's Soil Screening Levels in lieu of conducting a baseline risk assessment to determine the risk of contaminants.

While the use of total petroleum hydrocarbons (TPH) as an indicator of contamination is convenient for field screening, the risk to human health and the environment must be assessed through the use of laboratory analysis of hazardous constituents (e.g., benzene, toluene, ethylene dibromide (EDB), naphthalene, xylenes). The Permittee must revise the Interim Measures, Groundwater Investigation, and Vadose Zone Work Plans accordingly.

9. Site Specific Conceptual Model - The plans continue to provide what appears to be an outdated conceptual model of geologic, hydrologic, and contaminant conditions. However, regardless of the use of current data or the lack thereof, graphical representations of the conceptual model are of poor quality because the graphics are not always legible, are often too small to convey details, don't present sufficient numbers of cross-sections, and rely too much on the presentation of cartoons in lieu of detailed and accurate drawings (for example, Figures 2-8 and 2-9 in the Groundwater Investigation Work Plan).

NMED expected more in the discussion of site specific geology, as what was provided is similar to that presented in reports for the last 8 years or so. A site conceptual model encompassing the source area(s), the fuel percolation area, the light non-aqueous phased liquid (LNAPL) plume floating on groundwater, and the dissolved-phase contaminant plume in groundwater must be included in each of the plans. The model should be illustrated through the liberal use of detailed, accurate, and scaled geologic cross-sections, maps in plan view, and any other necessary graphical representations to clearly and accurately show geologic and hydrologic features, and contaminant levels.

NMED suggests that the geophysical logs, especially the electric logs, for KAFB-0115, KAFB-10624, KAFB-16 and Ridgecrest-3 wells would be useful for assisting in the interpretation of the stratigraphy of the area of interest, as these logs clearly show certain stratigraphic horizons in the vadose zone that are distinctive and widespread units ("marker beds"). The site-specific conceptual model in the Interim Measures, Groundwater Investigation, and Vadose Zone Work Plans must be revised to correct the above noted deficiencies.

10. Failure to Provide Graphics and Data Submittals – Section E of NMED's April 2, 2010 letter states "The investigation plans required under this letter shall include relevant maps and cross-sections that show concentration data for contaminants and other relevant information with supporting data posted on the maps and cross-sections in a ***legible*** (emphasis added) manner, and clearly showing which borings/wells contributed data towards construction of the maps and cross-sections and which did not. Tables including all existing soil borings, soil-gas monitoring wells, and groundwater monitoring wells, listing their surveyed location, sampling points and maximum depth of exploration shall also be included in the reports and plans. For soil-gas monitoring wells, tables and graphs shall also be included providing trends of TPH concentration versus time for the depths below ground surface of 25, 50, 150, 250, 350, and 450 feet."

Many of the figures in the Interim Measures, Groundwater Investigation, and Vadose Zone Work Plans are illegible and the required tables and graphs were not included, or were not provided in the format required. These tables and graphs are necessary to assess the adequacy of proposed

locations of borings/wells/SVE units. These tables and graphs of the required types, formats, and in legible form must be included in the revised Interim Measures, Groundwater Investigation, and Vadose Zone Work Plans.

11. Quality Assurance (QA)/Quality Control (QC) plan - The Quality Assurance Plan provided in Appendix D of Appendix A (or Appendix D of Appendix D in the GW Plan) is a general plan for the entire base (see Comment #1, Section A, Part 1 of this letter) and is not specific to the Bulk Fuels Spill Project. The Interim Measures, Groundwater Investigation, and Vadose Zone Work Plans must specify exactly what field and laboratory quality control samples are to be prepared or collected, as appropriate, and other aspects about quality control that are important to the Bulk Fuels Facility project, including the quality control targets that will be considered acceptable for each of the analytes of concern for each given media. The Permittee must revise the Interim Measures, Groundwater Investigation, and Vadose Zone Work Plans to correct these deficiencies.

12. Certification Statements - The Vadose Zone, Interim Measures, and Groundwater Investigation Work Plans and associated transmittal letters do not contain the required signed certification statement under RCRA and the New Mexico Hazardous Waste Act. Pursuant to 20.4.1.900 NMAC, incorporating 40 C.F.R. § 270.1 1 (d)(1), all plans and reports shall include a certification, signed by a chief or senior executive officer of the Facility stating:

> 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.

The revised Vadose Zone, Interim Measures, and Groundwater Investigation Work Plans or associated transmittal letters must include this signed certification.

13. Waste Management - The Waste Management Plan provided in Appendix E of Appendix A of the Vadose Zone and Interim Measures Work Plan, and Appendix E of Appendix D in the Groundwater Investigation Work Plan) is a general plan for entire base (see Comment #1, Section A, Part 1 of this letter) and is not specific to the Bulk Fuels Facility Spill project.

Investigation Derived Waste (IDW) includes, but is not limited to, general refuse, drill cuttings, excess sample material, water (e.g., decontamination, development, purge), spent materials, and used disposable equipment generated during the course of investigation, corrective action, or monitoring activities. All IDW shall be properly characterized and disposed of, and otherwise

managed in accordance with all federal, state, and local laws and regulations. The Permittee shall include a description of the anticipated IDW management process as a revision to the Interim Measures, Groundwater Investigation, and Vadose Zone Work Plans.

B. Interim Measures Work Plan

1. General Comments on Interim Measures Work Plan

The Interim Measures Work Plan was to address two major requirements of NMED's letter of April 2, 2010: 1) remove the Fuel Offloading Rack and excavate to a depth of 20 feet contaminated soil surrounding the Fuel Offloading Rack; and 2) conduct interim measures to remediate the LNAPL plume within five years. This Part (Part 1) of this letter addresses the deficiencies on addressing the first requirement; Part 2 addresses the second requirement to immediately take action to remediate the LNAPL plume floating on the groundwater. Rather than complying with NMED's April 2, 2010 direction to take immediate action vis à vis LNAPL remediation, the Permittee proposes characterization of the vadose zone for some unspecified time period, followed later by SVE. More specifically, the Interim Measures Work Plan includes: testing six wells to determine LNAPL transmissivity (Tn); conducting air sparging and multi-phase extraction pilot tests, and conducting characterization studies using PneuLog tests.

NMED emphasizes that interim measures are actions quickly taken to reduce or prevent the migration of contaminants, or reduce or prevent exposure to contaminants while long-term remedies are evaluated. While characterization studies may be useful for improving remediation efforts, or for proposing and designing a final remedy, interim measures for remediating LNAPL floating on groundwater need to be implemented immediately. Any effort to successfully remove LNAPL floating on groundwater must also involve the removal of LNAPL from the source(s) and fuel percolation areas within the vadose zone.

2. Specific Comments on Interim Measures Work Plan

1. Page 2-10, Section 2.4 – This section of the plan indicates that the Permittee is preparing a report on indoor air quality, and that the report is currently in draft. A copy of the final indoor air quality report must be provided to the NMED by **October 6, 2010**, and as indicated in the Compliance Schedule of Table 5 of this letter.
2. Page 3-1, Section 3 - Throughout Section 3 (for example, Sections 3.2, 3.2.2, 3.4.1, 3.4.2, 3.5) the Permittee states its intent to characterize and excavate only soils with "mobile LNAPL", and to leave any other contaminated soil for later remediation under the Corrective Measures Implementation Plan (CMI), which the Permittee referred to as a Corrective Measures Evaluation (CME). The term "mobile LNAPL" was coined by the Permittee and apparently means soil containing such a high concentration of fuel contamination that the soil is dripping wet with fuel.

The reasons given by the Permittee not to excavate other contaminated soils (soil without mobile LNAPL) is that a risk assessment would have to be developed separately for such soils, and the Permittee expresses its desire to delay excavation of such soils until long-term corrective actions

are initiated for the site. Due to the urgent need for action at this site, such an approach is not acceptable. The Permittee can rapidly develop target clean up goals based on NMED's risk requirements noted above, or simply use NMED's soil screening levels for hazardous constituents. Soils do not need to be dripping wet with fuel to pose a risk to human health or the environment. NMED estimates that a Corrective Measures Implementation Plan will not be approved for at least several years because of the inadequate state of site characterization today. Leaving contaminated soil in the ground that poses a significant risk to human health or the environment for what will likely be a fairly long time period before long-term corrective actions are initiated is unacceptable. As indicated in Comment #8 in Section A of Part 1 of this letter, all contaminated soil to a depth of 20 feet that represents an unacceptable risk to human health or the environment shall be excavated and removed from the Fuel Offloading Rack area.

As mentioned above, due to the urgent need to accelerate remediation, the Permittee is directed in Part 2 of this letter to implement interim measures, which includes removal of the remaining components of the Fuel Offloading Rack and excavation of contaminated soil. This work shall be completed in accordance with the Interim Measures Work Plan as modified by the requirements of this letter and in accordance with the Compliance Schedule in Table 5 of this letter.

3. Page 3-2, Section 3.2.2 – This section indicates that soil samples will be analyzed in the laboratory only if samples do not respond to a field test kit. This is an unacceptable approach. The Permittee shall use laboratory analysis all soil samples in shallow borings for TPH, VOCs, SVOCs, and lead.

4. Page 3-4, Section 3.4.2 – This section indicates that a detailed excavation plan for the Fuel Offloading Rack will be submitted to the NMED at a later date. NMED's April 2, 2010 letter intended for the Interim Measure Work Plan to be the detailed plan.

The excavation of contaminated soil and removal of structures at the Fuel Offloading Rack is a relatively simple "dig and haul" operation, and represents by far the easiest of the two major interim measures that the Permittee was directed to accomplish in NMED's letter of April 2, 2010. NMED requires the Permittee to begin excavation and removal of structures at the Fuel Offloading Rack immediately (see Section A of Part 2 of this letter).

5. Page 4-1, Section 4.2 – In part, this section states "Kirtland AFB proposes to install an IRM to remove, to the extent practicable within five years of work plan approval, mobile LNAPL present at the water table that has the potential to migrate along the water table and potentially further endanger the regional aquifer that provides drinking water for ABCWUA. Immobile LANPL and sorbed and dissolved fuel contamination in groundwater will be addressed by the future CME."

The NMED finds several unacceptable concepts related to these statements. First, as previously mentioned, NMED does not agree with the Permittee-coined terms "mobile LNAPL" and "immobile LNAPL." The point of the interim measure is to clean up contamination (LNAPL)

that poses a threat to groundwater, regardless of contaminant concentrations. Even LNAPL that is not migrating along the water table has the potential to contaminate groundwater with concentrations of hazardous constituents that are at unsafe levels for human consumption. Second, the phrase "to the extent practicable" suggests that the Permittee has already admitted defeat without even attempting to clean up the groundwater and the floating LNAPL. Third, the LNAPL floating on the water table endangers water supply wells in addition to those operated by the WUA. Lastly, like the cleaning up of contaminated soil around the Fuel Offloading Rack, the Permittee is stating its desire to delay clean up for at least several years while a final remedy through an approved CMI Plan is implemented, which is unacceptable. The Permittee must revise the Interim Measures Work Plan to remove the above-noted deficiencies.

6. *Page 4-4, Section 4.6* - In the last paragraph the Permittee states that "Routine system optimization will be performed … to maintain the highest mass extraction rate…"

The Permittee shall revise this section to explain in detail how the system will be optimized.

7. *Page 5-1, Section 5* - The Permittee states: "Vadose zone interim remedial measures will be implemented if data collected during the PneuLog profiling, supplemented by results of the concurrent vadose zone investigation, identify the presence of potentially mobile LNAPL within the vadose zone."

As mentioned above, the NMED does not agree with the Permittee-coined terms "mobile LNAPL" and "immobile LNAPL." It should be inarguable that fuel infiltrated from near or at the ground surface and has percolated through the vadose zone to groundwater. Some fuel is likely still draining to groundwater. However, hazardous constituents can still migrate to groundwater as vapor even in areas where the draining of liquid fuel to groundwater has stopped or never took place. The Permittee must revise the Interim Measures Work Plan to indicate that remediation of the vadose zone will be conducted to accomplish clean up of LNAPL floating on the groundwater, regardless of whether fuel-saturated conditions exist in the vadose zone in a given area.

8. *Page 5-2, Section 5.2* - The fourth paragraph states: "PneuLog will be performed at three locations…starting from the point(s) of release to the water table."

Figure 5-1 shows the proposed locations for PneuLog testing about 750 feet northeast of the Fuel Offloading Rack and approximately 750 feet north of the southern extent of the LNAPL plume that is floating on groundwater. According to the conceptual model provided in the Interim Measures Work Plan, the proposed locations for PneuLog testing could lead to missing the path of percolation that the fuel took to groundwater.

The Permittee must revise the Interim Measures Work Plan to include some PneuLog testing in the fuel percolation area. See Comment #4 in Section C of Part 1 of this letter for information on the area NMED has identified as the fuel percolation area. Indicate also in the Interim Measures Work Plan the significance of using three locations for PneuLog testing and explain in more

detail how the air flow potential of the geologic units will be assessed and used in the design to optimize SVE.

The Interim Measures Work Plan shall also be revised to indicate that geologic and geophysical (induction, gamma, and neutron) logs will be made for the boreholes used for PneuLog testing.

9. Figures. Figures 2-2 through 2-5 are very difficult, and in some cases impossible to read. Cross-section A-A' is not the view seen in Figure 2-8.

The Permittee shall revise the Interim Measures Work Plan to include corrected and legible figures.

C. Vadose Zone Work Plan

1. General Comments on Vadose Zone Work Plan

In NMED's letter of April 2, 2010, the Permittee was directed to submit a Vadose Zone Investigation Plan that describes the additional actions the Permittee will take to investigate vadose zone hydrology and geology, to identify and characterize the source of the releases at the Bulk Fuel Facility, and to identify the extent of soil and soil-gas contamination in the vadose zone from the surface to groundwater. The Vadose Zone Plan was to describe in detail all research, locations, depths and methods of exploration, field procedures, sampling and analysis of soil and soil gas and related quality control procedures, the results and the means by which the results are to be reported, and a schedule of the work.

The Vadose Zone Work Plan that has been submitted is inadequate to accomplish the objectives established in NMED's letter of April 2, 2010. A major reason is that the proposed borings and soil-vapor wells are located too far apart to characterize in adequate detail the contaminant and geologic conditions in the vadose zone. NMED therefore directs herein a general increase in the number of sampling points. The Permittee shall revise the Vadose Zone Work Plan to include all of the soil borings and soil-vapor well installations required by this letter.

For the convenience of providing further discussion in this letter, NMED has divided the vadose zone into five principal areas: the tank farm, pipeline, Fuel Offloading Rack, fuel percolation area, and the far field area of the soil-vapor plume. Each of these areas is discussed below.

1. Tank Farm – Contamination is known to occur from the surface to deep levels at the Tank Farm. In its letter of April 2, 2010, NMED directed that nine deep soil borings/soil-vapor wells be completed in the tank farm area; the Permittee proposed only three. Through its direction in it April 2, 2010 letter, NMED was hoping to avoid the time-consuming process of "dickering" with the Permittee on numbers of borings (and wells, to be discussed later). Nevertheless, in the interest of comity and upon further consideration, NMED agrees that by adjusting locations and completing some shallow borings, the tank farm area could be covered at least initially by five deep soil borings/soil-vapor wells and five shallow soil borings. Depending on what is found,

additional soil borings/soil-vapor wells may be needed, and NMED reserves its rights to require such additional borings, wells, or both in the future.

The Permittee shall complete the soil borings/soil-vapor wells at locations #16, 17, 19 and 20; and the soil vapor well at location #6 that are listed in Tables 1 and 2 of this letter, respectively, and shown on Figure 1 enclosed with this letter. The Permittee shall also complete shallow soil borings to a depth of at least 20 feet at locations #1 through 5, which are listed in Table 3 of this letter and shown also on Figure 1. Soil samples from the shallow borings shall be collected at depths of 0, 5, 10, 15, and 20 feet and shall be analyzed for TPH, VOCs, SVOCs, and lead.

2. *Pipeline* – The Permittee has not investigated the pipeline that runs between the tank farm, the pump house, and the Fuel Offloading Rack. In NMED's letter of April 2, 2010, the Permittee was directed to complete four deep soil borings/soil-vapor wells along the buried and exposed portions of the pipeline. The Permittee proposed none.

In lieu of completing deep soil borings/soil-vapor wells, the Permittee proposed to complete shallow borings along the buried portion of the pipeline extending south of the pump house. However, the Vadose Zone Work Plan is unclear as to the number of shallow boreholes that would be completed. Additionally, the proposed plan is inadequate because the entire length of pipeline between the tank farm and the Fuel Offloading Rack is not included in the investigation.

The Permittee shall complete the deep soil borings/soil-vapor wells at locations #4, 6, 7, 8, and 24 that are listed in Table 1 of this letter and shown on Figure 1. The Permittee shall also complete shallow borings along the entire length of the pipeline between the tank farm and the Fuel Offloading Rack, regardless of whether the pipeline runs underground or on the surface. The borings shall be spaced at intervals not to exceed 25 feet and are to be located on both sides of the pipeline. Soil samples from the shallow borings shall be collected at depths of 0, 5, 10, 15, and 20 feet. The soil samples from deep and shallow borings shall be analyzed for TPH, VOCs, SVOCs, and lead. Depending on the results, NMED may require further investigation of this area, including more and deeper borings.

3. *Fuel Offloading Rack* – The Fuel Offloading Rack is supposedly the main source of the fuel spill, but it has not been adequately characterized since discovery of the fuel leak 10 years ago. Previous investigative efforts appear to have been arbitrarily terminated once TPH concentrations were found to be less than 100 mg/kg in soil and below 100 ppmv in soil vapor. In NMED's letter of April 2, 2010, the Permittee was directed to complete a ***minimum*** of six deep soil sampling/vapor wells at the Fuel Offloading Rack to determine the full extent of contamination; the Permittee proposed four. NMED reaffirms its previous direction. The Permittee shall complete the soil borings/soil-vapor wells at locations #1, 2, 3, 4, 11, and 12 that are listed in Table 1 of this letter and shown in Figure 1.

4. *Fuel percolation area* – This area, east of the Fuel Offloading Rack, is currently believed to constitute the core of the contamination in the vadose zone, and represents the place where fuel presumably migrated to groundwater. In NMED's letter of April 2, 2010, the Permittee was

directed to complete a ***minimum*** of six deep soil sampling/vapor wells in order to significantly improve characterization of this area. This is critical to understanding the amount of fuel contamination in the vadose zone that must be remediated. The Permittee proposed to complete only two of the deep soil sampling/vapor wells that the NMED specified.

The Permittee did, however, propose an additional 3 deep soil sampling/vapor wells at locations further to the east. NMED agrees that these latter locations are necessary to properly characterize this area. Thus, to improve the understanding of the amount of fuel contamination in the vadose zone that must be remediated, the Permittee shall complete the soil borings/soil-vapor wells at locations #5, 9, 10, 21, 22, 23, 25, 26, and 27 listed in Table 1 and shown on Figure 1.

5. Far field area of Soil-Vapor plume – In its letter of April 2, 2010, NMED directed the Permittee to install six soil-vapor wells at locations north of the Fuel Offloading Rack and fuel percolation area to investigate the concentrations of hazardous constituents in soil gas that overlies groundwater in these areas. The Permittee shall complete the soil-vapor wells at locations #1, 2, 4, 3, 5, 6, 8, and 9; and the soil boring/soil-vapor well at location #24, that are listed in Tables 2 and 1, respectively, and shown on Figure 1.

6. Sampling Requirements Applicable to all Five Vadose Zone Areas - Soil samples from the deep borings shall be collected at a frequency of at least one sample every 10 feet for the first 50 feet, and at least one sample thereafter every 50 feet to total depth, and at least one sample at total depth in each boring. Each deep boring at each location shall be drilled from the surface to the water table, and each deep boring shall be completed as a permanent soil-gas monitoring well. The soil-gas monitoring wells shall be capable of yielding discrete samples of soil gas recovered from depths of 25, 50, 150, 250, 350, and 450 feet below the ground surface.

All boreholes that will have soil-vapor monitoring wells constructed in them shall be logged using induction (medium and deep), neutron, and gamma tools. Geologic logs shall also be prepared for these boreholes showing the geologic conditions from the surface to the total depth of each borehole.

The coordinates in Tables 1-3 are State Plane Coordinates in feet, NAD83. All boring/soil vapor well locations are also shown on Figure 1 enclosed with this letter.

Table 1. Borehole Locations for Soil Sampling and for Conversion to Soil-Vapor Monitoring Wells.

Location #	Easting	Northing	Characterization Purpose
1	1541119	1473793	Step out from Fuel Offloading Rack
2	1540808	1473503	Step out from Fuel Offloading Rack
3	1541123	1473310	Step out from Fuel Offloading Rack
4	1541425	1473313	Step out from Fuel Offloading Rack and piping

5	1541961	1473492	Fuel percolation area
6	1542002	1473057	Piping
7	1541794	1473061	Piping
8	1542370	1473058	Piping
9	1541898	1473276	Fuel percolation area
10	1541720	1473369	Fuel percolation area
11	1541776	1473740	Step out from Fuel Offloading Rack
12	1541658	1473505	Fuel percolation area and Fuel Offloading Rack
16	1541992	1472768	Fuel tanks
17	1542229	1472916	Fuel tanks
19	1542485	1472911	Fuel tanks
20	1542428	1472716	Fuel tanks
21	1541611	1473238	Fuel percolation area
22	1542137	1473266	Fuel percolation area
23	1542131	1473571	Fuel percolation area
24	1541620	1472955	Far Field and piping
25	1542807	1473592	Fuel percolation area
26	1542422	1473506	Fuel percolation area
27	1542360	1473808	Fuel percolation area

Table 2. Locations for Soil-Gas Monitoring Wells.

Location #	Easting	Northing	Characterization Purpose
1	1542900	1474092	Far Field
2	1543194	1474680	Far Field
3	1542306	1474093	Far Field
4	1541555	1475049	Far Field
5	1541248	1474141	Far Field
6	1542259	1472591	Far Field and fuel tanks
8	1542504	1475414	Far Field
9	1542436	1474878	Far Field

Table 3. Locations for Shallow Soil Borings in Tank Farm Area.

Location #	Easting	Northing
1	1542544	1472810
2	1542282	1472806
3	1542125	1472784
4	1542081	1472959
5	1541941	1472867

The Permittee shall revise the Vadose Zone Work Plan to incorporate the general comments and correct the deficiencies noted above.

2. Specific Comments on Vadose Zone Work Plan

1. Downhole Geophysical Logging - Section 3.2.1.1, Table 3-1, Topic 3, states "If proposed vapor monitoring points are screened in zones determined to be fine grained lithologic units adjust the screen location vapor monitoring points up or down to the nearest coarser grained unit."

Because individual fine grained or coarse grained beds do not necessarily extend laterally for any significant distances, any geophysical logs used to adjust screen locations must be generated for that particular borehole.

The Permittee must revise the Vadose Zone Work Plan to indicate the maximum distance that screened zones are to be adjusted from the required screen depths should adjustment be necessary. For screens that are to be set 100 feet apart as directed under this letter, the Permittee may adjust screens by no more than 25 feet. For screens that are to be set 25 feet apart, the Permittee may adjust screens by no more than 5 feet.
2. Seismic Refraction, Section 3.2.1.2 - NMED encourages the use of geophysical techniques; however, NMED is doubtful that seismic refraction will prove useful in this case. NMED is concerned that refraction will only detect shallow loose material near the surface, somewhat more dense subsurface material, and saturated material beginning at the water table. Although KAFB is free to conduct the refraction survey, the NMED will not allow such survey to delay completion of other work required for characterizing and cleaning up the Bulk Fuels Facility Spill.

If the Permittee proceeds with conducting the refraction survey, the following issues must be addressed in the revised work plan.

A. Explain why seismic refraction was chosen and not shallow reflection.

B. Explain how seismic refraction is expected to identify the difference between a fine-grained unit and a coarse-grained unit above the saturated zone at depths of 450-500 feet (see DQO step 5 for topic 1 on Table 3-1). Table 3-1, DQO step 6, topic 1 implies that refraction will be able to define a unit within 1-foot depth at a depth of 500 feet. These Data Quality Objectives cannot likely be achieved.

C. If the 1-foot depth is actually referring to the location of geophones, specify what the QC targets are for the seismic survey (for example, how close should the interpreted seismic interface be to the actual depth to water). Specify the site-specific conceptual model of the seismic layering. Indicate the expected thicknesses versus depth of units to be detected.

D. Explain what seismic source is planned to be used in this "noisy" environment that can carry an off-the-end shot for the 1500 foot line. Conceptually, specify how many shot points and what locations are planned per line.

E. Figure 3-1 shows 13 seismic lines that are all oriented in an east-west direction. Section 3.2.1.2 discusses orthogonal lines. Clarify how many lines are planned. Specify how the orthogonal lines will be placed, and show them on a corrected Figure 3-1. Explain why the proposed seismic lines are shown crossing buildings.

3. Resistivity, Section 3.2.1.3 – Like the refraction survey discussed in the proceeding comment, the NMED is doubtful that the IP/RES techniques will prove useful in this case. Although KAFB is free to conduct the resistivity survey, the NMED will not allow such a survey to delay completion of other work required for characterizing and cleaning up the Bulk Fuels Facility Spill.

If the Permittee proceeds with conducting the survey, the following issues must be addressed in the revised work plan.

A. As described in Section 3.2.1.3 of the plan, 56 stakes are proposed to be situated along 1,850 feet transects. This amounts to an electrode separation of about 30 feet, which would yield a shallowest apparent resistivity of the upper nominal 30 feet, with a value every 30 feet horizontally. Explain how the resistivity survey is expected to provide good results with all the surface interferences, cultural conditions, pipelines, surface topography changes, utilities, and other conditions known to be present at the site. Explain how close, for example, does the interpreted depth to groundwater need to be to meet the "Specify Limits on Decision Errors" concept on Table 3-1. Specify the QC procedures to be performed, such as calibrating to a known resistance and reciprocity tests.

B. Explain why the proposed resistivity lines are shown crossing buildings.

C. Indicate whether the geophysical parameters measured in the Sunbelt Geophysics report were taken into account in planning the resistivity investigation.

D. Specify what size transmitter is to be used to be able to measure the appropriate parameters with appropriate detail at large depths, and what electrode arrays are to be used.

E. Indicate if an analysis has been conducted modeling what MN, AB, and AB-MN spacings seem plausible based upon site-specific resistivities (estimated from resistivity or induction logs) and equipment specifications.

F. F. Indicate and explain the computer model by which the data are to be interpreted.

4. Page 3-5, Section 3.2.3 – Substitute semi-volatile organic compounds (SVOCs) for polycyclic aromatic hydrocarbons (PAHs) and add lead to the parameters to be analyzed for in soil. The Permittee must revise the Vadose Zone Work Plan accordingly.

5. Page 3-6, Section 3.2.3 – The first paragraph on this page says that soil samples containing LNAPL will not be sent to the laboratory for chemical analysis. All soil samples, including those containing LNAPL, must be sent to a laboratory and analyzed for TPH, VOCs, SVOCs, and lead. The Permittee must revise the Vadose Zone Work Plan accordingly.

6. Page 3-6, Section 3.2.4 – This section states that screens on soil-vapor monitoring wells will be set to "anticipated depths" of 25, 50, 150, 250, 350, and 450 feet. The Permittee must revise the Vadose Zone Work Plan to indicate the maximum distance that screened zones are to be adjusted from the required screen depths, should adjustment be necessary. For screens that are to be set 100 feet apart as directed under this letter, the Permittee may adjust screens by no more than 25 feet. For screens that are to be set 25 feet apart, the Permittee may adjust screens by no more than 5 feet. The Permittee must revise the Vadose Zone Work Plan accordingly.

7. Cross-section "A-A" - Cross-section A-A' location shown on Figures 2-2 through 2-5 does not correspond to Cross-Section A-A' shown in Figure 2-8. Supply the intended cross-section A-A' with data shown clearly and legibly, and with appropriate data.

D. Groundwater Investigation Work Plan

General Comments on Groundwater Investigation Work Plan

In NMED's letter of April 2, 2010, the Permittee was directed to submit a Groundwater Investigation Work Plan that describes the additional actions the Permittee will take to characterize the nature, horizontal and vertical extent, and the fate and rate of migration of the groundwater contamination. The Groundwater Investigation Work Plan was also to include construction details and the locations and depths of the groundwater monitoring wells to be installed, actions to characterize the geology and hydrogeology at and below the water table,

groundwater flow direction and velocity, field procedures, and the sampling and analysis of groundwater and related quality control. The Groundwater Investigation Work Plan was also to describe the means *(e.g.,* cross-sections, plan views) by which results would be reported after the investigation and include a schedule to complete the work.

The leading (northern) edge and the eastern and western margins of the dissolved-phase and LNAPL plumes are as yet undefined, and the nature and concentrations of contaminants in the core of each of the plumes are poorly characterized because existing wells are located too far apart (generally at distances greater than 500 feet), vertical characterization information is nonexistent, and water quality beneath the LNAPL plume has not been assessed. Additionally, the vertical extent of contaminated groundwater, key aspects of the hydrology of the groundwater (hydraulic conductivity, velocity), and the geology (horizontal and vertical characteristics) of the saturated zone are poorly defined or are unknown.

In general, the Groundwater Investigation Work Plan proposes too few wells, both in a vertical and horizontal sense, than is needed to adequately characterize the geology, hydrology, and the nature and extent of contamination over such a large area of groundwater contamination. As mentioned earlier, NMED was hoping to avoid the time-consuming process of "dickering" with the Permittee on numbers of borings and wells by providing clear and specific direction in its April 2, 2010 letter. Nevertheless, in the interest of comity and upon further consideration, NMED agrees that by adjusting locations some well locations directed in NMED's April 2, 2010 letter can be replaced with some proposed by the Permittee in the Groundwater Investigation Work Plan. NMED nonetheless directs an increase in the number of sampling points over that proposed by the Permittee, with the goal of achieving adequate site characterization more quickly to address the urgent matter of cleaning up the Bulk Fuels Facility Spill. Depending on what is found, additional wells may be needed, and NMED reserves its rights to require such additional borings, wells, or both in the future. The Permittee shall revise the Groundwater Investigation Work Plan to include all of the well installations required by this letter.

NMED has identified several other general deficiencies with the Groundwater Investigation Work Plan, which includes issues related to background water quality, vertical characterization, water quality beneath the LNPAL plume, rate of contaminant migration, cluster/nested wells, and characterization of plume cores and margins. These general deficiencies are discussed below.

1. Background Water Quality - Only two upgradient wells have been installed that potentially may yield groundwater samples that are free from contamination. Both of these wells were only recently completed; none is screened appreciably below the water table to provide vertical characterization of water quality, geology, and hydrologic conditions. The Permittee must complete the background cluster/nested wells at location #6 listed in Table 4 of this letter and shown on Figure 2 (enclosed).

2. Vertical Characterization – The plan identifies proposed wells that are to be screened at various depths below the water table as "B" and "C" wells, with the "C" wells the deepest screened well at a given cluster/nested well location. Due to urgency of this matter, the NMED

does not approve of "C" well installation being contingent on "B" well results. Given that the pumping of water supply wells is known to induce vertical gradients in groundwater, can cause significant components of vertical flow in the vicinity of such wells, and draws water preferentially from productive zones that may be deeper than the water table, vertical characterization of groundwater quality, hydrology, and geology is required for all well installations specified by this letter.

3. Water Quality Beneath the LNAPL Plume - Although the lack of water quality information was identified specifically by the NMED as a data gap, the Groundwater Investigation Work Plan states that groundwater at well locations within the boundaries of the LNAPL plume will not be sampled and analyzed. This is an unacceptable approach. Knowledge of water quality beneath the LNAPL plume is crucial to understand the full extent and magnitude of the groundwater contamination.

4. Rate of Contaminant Migration - Although a critical question to be answered, it was not clear in the Groundwater Investigation Work Plan if the Permittee has a plan to address the rate of migration of either the dissolved-phase or LNAPL contaminant plumes, and in particular, the time it would take for the dissolved-phase plume to reach surrounding well fields. The Permittee must clarify this point.

5. Cluster versus Nested Wells – The NMED has no objections to the use of nested wells instead of cluster wells, provided the nested wells are properly constructed. However, in this case the NMED will not accept wells that are constructed with 3-inch diameter casing and screens. Three-inch diameter casing and screens are inappropriate for constructing groundwater monitoring wells that will be installed to depths of 500 feet or more. The Permittee shall design wells to be constructed in cluster or nested configurations using casing and screen that are no smaller than 5 inches in diameter. The borehole surrounding the well casing for a nested or cluster well must be of sufficient diameter to allow for an adequate annular space between the borehole and well casing and screen. The annular space must be of sufficient size to allow for proper construction of filter packs and seals, and for the installation of grouting (see the groundwater monitoring well construction requirements set forth in Part 2 of this letter).

6. Characterization of Plume Cores – The dissolved-phase and LNAPL plumes extend off base to nearly 0.9 to 0.5 miles, respectively from the presumed source, yet a total of only eight wells currently exist off-base to characterize the cores of both plumes. Of these eight wells, this includes two wells where groundwater has not been sampled for water quality in the past and one well that was only very recently installed at Bullhead Park for which no water quality data has been submitted to the NMED.

In NMED's letter of April 2, 2010, the Permittee was directed to install groundwater monitoring wells at a ***minimum*** of eight additional locations to characterize the concentrations of contaminants, and the geologic and hydrologic conditions that exist off-base in the plume cores; instead, the Permittee proposed only four.

To achieve the objective of providing initial plume-core characterization, the Permittee shall install the groundwater monitoring wells at locations #11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, and 23 listed in Table 4 and shown on Figure 2.

7. Characterization of Plume Margins – Only five existing wells define the edge of the plume off-base (including one well recently installed). In NMED's letter of April 2, 2010, the Permittee was directed to install groundwater monitoring wells at a ***minimum*** of eight additional locations to characterize the concentrations of contaminants, and the geologic and hydrologic conditions that exist off base along the plume margins; instead, the Permittee proposed five.

To adequately provide initial plume-edge characterization, the Permittee shall install the groundwater monitoring wells at locations #1, 2, 3, 4, 5, 7, 8, 9, 10, 24, 25, 26, 27, and 28 that are listed in Table 4 and shown on Figure 2.

Three groundwater monitoring wells shall be installed at different depths at each of the well locations listed in Table 4. The screen depths shown in Table 4 are distances (in feet) that the top of the screens shall be set below the water table, except wells screened across the water table (those with screen depths of zero in Table 4) may have screens that extend above the water table. Screen lengths for wells shall not exceed 15 feet, with the exception that wells screened across the water table shall have screens 20 feet long, with no more than 15 feet of screen length situated below the water table.

The geologic conditions encountered from the surface to the total depth of the borings at each well location shall be logged. Boreholes completed for well installations at all locations shall also be logged using induction (medium and deep), neutron, and gamma (large crystal) tools. Geophysical and geologic logging at a given cluster well location is required only in the well at the location having the deepest screened interval.

Coordinates in Table 4 are State Plane Coordinates in feet, NAD83. All of the locations listed in Table 4 are also shown on Figure 2 enclosed with this letter.

Table 4. Well locations and screen depths relative to the water table.

Location #	Easting	Northing	Screen Depths	Characterization Purpose
1	1542189	1476725	0, 15, 40	Plume margin, deep characterization
2	1541984	1476042	0, 15, 40	Plume margin, deep characterization
3	1543703	1476600	0, 15, 40	Plume margin, deep characterization
4	1543372	1475065	0, 15, 40	Plume margin, deep characterization
5	1543643	1477939	0, 15, 85	Plume margin, deep characterization
6	1541430	1472370	15, 40*	Background water quality, deep characterization

7	1542812	1473601	0, 15, 40	Plume margin, deep characterization
8	1542722	1477726	0, 15, 40	Plume margin, deep characterization
9	1543054	1477788	0, 15, 40	Plume margin, deep characterization
10	1543774	1477304	0, 15, 40	Plume margin, deep characterization
11	1541774	1473718	0, 15, 85	Plume core, deep characterization
12	1542362	1473801	0, 15, 85	Plume core, deep characterization
13	1542305	1474340	15, 85*	Plume core, deep characterization
14	1542736	1474715	0, 15, 85	Plume core, deep characterization
15	1542860	1475860	0, 15, 85	Plume core, deep characterization
16	1542189	1475207	0, 15, 85	Plume core, deep characterization
17	1541731	1473291	0, 15, 85	Plume core, deep characterization
18	1542203	1474071	0, 15, 85	Plume core, deep characterization
19	1542565	1475360	0, 15, 85	Plume core, deep characterization
20	1542535	1475975	0, 15, 85	Plume core, deep characterization
21	1543199	1475767	0, 15, 85	Plume core, deep characterization
22	1543068	1476494	0, 15, 85	Plume core, deep characterization
23	1541968	1474648	0, 15, 85	Plume core, deep characterization
24	1541682	1474703	15, 40*	Plume margin, deep characterization
25	1541025	1474360	15, 40*	Plume margin, deep characterization
26	1540407	1474016	15, 40*	Plume margin, deep characterization
27	1543712	1475683	15, 40*	Plume margin, deep characterization
28	1543364	1477684	0, 15, 40	Plume margin, deep characterization

* - water table well already exists

The Permittee shall revise the Groundwater Investigation Work Plan to incorporate the general comments and correct the deficiencies noted above.

Specific Comments on Groundwater Investigation Work Plan

1. Page 3-6, Section 3.3.4 and Figure 3-3 – Well construction details are missing, as the wrong figure was submitted for a well construction diagram in the Work Plan. The Permittee shall revise the Groundwater Investigation Work Plan to correct the deficiency noted above.

2. *Page 3-4, Section 3.3.2* – This section states that "NMED will be notified regarding any deviations in well constructions per Section 4.0." Aside from the fact that there is no Section 4.0, well construction and any changes thereto must be approved in advance by the NMED. E-mail or telephone approval may suffice to facilitate in-field decision-making. The Permittee shall revise the Groundwater Investigation Work Plan accordingly.

3. *Page 3-5, Section 3.3.3* – Soil samples shall be collected at well locations #11, 12, 17, and 18 listed in Table 4 from the deepest borehole at each location. The samples shall be collected at a frequency of at least one sample every 10 feet for the first 50 feet of the borehole, then at least one sample every 50 feet to the bottom of the borehole, and at total depth of the borehole. The soil samples must be analyzed in the laboratory for TPH, VOCs, SVOCs, and lead. The Permittee shall revise the Groundwater Investigation Work Plan accordingly.

4. *Page 3-7, Section 3.3.5* – This section indicates that wells screened below the water table will be considered by the Permittee to be "piezometers" (normally for measuring only hydraulic head). Groundwater samples must be collected from all wells, regardless if the wells are screened at the water table or deeper, and all samples must be analyzed for TPH and hazardous constituents. The Permittee shall revise the Groundwater Investigation Work Plan accordingly.

5. *Page 3-7, Section 3.3.5* – This section states that wells located within the area of the floating LNAPL will not be developed. All wells, including those within the LNAPL plume, shall be properly developed to provide representative water samples. The Permittee shall revise the Groundwater Investigation Work Plan accordingly.

6. *Page 3-7, Section 3.3.6* – This section states that groundwater at wells located within the area of the floating LNAPL will not be sampled. Groundwater in all wells will be sampled, including those within the LNAPL plume. The Permittee shall revise the Groundwater Investigation Work Plan accordingly.

7. *Page 3-7, Section 3.3.6* – For analysis of groundwater samples, add lead and substitute SVOCs for PAHs, and dissolved iron and dissolved manganese for iron and manganese, respectively. Samples must not be filtered, except for sample fractions for dissolved iron and dissolved manganese.

Add alkalinity and pH to the list of field parameters.

The Permittee shall revise the Groundwater Investigation Work Plan accordingly.

8. *Page 3-6, Section 3.3.4* - It is not clear how many wells are actually proposed because wells KAFB-10629, KAFB-10630, and KAFB-10638 are not listed on Table 3-2 of the Groundwater Investigation Work Plan. The Permittee must clarify or resolve this discrepancy in a revision to the Groundwater Investigation Work Plan.

9. *Page 3-1, Section 3.1.1* - Indicate what geophysical logs will be run and at what stage of the borehole/well installation process. The discussion should be included in Section 3.3 instead of Section 3.1.1. The Permittee shall revise the Groundwater Investigation Work Plan accordingly.

10. *Page 3-2, Section 3.3.1* - See specific Comments #2 and 3 for the Vadose Zone Work Plan regarding surface geophysical surveys.

PART 2

A. Direction to Conduct Interim Measures and Other Actions

In NMED's letter of April 2, 2010, the Permittee was informed that the NMED has determined that the Bulk Fuel Facility Spill poses a threat to human health and the environment, and furthermore, endangers the groundwater resource – including water supply wells – relied upon by the WUA for delivery of safe drinking water to its customers. The contamination also threatens KAFB and the Veterans Administration ("VA") Hospital water-supply wells. The large extent of this contamination and its proximity to water supply wells requires that urgent action be taken.

The NMED has estimated that nearly 8 million gallons of fuel have been released at the Bulk Fuels Facility. The Permittee is operating four SVE units on the Permittee's property; however, these soil-vapor extraction units will not clean up the contamination thus far known to occur from the Bulk Fuels Facility Spill in a reasonable time frame. Because the Permittee's Interim Measures Work Plan does not contain any interim measures that could be implemented immediately, the NMED herein is directing the Permittee to:

1. conduct additional soil vapor extraction,
2. improve the Operation and Maintenance Plan for the SVE units,
3. begin immediate excavation of contaminated soil at the Fuel Offloading Rack,
4. provide an estimate of the contaminant migration rate,
5. install sentry wells,
6. log existing wells, including using geophysical methods,
7. submit critical data to the NMED, and
8. provide adequate funding to the WUA for sampling and analysis of well water.

SVE and these other actions must be initiated or completed, as appropriate, by the deadlines indicated in this letter and in the Compliance Schedule in Table 5. Additionally, this letter specifies minimum requirements that the Permittee must meet regarding well installations, well development, sampling, geophysical logging, preparing geologic logs, notification of activities, field and laboratory quality control, and reporting.

1. Soil Vapor Extraction

a. The Permittee has demonstrated that SVE has worked to remove contaminate vapors from the vadose zone. The Permittee shall install and operate additional SVE units at the following locations:

i. No later than **October 6, 2010** (Table 5) at existing groundwater monitoring wells KAFB-3411, KAFB-10614, and KAFB-10624, which are located in the core of the vadose zone contamination.
ii. No later than **November 8, 2010** (Table 5) at soil boring/soil-vapor monitoring well locations #4, 5, 9, 10, 11, 12, and 21 that are listed in Table 1 of this letter. These wells, to be located in the core of contamination, should be designed to serve both as vapor extraction wells and as soil-vapor monitoring wells. The Permittee must also conduct geologic logging and borehole geophysical logging at each location. The Permittee shall comply with the collection and analysis of soil samples as specified in Part 1 of this letter for well installations.
iii. No later than **October 6, 2010** (Table 5) or 60 days after required access is granted, which ever is later, at existing groundwater monitoring wells KAFB-10617 and 10618 which are located at the northern extent of the LNAPL plume.
iv. No later than **November 8, 2010** (Table 5) or 60 days after required access is granted, which ever is later, at existing groundwater monitoring wells KAFB-10610 which is located at the northern extent of the 1-foot thick layer of LNAPL plume.
v. No later than **November 8, 2010** (Table 5) or 60 days after required access is granted, which ever is later, locations #3, 8 and 9 on Table 2 of this letter shall be made ready for conducting future soil vapor extraction by completing soil-vapor monitoring/extraction wells at this location. The Permittee must conduct geologic logging and borehole geophysical logging at this location and shall comply with the collection and analysis of soil samples as specified in Part 1 of this letter for well installations.

b. The Permittee shall continue to operate SVE units at the locations of the four existing SVE units (located at the Fuel Offloading Rack, KAFB-1065, KAFB-1066, and KAFB-1068).

Until such time that the interim measures plan is approved by the NMED, the Permittee shall continue to operate all SVE units 24 hours per day, 7 days a week, except when necessary to perform maintenance or repairs. If maintenance or repairs are necessary, the maintenance or repairs shall be completed as quickly as practicable, and the unit returned to service immediately after maintenance or repairs are completed. Any maintenance or repairs that will take more than 3 calendar days shall be reported in writing to the NMED within 24 hours of discovery that the maintenance or repairs will take more than 3 days. The Permittee shall explain in the report why the maintenance or repairs will take more than 3 calendar days and why the delay is beyond the control of the Permittee.

The SVE units shall be similar to those currently in use for the Bulk Fuels Facility Spill and shall be capable of extracting soil vapor at a minimum flow rate of 27 SCFM. The SVE units shall also average over a period of 12 months an operating efficiency (operating time relative to down time) of no less than 85%. The SVE units shall meet the regulatory requirements for air emissions enforced by the City of Albuquerque Environmental Health Department. The Permittee is responsible for obtaining all necessary permissions and permits to construct and operate the SVE units.

If the City of Albuquerque Environmental Health Department will not issue an air permit to operate the SVE units specified by this letter, the Permittee shall immediately notify the NMED in writing and shall substitute a different technology for conducting SVE and treating emissions that will meet the regulatory requirements enforced by the City of Albuquerque Environmental Health Department and the deadlines set forth in this letter in the Compliance Schedule shown in Table 5.

2. Operation and Maintenance (O&M) Plan

The Permittee shall modify its O&M Plan to reduce down time of SVE units by maintaining in inventory commonly-needed spare parts for maintenance and repairs, and keeping a spare engine available for SVE units that suffer catastrophic engine failures. The spare parts and engine shall be maintained by the Permittee in inventory by **September 7, 2010**. The Permittee shall provide NMED with a written list of the spare parts and spare engine kept in inventory by **October 6, 2010** (Table 5).

3. Excavation of Soil and Removal of Fuel Offloading Rack

The Permittee shall by **October 6, 2010** (Table 5) begin removal of the remaining components of the Fuel Offloading Rack and excavation of contaminated soil to 20 feet. The excavation of soil and removal of the Fuel Offloading Rack shall be completed by **October 6, 2011** (Table 5), and a report on completion of the work submitted to the NMED by **January 15, 2012** (Table 5). Any soil contamination left in place must meet NMED's requirements for clean up (see Comment # 8 of Section A of Part 1 of this letter). The Permittee may use direct push sampling and field analysis to help determine which soils require excavation. However, laboratory analysis shall be conducted to determine the concentrations of hazardous constituents in soil for the purpose of defining the final extent of excavation, for risk assessment, and for waste determinations.

Soil shall be sampled to determine whether all contaminated soil that poses an unacceptable risk to human health or the environment has been removed to a depth of at least 20 feet. Soil samples shall be analyzed in the laboratory for TPH, VOCs, SVOCs, and lead, and collected on all sides and the bottom of the excavation at a spacing not to exceed 25 feet.

4. Estimates of Contaminant Migration Rate

The Permittee must provide NMED by **September 7, 2010** (Table 5) with calculations showing the estimated velocity of and the travel time for the dissolved-phase contaminant plume to first reach the closest well in the Ridgecrest well field, the Veteran Administration (VA) Hospital Well, and KAFB production wells KAFB-3, KAFB-15, and KAFB-16. The calculations shall consider the direction and gradient of groundwater flow, and the geologic and hydrologic properties of the aquifer under a worse-case scenario. The Permittee shall provide the source of all information used to support the required calculations.

5. Installation of Sentry Wells

a. The Permittee must install groundwater monitoring wells (water table, intermediate, and deep wells referred to as A, B, and C wells) at location #28 of Table 4 of this letter, north of the leading edge of the dissolved-phase contaminant plume, by no later than **November 8, 2010** (Table 5) or 90 days after required access is granted, which ever is later. These wells will serve as sentry wells for the northern extent of the dissolved-phase plume.
b. The Permittee must install B and C groundwater monitoring wells at existing well locations KAFB-10613 and KAFB-1064, near the V.A. Hospital, by no later than **November 8, 2010** (Table 5) or 90 days after required access is granted, which ever is later. These wells will serve as sentry wells for the V.A. Hospital.
c. The Permittee must install A, B, and C groundwater monitoring wells at location #3 listed in Table 4 of this letter, on the east edge of the dissolved-phase contaminant plume, by no later than **November 8, 2010** (Table 5) or 90 days after required access is granted, which ever is later. These wells will serve as sentry wells for the northeastern extent of the dissolved-phase plume.
d. The Permittee must install A, B, and C groundwater monitoring wells at location #1 listed in Table 4 of this letter, on the west edge of the dissolved-phase contaminant plume no later than **November 8, 2010** (Table 5) or 90 days after required access is granted, which ever is later. These wells will serve as sentry wells for the northwestern extent of the dissolved-phase plume.
e. The Permittee must also conduct geologic and borehole geophysical logging of each well discussed in paragraphs a-d of this section. Geologic logging must be completed during the drilling of the boreholes; geophysical logging must be completed within 30 days of well completion (Table 5). Copies of the geologic and geophysical logs must be provided to the NMED by the submittal dates for quarterly reports specified in NMED's letter of June 4, 2010.

Wells constructed in cluster or nested configuration must meet the requirements set forth in Comment # 5 of Section D of Part 1 of this letter. Groundwater samples shall be collected and analyzed in a laboratory at a quarterly frequency from each sentry well in accordance with the direction in NMED's letter of June 4, 2010, and directions under this letter.

6. Geophysical logging of Existing Wells

The Permittee must conduct borehole geophysical logging (medium and deep induction, gamma, and neutron) at all existing groundwater monitoring wells. Copies of the geophysical logs must be provided to the NMED by **October 6, 2010** (Table 5).

7. Submitting Critical Data to NMED

The Permittee failed to provide certain critical information required in NMED's April 2, 2010 letter. The Permittee must provide the following information to the NMED by **September 7, 2010** (Table 5):

i. tables in electronic format (Excel™) showing the locations (x, y, z), sampling points, and maximum depths of all soil borings and vapor and groundwater monitoring wells;
ii. Survey plats for all wells.
iii. tabulated data in electronic format (Excel™) and graphs showing hydrocarbons (HC) and trends of major hazardous constituent (such as benzene, toluene, ethylene dibromide, xylenes, naphthalene, ethylbenzene, and lead) concentrations versus time for soil vapor for each extraction and each soil-vapor and groundwater monitoring well, as applicable.
iv. tabulated data in electronic format (Excel™) and graphs showing trends of TPH and major hazardous constituent (such as benzene, toluene, ethylene dibromide, xylenes, naphthalene, ethylbenzene, and lead) concentrations versus time for groundwater for each groundwater monitoring well.
v. Cross-sections showing the geology of the site drawn to a horizontal scale of 1 inch equals 50 feet, a vertical scale of 1 inch = 50 feet, and along the orientations A-A', B-B', C-C', and D-D' as shown on Figure 3 enclosed with this letter.
vi. Cross-sections showing the geology of the site drawn to a horizontal scale of 1 inch equals 300 feet, a vertical scale of 1 inch = 50 feet, and along the orientations A-A', B-B', C-C', and D-D' as shown on Figure 4 enclosed with this letter.
vii. Cross-sections showing concentrations of major hazardous constituents in soil, drawn to a horizontal scale of 1 inch equals 50 feet, a vertical scale of 1 inch = 50 feet, and along the orientations A-A', B-B', C-C', and D-D' as shown on Figure 3 enclosed with this letter.
viii. Cross-sections showing concentrations of major hazardous constituents in soil vapor, drawn to a horizontal scale of 1 inch equals 50 feet, a vertical scale of 1 inch = 50 feet, and along the orientations A-A', B-B', C-C', and D-D' as shown on Figure 3 enclosed with this letter.
ix. Cross-sections showing concentrations of major hazardous constituents in groundwater, drawn to a horizontal scale of 1 inch equals 300 feet, a vertical scale of 1 inch = 50 feet, and along the orientations A-A', B-B', C-C', and D-D' as shown on Figure 4 enclosed with this letter.

8. Sampling and Analysis of Water Production Wells

NMED understands that the Permittee is providing funding to the WUA to analyze groundwater samples from WUA water-supply wells threatened by contamination originating from the Bulk Fuels Facility Spill. NMED has also become aware that the analytical method used by the WUA to test for ethylene dibromide (EDB) is 524.2 rather than Method 504.1, the latter which is normally used for purposes of determining compliance with Safe Drinking Water Act.

NMED does not consider analysis by Method 524.2 to be sufficiently sensitive to provide adequate early-warning protection for the WUA wells. The Permittee shall continue to collaborate with the WUA to ensure that water quality is safe for human consumption, but will also ensure the samples are analyzed by Method 504.1. The Permittee shall provide copies of the laboratory results to the NMED in quarterly reports in accordance with the reporting requirements of NMED's letter of June 4, 2010.

B. Technical Requirements for Conducting Interim Measures

1. Notification of Sampling and other Field Activities

The Permittee shall notify the NMED in writing of field sampling or other field activities undertaken in accordance with the requirements of this letter, and shall provide the NMED the opportunity to collect split samples upon request by the NMED. For such sampling or other field activities, the Permittee shall provide the NMED with as much advance notice as is practicable, but no less than 15 days prior to the conduct of such sampling. The Permittee shall notify the NMED in writing a minimum of 15 days prior to the implementation of the Interim Measures, Groundwater Investigation and Vadose Zone Work Plans. Notification of sampling or other field activities may be made by email, fax, or letter.

2. Soil-Vapor Well Construction

Soil-vapor monitoring wells shall be designed and constructed in a manner that will yield high-quality samples. Soil vapor wells shall not be installed with the use of any fluids. Soil vapor wells may be completed by backfilling with native materials. The Permittee shall not sample the well before the expiration of the 24-hour equilibration period following completion of installation. Information on the design and construction of soil-vapor monitoring wells shall be recorded as for groundwater monitoring wells.

3. Groundwater Monitoring Well Construction

Groundwater monitoring wells shall be designed and constructed in a manner that will yield high quality samples, ensure that the well will last the duration of the project, and ensure that the well will not serve as a conduit for hazardous constituents to migrate between different stratigraphic

units or aquifers. The design and construction of groundwater monitoring wells shall comply with the guidelines established in various RCRA guidance, including, but not limited to:

EPA, *RCRA Groundwater Monitoring Technical Enforcement Guidance Document*, OSWER-9950.1, September, 1986; and

Aller, L., Bennett, T.W., Hackett, G., Petty, R.J., Lehr, J.H., Sedoris, H., Nielsen, D.M., and Denne, J.E., *Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells*, EPA 600/4-89/034, 1989.

1. Drilling Methods

The Permittee shall abide by the following conditions:

1. Drilling shall be performed in a manner that minimizes impacts to the natural properties of the subsurface materials;
2. Drilling shall be performed in a manner that contamination and cross-contamination of groundwater and aquifer materials is avoided;

1. The drilling method shall allow for the collection of representative samples of rock, unconsolidated sediment, and soil;
2. The drilling method shall allow the Permittee to determine when the appropriate location for the screened interval(s) has been encountered;
3. The drilling method shall allow for the proper placement of a filter pack and annular sealant for each monitored zone, and the borehole diameter shall be at least four inches larger in diameter than the nominal diameter of the well casing and screen to allow adequate space for emplacement of the filter pack and annular sealants;
4. The drilling method shall also allow for the collection of representative groundwater samples; and
5. Drilling fluids, including air, shall be used only when minimal impact to the surrounding formation and groundwater can be ensured.

All drilling equipment shall be in good working condition and capable of performing the planned tasks. Drilling rigs and equipment shall be operated by properly trained crews. Drilling equipment shall be properly decontaminated before initiation of drilling for each boring. Precautions shall be taken to prevent the migration of contaminants between geologic, hydrologic, or other identifiable zones during drilling and well installation activities.
The drilling and sampling shall be conducted under the direction of a qualified engineer or geologist. Known site features and/or site survey grid markers shall be used as references to locate each boring prior to surveying the location.

2. Well Construction Materials

When selecting construction materials, the primary concern shall be selecting well construction materials that will not contribute to or remove hazardous waste or constituents from groundwater

samples. Other factors to be considered include the tensile strength, compressive strength, and collapse strength of the materials; the length of time the monitoring well will be in service; and the material's resistance to chemical and microbiological corrosion.

3. Design and Construction of Screens and Filter Packs

Screens and filter packs shall be designed to allow accurate sampling of the saturated zone that the well is intended to sample, minimize the passage of formation materials (turbidity) into the well, and ensure sufficient structural integrity to prevent the collapse of the intake structure. The filter pack shall be installed in a manner that prevents bridging and particle-size segregation. Filter packs shall be installed by the tremie pipe method. At least two inches of filter pack material shall be installed between the screen and the borehole wall, and two feet of filter pack material shall extend above the top of the screen. A minimum of six inches and a maximum of two feet of filter pack material shall also be placed under the bottom of the screen. The precise volume of filter pack material required shall be calculated and recorded before placement, and the actual volume used shall be determined and recorded during construction. Any significant discrepancy between the calculated and actual volume shall be explained. Prior to installing the filter pack annular seal, a one to two-foot layer of chemically inert fine sand shall be placed over the filter pack to prevent the intrusion of annular sealants into the filter pack.

4. Design and Construction of Annular Seals

The annular space between the casing and the borehole wall shall be properly sealed to prevent cross-contamination. The materials used for annular sealants shall be chemically inert with respect to the highest anticipated concentration of chemical constituents expected in the groundwater. The precise volume of annular sealant required shall be calculated and recorded before placement, and the actual volume shall be determined and recorded during construction. Any significant discrepancy between the calculated volume and the actual volume shall be explained.

During construction, an annular seal shall be placed on top of the filter pack. This seal shall normally consist of a high solids (10 to 30 percent) bentonite material in the form of bentonite pellets, granular bentonite, or bentonite chips. The seal shall be placed in the annulus through a tremie pipe. A tamping device shall be used to ensure that the seal is emplaced at the proper depth. The bentonite seal shall be placed above the filter pack with a minimum of two-foot vertical thickness. The bentonite seal shall be allowed to completely hydrate in conformance with the manufacturer's specifications prior to installing the overlying annular grout seal. A grout seal shall be installed on top of the filter pack seal. The grout shall be placed into the annular space by the tremie pipe method, from the top of the filter pack annular seal to within a few feet of the ground surface; however, the grout shall be installed at intervals necessary to allow it time to cure and not damage the filter pack or filter pack annular seal during installation of the grout. The grout seal shall be allowed to cure for a minimum of 24 hours before the concrete surface pad is installed. All grouts shall be prepared in accordance with the manufacturer's specifications.

5. Surface Completion Methods

Monitoring wells may be completed either as flush-mounted wells, or as above-ground completions. A surface seal shall be installed over the grout seal and extended vertically up the well annulus to the land surface. The lower end of the surface seal shall extend a minimum of one foot below the frost line to prevent damage from frost heaving. The composition of the surface seal shall be neat cement or concrete. In above-ground completions wherein the well casing rises or sticks up above ground level, a three-foot square by four-inch thick concrete surface pad shall be installed around the well immediately after the protective casing is installed. The surface pad shall be sloped so that drainage will be off the pad and away from the protective casing. In addition, a minimum of one inch of the finished pad shall be below grade or ground elevation to prevent washing and undermining by soil erosion.

Protective casing with a locking cover shall be installed around the well casing (stickup or riser) to prevent damage or unauthorized entry. The protective casing shall be anchored in the concrete surface pad below the frost line and extend at least several inches above the casing stickup. A weep hole shall be drilled into the protective casing just above the top of the concrete surface pad to prevent water from accumulating and freezing inside the protective casing. A cap shall be placed on the well riser to prevent the entry of foreign materials into the well, and a lock shall be installed on the cover of the protective casing to provide security against tampering. If a well is located in an area that receives vehicular traffic, a minimum of three bumper guards consisting of steel pipes three to four inches in diameter and a minimum of five-feet in length shall be installed next to the concrete surface pad. The bumper guards shall be installed to a minimum depth of two feet below the ground surface in a concrete footing and extend a minimum of three feet above ground surface. The pipes that form the bumper guards shall be filled with concrete to provide additional strength, and shall be painted a bright color to make them readily visible.
If flush-mounted completions are required (e.g., in active roadway areas), a protective structure such as a traffic-rated utility vault or meter box shall be installed around the casing. In addition, measures should be taken to prevent the accumulation of surface water in the protective structure and around the well intake. These measures shall include outfitting the protective structure with a steel lid or manhole cover that has a rubber seal or gasket, and ensuring that the bond between the cement surface seal and the protective structure is watertight. A lock shall be installed on the lid or cover of the protective structure to prevent unauthorized access to the well.

6. Well Development Methods

All monitoring wells shall be developed to create an effective filter pack around the screen, correct damage to the formation caused by drilling, remove residual drilling mud or other drilling additives, if present, and fine particles from the formation near the borehole, and assist in restoring the original water quality of the aquifer in the vicinity of the well. Monitoring wells shall be developed until the column of water in each well is free of visible sediment, and the pH, temperature, turbidity, and specific conductance have stabilized to within 10%. If a well is pumped dry, the water level shall be allowed to sufficiently recover before the next development period is initiated.

If water is introduced to a borehole during drilling and completion, then at minimum the same volume of water shall be removed from the well during development. In addition, the volume of water withdrawn from or introduced into a well during development shall be recorded. Well development must be completed within 30 days of installation.

4. Surveying Requirements for Groundwater Monitoring and Soil-Vapor Wells

The horizontal and vertical coordinates of the measuring point at the top of each monitoring well casing and the ground surface elevation at each monitoring well location shall be determined by a registered New Mexico professional land surveyor or licensed Professional Engineer. Horizontal coordinates shall be measured in accordance with the State Plane Coordinate System. Horizontal positions shall be measured to the nearest 0.1 foot, and vertical elevations shall be measured to the nearest 0.01 foot.

5. Well Completion Reports

For each monitoring well, the Permittee shall submit to the NMED a completion summary report which shall include a well construction log and diagram, a geologic log, and a well development log. The report for each well shall be submitted in accordance with the quarterly schedule set forth in NMED's letter of June 4, 2010.

6. Well Construction Diagrams and Logs

Information on the design, construction, and development of each monitoring well shall be recorded. Construction diagrams and logs shall include the following information:

1. Well, boring name/number;
2. Date/time of construction;
3. Borehole diameter and casing diameter;
4. Surveyed location coordinates;
5. Total depth, expressed both as depth below ground surface and elevation above sea level;
6. Name of drilling contractor;
7. Casing length;
8. Casing materials;
9. Casing and screen joint type;
10. Screened intervals, expressed both as depth(s) below ground surface and elevation(s) above sea level;
11. Screen materials;
12. Screen slot size and design;
13. Filter-pack material and size;
14. Filter-pack volume (calculated and actual);
15. Filter-pack placement method;

16. Filter-pack interval(s), expressed both as depth(s) below ground surface and elevation(s) above sea level;
17. Annular sealant composition;
18. Annular sealant placement method;
19. Annular sealant volume (calculated and actual);
20. Annular sealant interval, expressed both as depth below ground surface and elevation above sea level;
21. Surface sealant composition;
22. Surface seal placement method;
23. Surface sealant volume (calculated and actual);
24. Surface sealant interval, expressed both as depth below ground surface and elevation above sea level;
25. Surface seal and well apron design and construction;
26. Development procedure and turbidity measurements;
27. Well development purge volume(s) and stabilization parameter measurements;
28. Type, design, and construction of protective casing;
29. Type of cap and lock;
30. Ground surface elevation above sea level;
31. Survey reference point elevation above sea level on well casing;
32. Top of casing elevation above sea level;
33. Top of protective steel casing elevation above sea level;
34. Drilling method(s); and
35. Types, quantities, and dates/times that additives were introduced, if any.

7. Measurement of Groundwater Levels

Groundwater levels shall be measured in all monitoring wells associated with the Bulk Fuels Facility Spill within 72 hours from the start of monitoring the water level in the first well. Groundwater levels shall be obtained prior to purging for any sampling event. Measurement data and the date and time of each measurement shall be recorded on a field log. The depth to groundwater shall be measured to the nearest 0.01 foot. The depth to groundwater shall be recorded relative to the surveyed well casing rim.

8. Sampling of Environmental Media

Sampling of environmental media (groundwater, soil, and soil vapor) shall comply with the requirements set forth in NMED's letter of June 4, 2010, and in accordance with the additional requirements provided herein.

1. Soil Sampling Requirements

Relatively undisturbed discrete soil and rock samples shall be obtained during the advancement of each boring for the purpose of logging and analytical testing. A split-barrel sampler lined with brass sleeves, a coring device, or other method approved in advance by the NMED shall be used to obtain samples during the drilling of each boring.

Soil samples are subject to the same field quality assurance, laboratory quality assurance, data validation, and reporting requirements as for groundwater and soil-vapor samples; including requirements to collect or prepare, as appropriate, and analyze field quality control samples. Soil samples collected for the purpose of analyzing for VOCs and SVOCs shall not be mixed to homogenize samples for any reason.

2. Groundwater Sample Collection

Groundwater samples shall be obtained within eight hours of the completion of well purging. Groundwater in monitoring wells with low recharge rates and that purge dry shall be sampled when the water level in the well has recovered sufficiently to collect the required samples. Sample collection methods shall be documented in field monitoring logs. Samples shall be placed into appropriate clean containers. Decontamination procedures shall be established and, implemented, for nondedicated water sampling equipment.

The Permittee shall obtain groundwater samples for dissolved metals analysis using disposable in-line filters with a 0.45 micron mesh size.

9. Field Quality Control

Field duplicates shall consist of two samples collected sequentially. Field duplicate samples shall be collected and analyzed at a frequency of at least 10 percent of the total number of environmental samples submitted for analysis. At a minimum, one duplicate sample per sampling event shall always be collected and analyzed.

Field blanks shall be prepared and analyzed at a frequency of no less than one per day. Field blanks shall be generated by filling sample containers in the field with deionized water and submitting the field blank, along with the groundwater samples, to an analytical laboratory.

Equipment blanks shall be prepared and analyzed at a rate of at least five percent of the total number of environmental samples submitted for analysis, but no less than one equipment blank per sampling day. Equipment blanks shall be generated by rinsing decontaminated sampling equipment with deionized water, and capturing the rinsate water in an appropriate clean container. The equipment blank then shall be submitted with the groundwater samples to the analytical laboratory for the same analyses as the environmental samples.

Trip blanks shall be prepared using deionized water. Trip blanks shall be managed exactly the same as environmental samples. Trip blanks shall accompany sampling personnel into the field

throughout sampling activities, and then shall be placed into a shipping container with environmental samples for shipment to the analytical laboratory. Trip blanks shall be analyzed at a frequency of one for each shipping container holding samples for VOC analysis.

10. Laboratory Quality Assurance

The Permittee shall ensure that contract analytical laboratories maintain internal quality assurance programs in accordance with EPA and industry-accepted practices and procedures. At a minimum, the laboratories shall use a combination of standards, blanks, surrogates, duplicates, matrix spike/matrix spike duplicates (MS/MSD), and other laboratory control samples to assess data quality. The laboratories shall establish control limits for individual chemicals or groups of chemicals based on the long-term performance of the test methods. In addition, the laboratories shall establish internal QA/QC procedures that meet EPA's laboratory certification requirements. Specific procedures to be completed are identified in the following sections. If a laboratory is unable or unwilling to meet the requirements of this Permit, the Permittee shall select a different laboratory that can and will meet the requirements.

1. Laboratory Equipment Calibration Procedures

The laboratories' equipment calibration procedures, calibration frequency, and calibration standards shall be in accordance with the EPA test method requirements and documented in quality assurance and standard operating procedures manuals. All instruments and equipment used by laboratories shall be operated, calibrated, and maintained according to manufacturers' guidelines and recommendations. Operation, calibration, and maintenance shall be performed by personnel who have been properly trained in these procedures. A routine schedule and record of instrument calibration and maintenance shall be kept on file at the laboratories.

2. Laboratory QC Samples

Analytical procedures shall be evaluated for quality by analyzing reagent blanks or method blanks, surrogates, MS/MSDs, and laboratory duplicates, as appropriate for each method. At a minimum, laboratories shall analyze laboratory blanks, MS/MSDs, and laboratory duplicates at a frequency of at least one in 20 for all batch runs requiring EPA test methods and at a frequency of at least one in 10 for non-EPA test methods. All laboratory quality control data reported with the Facility's sample analysis results must be related to the analysis of the Facility's samples.

11. Data Validation

The Permittee shall evaluate all sample data, and all field and laboratory QC results for acceptability. Each group of samples shall be evaluated using data validation guidelines contained in EPA guidance documents, the latest version of SW-846, and industry-accepted methods and procedures. Additionally, the Permittee shall evaluate all data for compliance with the following parameters:

1. Representativeness -- The Permittee shall implement procedures to assure representative samples are collected and analyzed, such as repeated measurements of the same parameter at the same location over several distinct sampling events. The Permittee shall note any procedures or variations that may affect the collection or analysis of representative samples and shall qualify the data accordingly;

2. Comparability -- To assure comparability of data, the Permittee shall implement standard collection and analytical procedures, and shall report analytical results in appropriate units for comparison with other data (e.g., past studies, comparable sites, screening levels, and cleanup standards). Any procedure or variation that may affect comparability shall be noted, and the data shall be qualified appropriately;

3. Completeness -- The Permittee shall evaluate all laboratory data for completeness with respect to data quality objectives. The degree of completeness shall be reported with the data in any reports in which the data are referenced;

4. Accuracy -- The Permittee shall evaluate all data for accuracy with respect to percent recovered of spiked samples. Results shall be reported for each analyte in any report in which the data are cited; and

5. Precision -- The Permittee shall evaluate all data for precision with respect to RPDs of duplicate samples. Results shall be reported for each analyte in any report in which the data are cited.

12. Waste Management

Waste management of investigation derived waste shall be in accordance with that set forth in Part 1 of this letter.

13. Geophysical Logs

Geophysical logging shall be conducted using induction (deep, medium), neutron, and gamma (large crystal) tools. Geophysical logging at cluster/nested well locations is required in only the well at each location that has the deepest screened interval.

Geophysical logs submitted to the NMED must show results of the induction logging (medium and deep) in millimhos per meter, neutron logging in American Petroleum Institute (API) neutron units, and gamma logging in API calibrated counts per second, the results of each method plotted versus depth from the surface to total depth of the borehole for which the log represents. The name of the borehole, location of the borehole, the date(s) that the borehole was completed, the drilling method, and the elevation of the top of the borehole shall also be noted on the boring log. The data must be provided to the NMED in hard copy and in digital format.

14. Field and Geologic Logs

The physical characteristics of soil and rock samples, such as mineralogy and lithic content, ASTM soil classification, moisture content, texture, color, presence of stains or odors, field screening results, depth, location, method of sample collection, the presence of any water-bearing zones and any unusual or notable conditions encountered during drilling shall be recorded in a field log. Field logs shall be completed by a qualified geologist.

The Permittee shall prepare geologic logs for each borehole showing relative to borehole depth the rock types, thickness of rock units, and water bearing zones (including that at and below the water table). The name of the borehole, location of the borehole, the date(s) that the borehole was completed, the drilling method, and the elevation of the top of the borehole shall also be noted on the boring log. The data must be provided to the NMED in hard copy and in digital format.

15. Reporting

Unless specified otherwise in this letter, the Permittee shall report to the NMED the information that is required by NMED's letter of June 4, 2010, and by the indicated schedules in that letter. Reporting for the additional SVE units required to be installed under Part 2 of this letter shall also be in accordance with NMED's letter of June 4, 2010.

Final Direction

The Permittee shall meet the deadlines specified in the Compliance Schedule of Table 5 of this letter. The Interim Measures, Groundwater Investigation, and Vadose Zone Work Plans must be completely revised and resubmitted. The Permittee shall submit to NMED by **September 7, 2010** (Table 5) revisions of the Vadose Zone, Interim Measures, and Groundwater Investigation Work Plans that correct the deficiencies noted herein and incorporate the requirements set forth in this letter. The Permittee shall also implement the interim measures and other actions as directed under Part 2 of this letter by the dates indicated and in accordance with the schedule in Table 5.

The investigation plans required under this letter shall include relevant maps and cross-sections that show concentration data for contaminants and other relevant information with supporting data posted on the maps and cross-sections in a legible manner, and clearly showing which borings/wells contributed data towards construction of the maps and cross-sections and which did not. Tables including all existing soil borings, soil-gas monitoring wells, and groundwater monitoring wells, listing their surveyed location, sampling points and maximum depth of exploration shall also be included in the reports and plans. For soil-gas monitoring wells, tables and graphs shall also be included providing trends of TPH concentrations versus time for the depths below ground surface of 25, 50, 150, 250, 350, and 450 feet.

To the extent any requirement of this letter requires access to property not owned or controlled by the Permittee, the Permittee shall use its best efforts to obtain access from the present owners of such property to conduct the required activities. In the event that access is not obtained when necessary, the Permittee shall immediately notify the NMED in writing regarding its best efforts and its failure to obtain such access.

Table 5. Compliance Schedule.

Revisions to Work Plans	
Submittal	Due Date
Interim Measures Work Plan	September 7, 2010
Vadose Zone Work Plan	September 7, 2010
Groundwater Investigation Work Plan	September 7, 2010
Other Document Submittals	
Indoor Air Quality Report	October 6, 2010
Interim Measures and other Actions	
Install and operate SVE units at KAFB-3411, KAFB-10614, and KAFB-10624	October 6, 2010
Install and operate SVE units at soil boring/monitoring well locations #4, 5, 9, 10, 11, and 12 (see Table 1)	November 8, 2010 or 60 days after required access is granted, which ever is later
Install and operate SVE units at KAFB-10617 and KAFB-10618	October 6, 2010
Install and operate SVE units at soil boring/monitoring well location KAFB-10610	November 8, 2010 or 60 days after required access is granted, which ever is later
Prepare for SVE operation at soil boring/monitoring well locations #3, 8, and 9 (see Table 2)	November 8, 2010 or 60 days after required access is granted, which ever is later
Operate SVE units at Fuel Offloading Rack and KAFB-1065, KAFB-1066, and KAFB-1068	Immediately, except operation of SVE Unit at Fuel Offloading Rack may be temporarily suspended while excavating soil and removing remaining components of the Fuel Offloading Rack.
Maintain spare parts and spare engine for SVE units in inventory	September 7, 2010
Report that spare parts and spare engine for SVE units is in inventory	October 6, 2010
Begin excavation of contaminated soil and removing remaining components of the Fuel Offloading Rack.	October 6, 2010
Complete excavation of contaminated soil and	October 6, 2011

removing remaining components of the Fuel Offloading Rack.	
Report on completion of excavation of contaminated soil and removing remaining components of the Fuel Offloading Rack.	January 15, 2012
Submit estimate of contaminant migration rate to NMED	September 7, 2010
Complete A, B, and C sentry wells at location #28 (see Table 4)	November 8, 2010 or 90 days after required access is granted, which ever is later
Complete B and C sentry wells at KAFB-10613 and KAFB-1064	November 8, 2010 or 90 days after required access is granted, which ever is later
Complete A, B, and C sentry wells at location #3 (see Table 4)	November 8, 2010 or 90 days after required access is granted, which ever is later
Complete A, B, and C sentry wells at location #1 (see Table 4)	November 8, 2010 or 90 days after required access is granted, which ever is later
Complete geologic logs of new wells at locations #1, 3, 28, KAFB-10613 and KAFB-1064	During drilling of each well
Complete geophysical logs of new wells at locations #1, 3, 28, KAFB-10613 and KAFB-1064	Within 30 days of well completion
Submit copies of geologic and geophysical logs for locations #1, 3, 28, KAFB-10613 and KAFB-1064	In accordance with NMED letter of June 4, 2010
Submit copies of geophysical logs of existing wells	October 6, 2010
Submit critical data to NMED (Section A.7 of Part 2).	September 7, 2010
Notification of sampling and other field activities (Section B.1 of Part 2)	No less than 15 days prior to implementation
Submit geologic and geophysical logs for sentry wells	In accordance with NMED letter of June 4, 2010
Submit water quality data for WUA wells	In accordance with NMED letter of June 4, 2010
Submit well completion reports	In accordance with NMED letter of June 4, 2010
Submit report on all SVE units	In accordance with NMED letter of June 4, 2010
Report to NMED if any SVE units will not receive an air emissions permit to operate	Immediately
Report to NMED down time of SVE units that will exceed a duration of 72 hours	Within 24 hours of discovery that repairs or maintenance will take more than 72 hours to complete

The Permittee shall respond directly to my attention, with copy to Mr. Bill Olson of the NMED's Ground Water Quality Bureau, and Mr. William Moats (NMED HWB, 5500 San Antonio NE, Albuquerque, NM 87109), on all correspondence and required plans and reports related to the Bulk Fuels Facility Spill, unless otherwise directed by NMED. All submittals and correspondence must be submitted in hardcopy and electronic format.

If you have any questions regarding the technical aspects of this letter, please contact Mr. William Moats of my staff at (505) 222-9551. Any other questions should be directed to me at 505-476-6016.

Sincerely,

James P. Bearzi
Chief
Hazardous Waste Bureau

Enclosures: Figures 1-4

cc: J. Kieling, NMED HWB
W. Moats, NMED HWB
W. McDonald, NMED HWB
S. Brandwein, NMED HWB
B. Olsen, HWB GWQB
A. Puglisi, HWB GWQB
B. Swanson, HWB GWQB
L. Barnhart, NMED OGC
B. Gallegos, AEHD
B. Gastian, ABCWUA
L. King, EPA-Region 6 (6PD-N)
File: Reading and KAFB 2010

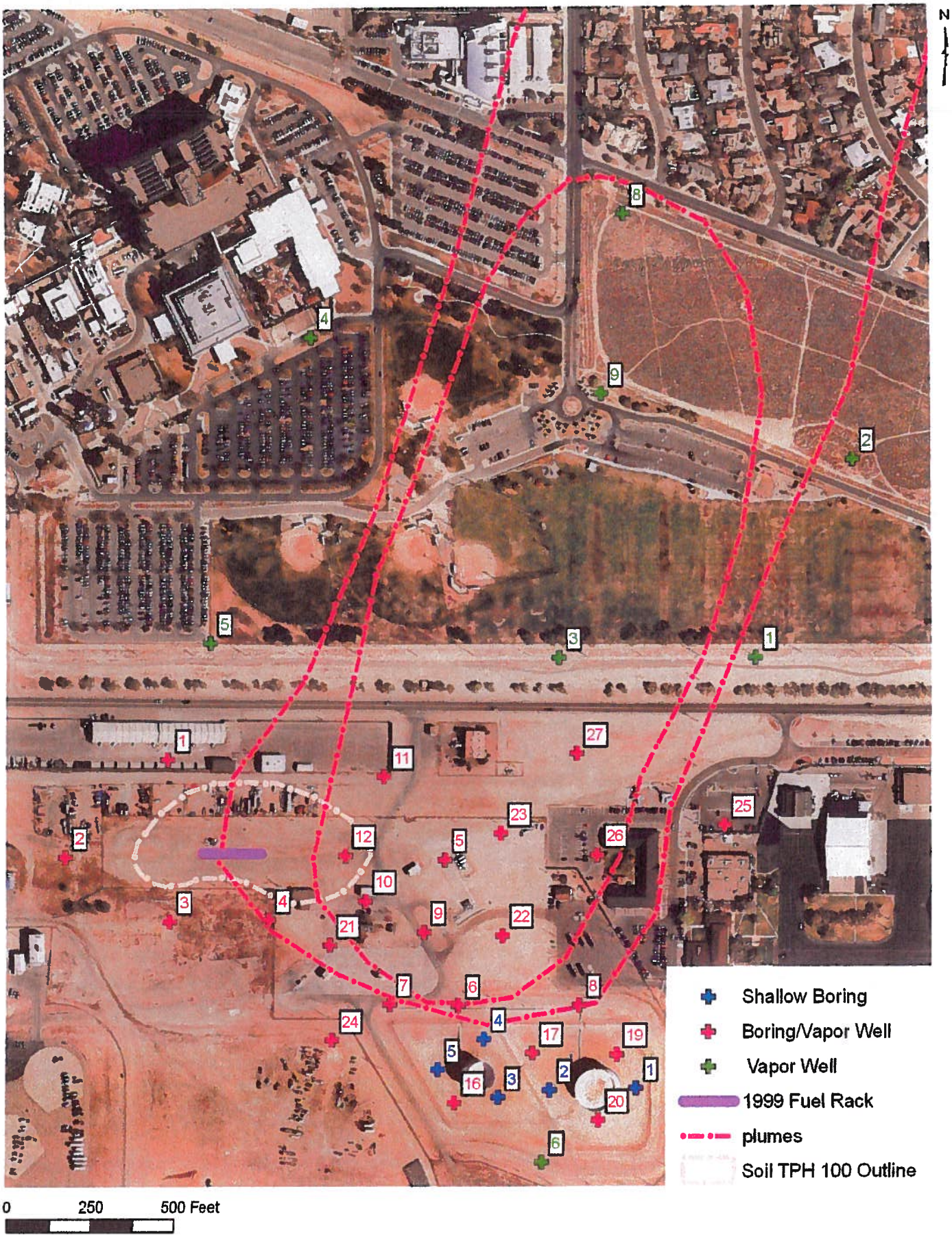

Figure 1. Soil Boring and
Soil-Vapor Monitoring Well Locations

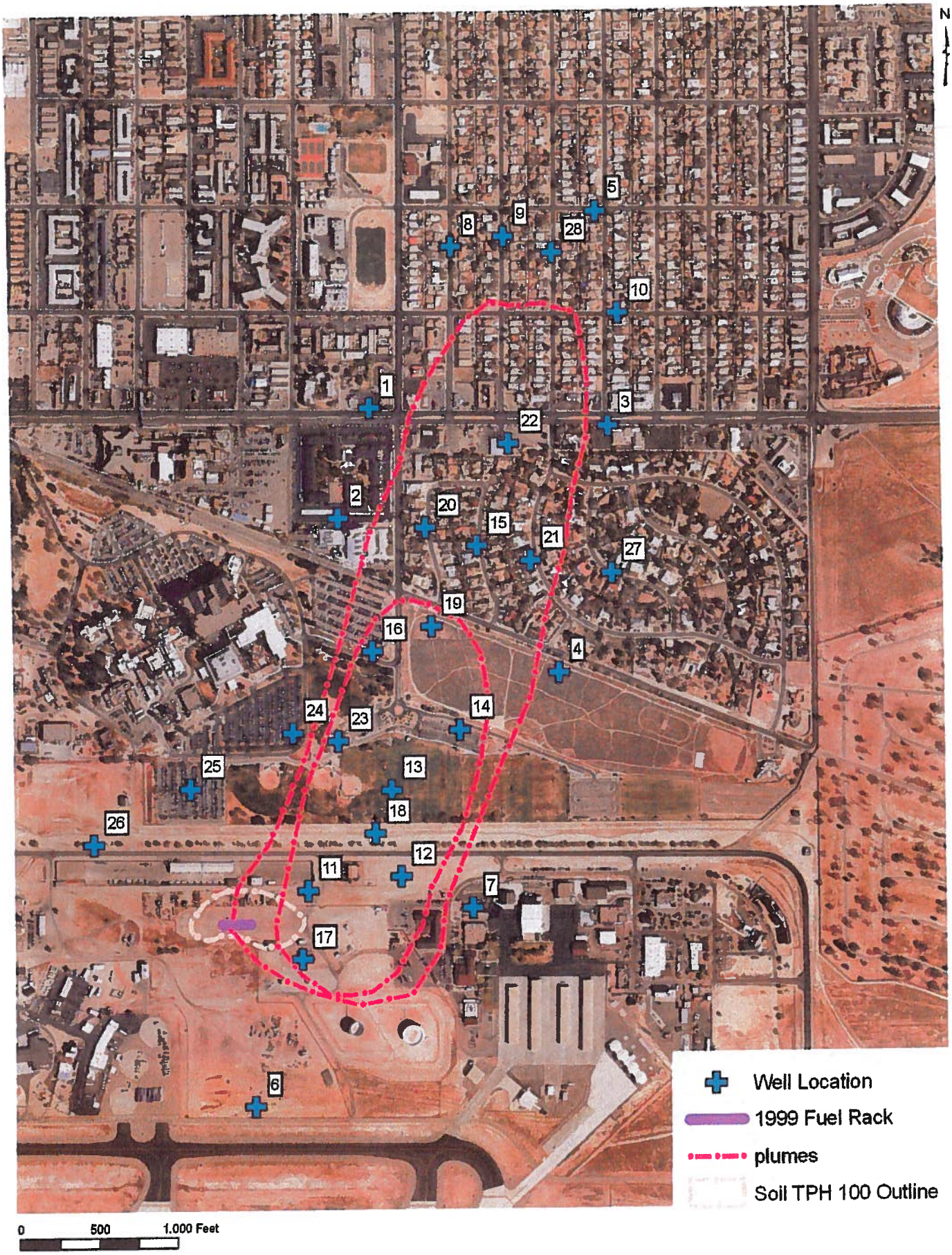

Figure 2. Groundwater Monitoring Well Locations

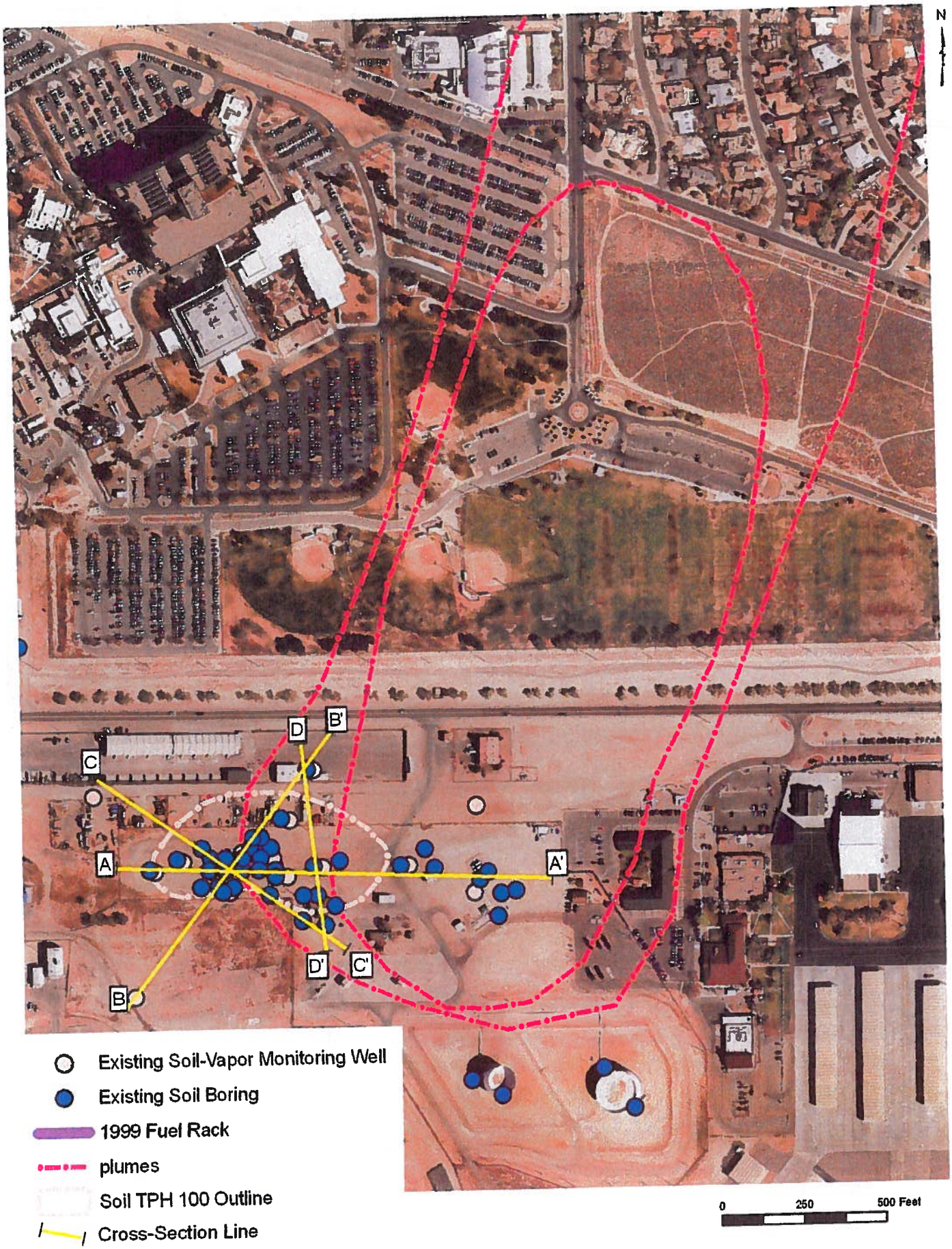

Figure 3 Existing Soil Boring, Soil-Vapor Monitoring Well and Cross-Section Locations

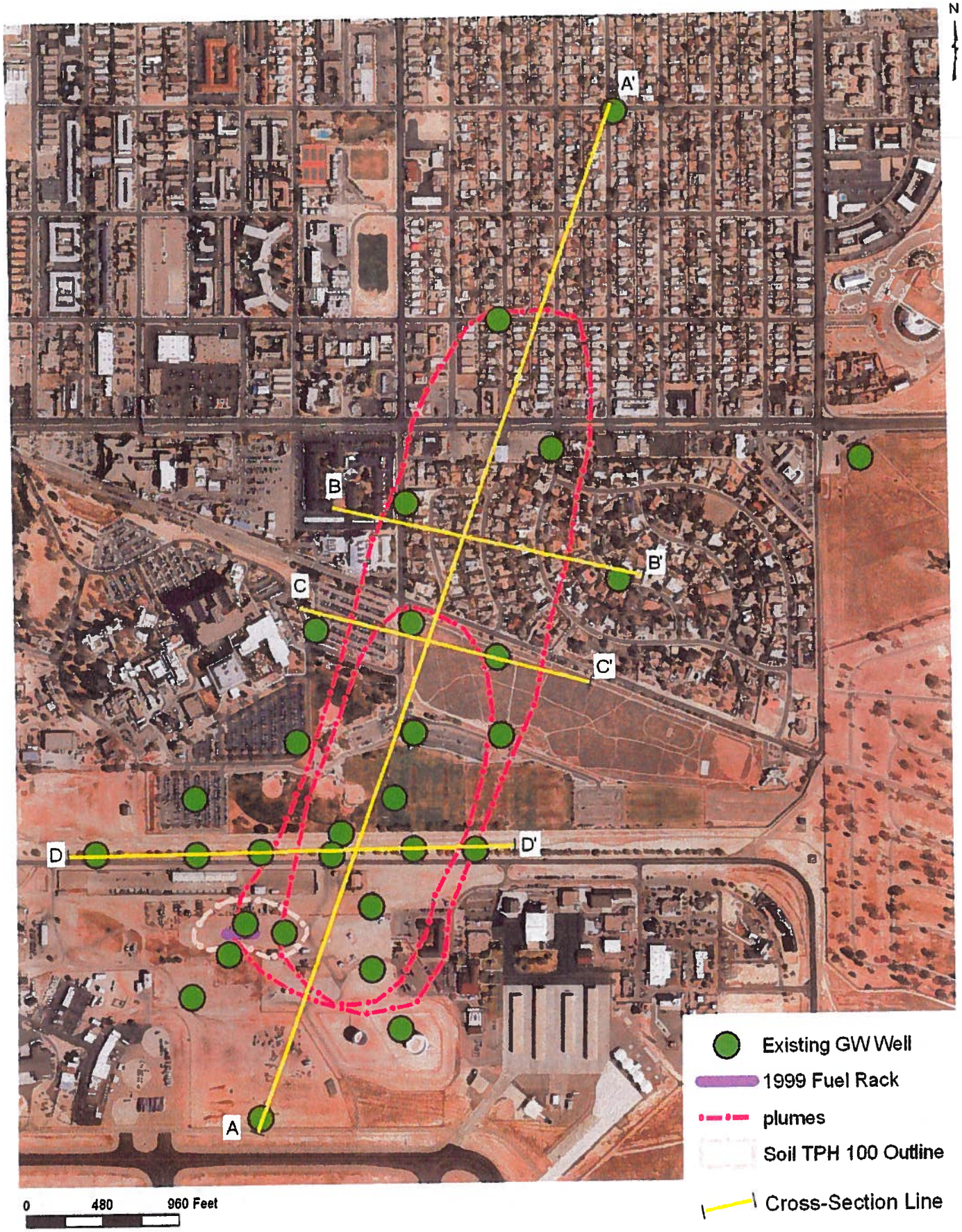

Figure 4. Existing Well and Cross-Section Locations

APPENDIX B

Project Schedule

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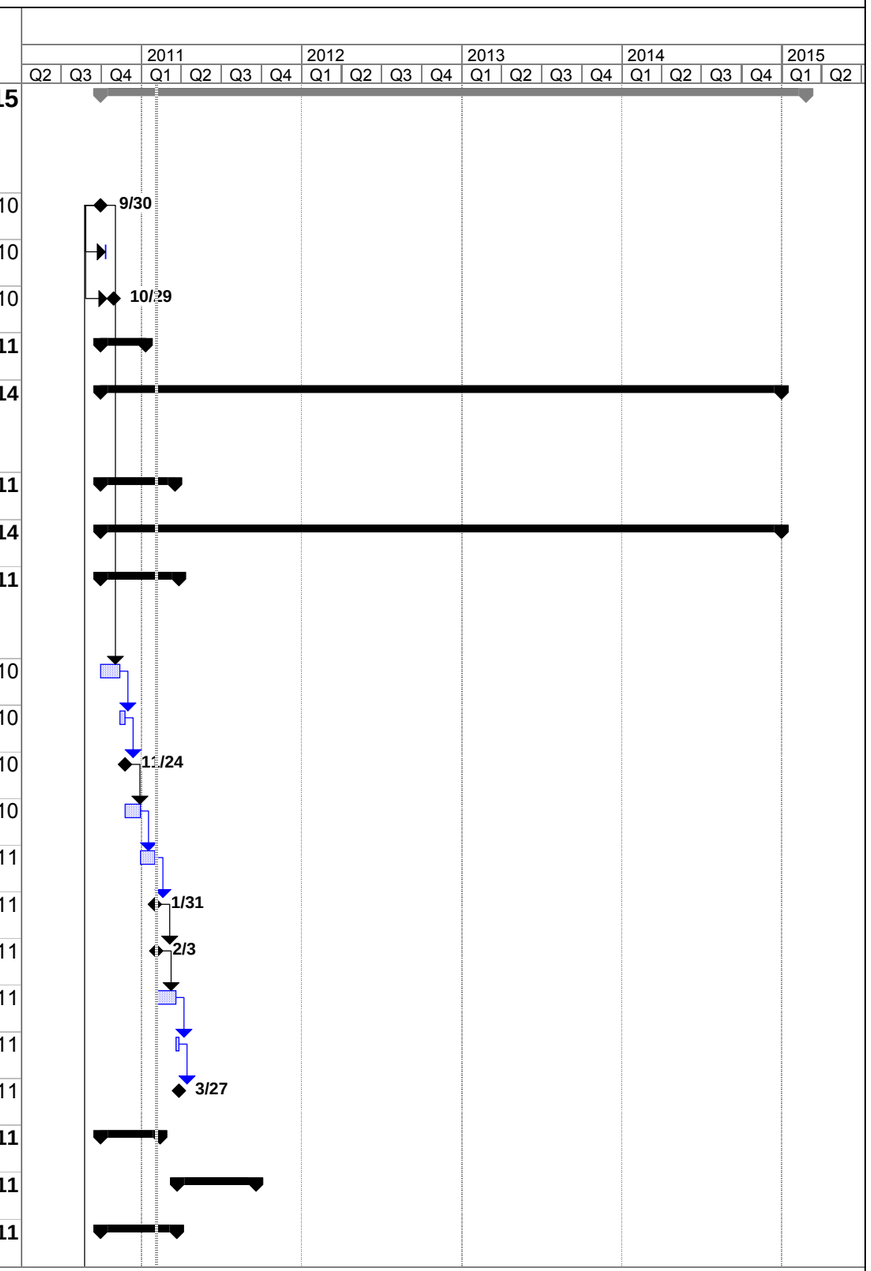
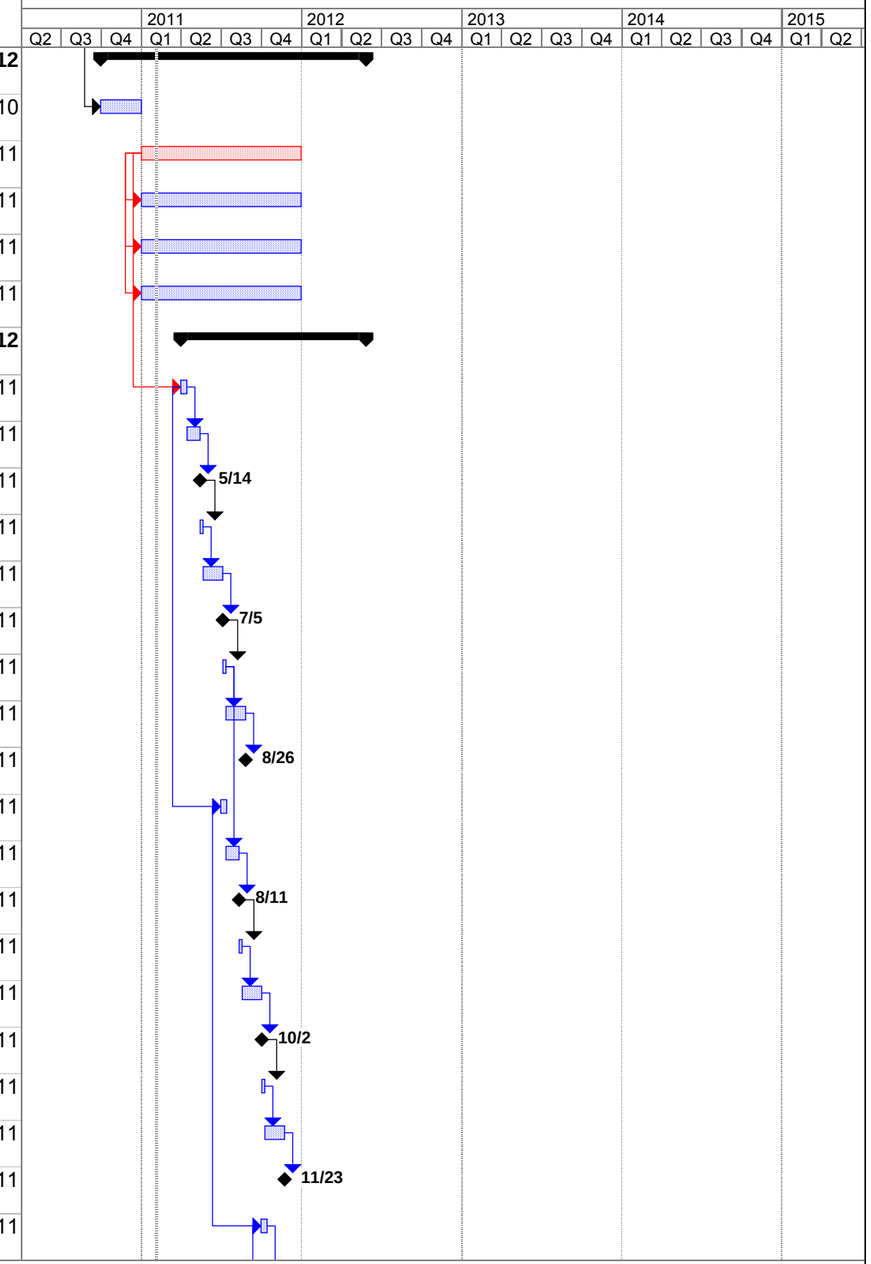
Activity ID	CLIN Sub-CLIN	Task Name	Duration	Start	Finish
0	**2001**	**Kirtland Air Force Base Environmental Remediation Services at Bulk Fuels Facility (BFF)**	**1610 days**	**Thu 9/30/10**	**Wed 2/25/15**
1		Task Order Award/Notice to Proceed	0 days	Thu 9/30/10	Thu 9/30/10
2		Project Kick-Off Meeting	1 day	Mon 10/11/10	Mon 10/11/10
3		Submit Well Permit Application	0 days	Fri 10/29/10	Fri 10/29/10
4	**2001AA**	**Project Management Plan (PMP) and Quality Assurance Surveillance Plan (QASP)**	**103 days**	**Thu 9/30/10**	**Mon 1/10/11**
12	**2001AB**	**Site Plans in Accordance w / Performance Work Statement (PWS) and Community Relations**	**1554 days**	**Thu 9/30/10**	**Wed 12/31/14**
13		**Community Relations Plan (CRP)**	**170 days**	**Thu 9/30/10**	**Fri 3/18/11**
23		**Community Relations**	**1554 days**	**Thu 9/30/10**	**Wed 12/31/14**
99		**Pre-Remedy Monitoring Work Plan, Health and Safety Plan (HASP), Quality Assurance Project Plan (QAPP)**	**179 days**	**Thu 9/30/10**	**Sun 3/27/11**
100		Prepare Draft Pre-Remedy Monitoring Work Plan, HASP, QAPP	44 days	Thu 9/30/10	Fri 11/12/10
101		Army/Air Force Review	12 days	Sat 11/13/10	Wed 11/24/10
102		Army/Air Force Approval of Draft	0 days	Wed 11/24/10	Wed 11/24/10
103		Respond to Army/Air Force Comments - Pre-Remedy Monitoring Work Plan	35 days	Thu 11/25/10	Wed 12/29/10
104		Commander's Review	33 days	Thu 12/30/10	Mon 1/31/11
105		Commander's Approval	0 days	Mon 1/31/11	Mon 1/31/11
106		Submit To Regulators	0 days	Thu 2/3/11	Thu 2/3/11
107		Regulator/Stakeholder Review	45 days	Fri 2/4/11	Sun 3/20/11
108		Prepare Final Pre-Remedy Monitoring Work Plan, HASP, QAPP	7 days	Mon 3/21/11	Sun 3/27/11
109		Regulator/Stakeholder Approval of Final	0 days	Sun 3/27/11	Sun 3/27/11
110		**Vadose Zone, Groundwater and Interim Measures Work Plans - Part I**	**136 days**	**Thu 9/30/10**	**Sat 2/12/11**
137		**Vadose Zone, Groundwater and Interim Measures Work Plans - Part II**	**180 days**	**Thu 3/24/11**	**Mon 9/19/11**
159		**Light Non-Aqueous Phase Liquid (LNAPL) Containment Work Plan**	**174 days**	**Thu 9/30/10**	**Tue 3/22/11**



Project: Kirtland Air Force Base Enviro
Date: Thu 2/3/11

Task		Milestone		Rolled Up Critical Task		Split		Group By Summary	
Critical Task		Summary		Rolled Up Milestone		External Tasks		Deadline	
Progress		Rolled Up Task		Rolled Up Progress		Project Summary			

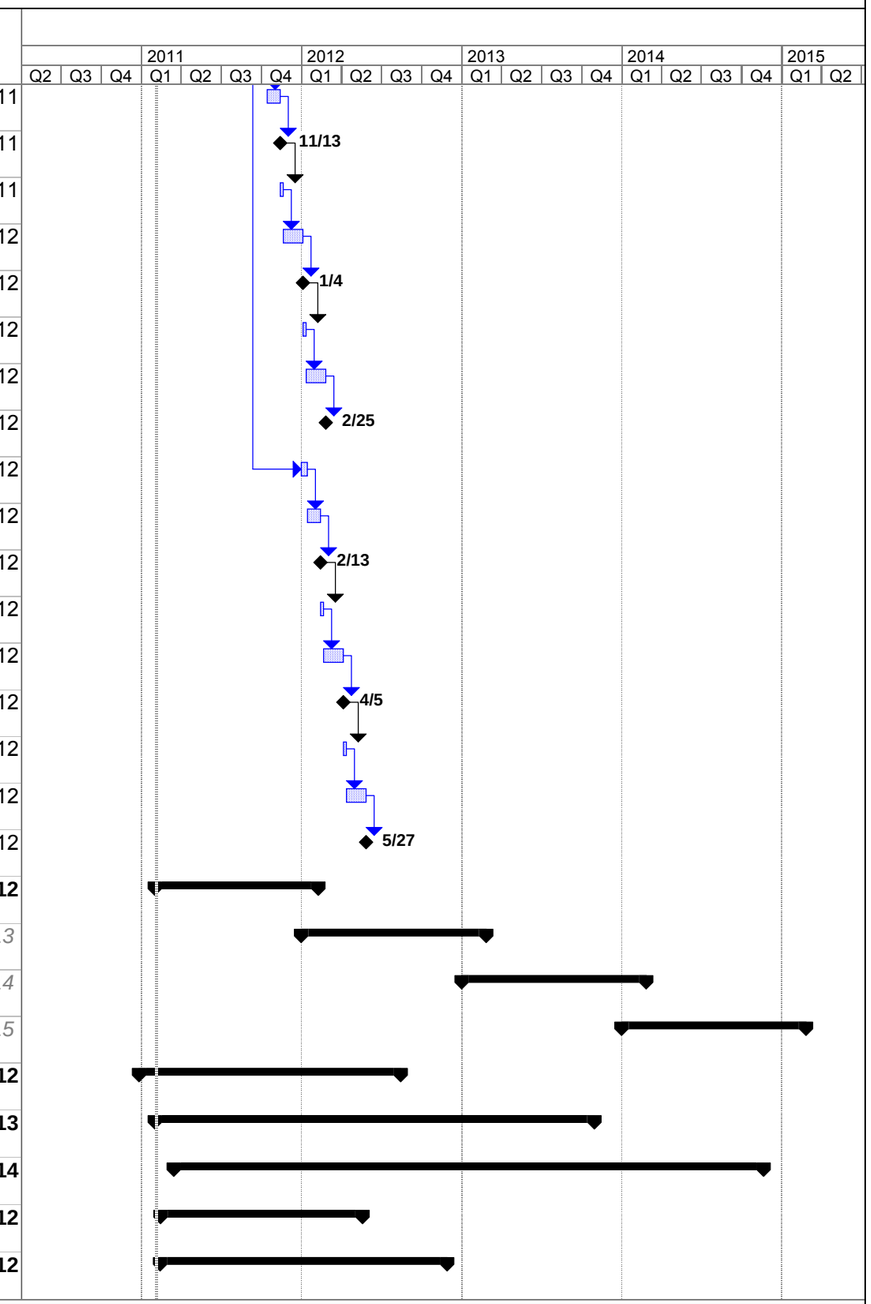
Activity ID	CLIN Sub-CLIN	Task Name	Duration	Start	Finish
171	**2001BA**	**Pre-Remedy Quarterly Monitoring and SVE Operation FY 2011**	**606 days**	**Thu 9/30/10**	**Sun 5/27/12**
172		Air Permitting	93 days	Thu 9/30/10	Fri 12/31/10
173		SVE System Operation	365 days	Sat 1/1/11	Sat 12/31/11
174		Monthly Ground Water Level & LNAPL Measurements	365 days	Sat 1/1/11	Sat 12/31/11
175		Quarterly Soil Gas Sampling	365 days	Sat 1/1/11	Sat 12/31/11
176		Quarterly Groundwater Sampling	365 days	Sat 1/1/11	Sat 12/31/11
177		**Quarterly Pre-Remedy Reports**	**423 days**	**Fri 4/1/11**	**Sun 5/27/12**
178		Prepare Draft Quarterly Pre-Remedy Monitoring Report	14 days	Fri 4/1/11	Thu 4/14/11
179		Army/Air Force Review	30 days	Fri 4/15/11	Sat 5/14/11
180		Army/Air Force Approval	0 days	Sat 5/14/11	Sat 5/14/11
181		Prepare Draft Final Quarterly Pre-Remedy Monitoring Report	7 days	Sun 5/15/11	Sat 5/21/11
182		Regulator/Stakeholder Review	45 days	Sun 5/22/11	Tue 7/5/11
183		Regulator/Stakeholder Approval	0 days	Tue 7/5/11	Tue 7/5/11
184		Prepare Final Quarterly Pre-Remedy Monitoring Report	7 days	Wed 7/6/11	Tue 7/12/11
185		Regulator/Stakeholder Review	45 days	Wed 7/13/11	Fri 8/26/11
186		Regulator/Stakeholder Approval	0 days	Fri 8/26/11	Fri 8/26/11
187		Prepare Draft Quarterly Pre-Remedy Monitoring Report	14 days	Fri 7/1/11	Thu 7/14/11
188		Army/Air Force Review	30 days	Wed 7/13/11	Thu 8/11/11
189		Army/Air Force Approval	0 days	Thu 8/11/11	Thu 8/11/11
190		Prepare Draft Final Quarterly Pre-Remedy Monitoring Report	7 days	Fri 8/12/11	Thu 8/18/11
191		Regulator/Stakeholder Review	45 days	Fri 8/19/11	Sun 10/2/11
192		Regulator/Stakeholder Approval	0 days	Sun 10/2/11	Sun 10/2/11
193		Prepare Final Quarterly Pre-Remedy Monitoring Report	7 days	Mon 10/3/11	Sun 10/9/11
194		Regulator/Stakeholder Review	45 days	Mon 10/10/11	Wed 11/23/11
195		Regulator/Stakeholder Approval	0 days	Wed 11/23/11	Wed 11/23/11
196		Prepare Draft Quarterly Pre-Remedy Monitoring Report	14 days	Sat 10/1/11	Fri 10/14/11



Project: Kirtland Air Force Base Enviro
Date: Thu 2/3/11

Task	Milestone	Rolled Up Critical Task	Split	Group By Summary
Critical Task	Summary	Rolled Up Milestone	External Tasks	Deadline
Progress	Rolled Up Task	Rolled Up Progress	Project Summary	

Activity ID	CLIN Sub-CLIN	Task Name	Duration	Start	Finish
197		Army/Air Force Review	30 days	Sat 10/15/11	Sun 11/13/11
198		Army/Air Force Approval	0 days	Sun 11/13/11	Sun 11/13/11
199		Prepare Draft Final Quarterly Pre-Remedy Monitoring Report	7 days	Mon 11/14/11	Sun 11/20/11
200		Regulator/Stakeholder Review	45 days	Mon 11/21/11	Wed 1/4/12
201		Regulator/Stakeholder Approval	0 days	Wed 1/4/12	Wed 1/4/12
202		Prepare Final Quarterly Pre-Remedy Monitoring Report	7 days	Thu 1/5/12	Wed 1/11/12
203		Regulator/Stakeholder Review	45 days	Thu 1/12/12	Sat 2/25/12
204		Regulator/Stakeholder Approval	0 days	Sat 2/25/12	Sat 2/25/12
205		Prepare Draft Quarterly Pre-Remedy Monitoring Report	14 days	Sun 1/1/12	Sat 1/14/12
206		Army/Air Force Review	30 days	Sun 1/15/12	Mon 2/13/12
207		Army/Air Force Approval	0 days	Mon 2/13/12	Mon 2/13/12
208		Prepare Draft Final Quarterly Pre-Remedy Monitoring Report	7 days	Tue 2/14/12	Mon 2/20/12
209		Regulator/Stakeholder Review	45 days	Tue 2/21/12	Thu 4/5/12
210		Regulator/Stakeholder Approval	0 days	Thu 4/5/12	Thu 4/5/12
211		Prepare Final Quarterly Pre-Remedy Monitoring Report	7 days	Fri 4/6/12	Thu 4/12/12
212		Regulator/Stakeholder Review	45 days	Fri 4/13/12	Sun 5/27/12
213		Regulator/Stakeholder Approval	0 days	Sun 5/27/12	Sun 5/27/12
214		**Monthly Project Status Report (PSR)**	**373 days**	**Tue 2/1/11**	**Wed 2/8/12**
270	*2001BB*	*Pre-Remedy Quarterly Monitoring and SVE Operation FY 2012*	*422 days*	*Sun 1/1/12*	*Mon 2/25/13*
373	*2001BC*	*Pre-Remedy Quarterly Monitoring and SVE Operation FY 2013*	*421 days*	*Tue 1/1/13*	*Tue 2/25/14*
476	*2001BD*	*Pre-Remedy Quarterly Monitoring and SVE Operation FY 2014*	*421 days*	*Wed 1/1/14*	*Wed 2/25/15*
579	**2001CA**	**Complete Investigation at BFF Vadose Zone**	**597 days**	**Mon 12/27/10**	**Tue 8/14/12**
635	**2001CB**	**Complete Investigation for BFF Groundwater**	**1003 days**	**Tue 2/1/11**	**Wed 10/30/13**
711	**2001DA**	**Installation of Interim Measure (IM) for Light Non-Aqueous Phase Liquid (LNAPL)**	**1346 days**	**Tue 3/15/11**	**Thu 11/20/14**
848	**2001EA**	**Interim Measure (IM) for Vadose Deep / Shallow Zone**	**461 days**	**Mon 2/14/11**	**Sat 5/19/12**
903	**2001GA**	**Groundwater IM**	**655 days**	**Sun 2/13/11**	**Wed 11/28/12**



Project: Kirtland Air Force Base Enviro
Date: Thu 2/3/11

Task		Milestone		Rolled Up Critical Task		Split		Group By Summary	
Critical Task		Summary		Rolled Up Milestone	◇	External Tasks		Deadline	
Progress		Rolled Up Task		Rolled Up Progress		Project Summary			

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APPENDIX C

Waste Management Plan

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KIRTLAND AIR FORCE BASE
ALBUQUERQUE, NEW MEXICO

WASTE MANAGEMENT PLAN
BULK FUELS FACILITY SPILL
SOLID WASTE MANAGEMENT UNITS ST-106 AND SS-111

February 2011

Prepared for
U.S. Army Corps of Engineers
Albuquerque District
Albuquerque, New Mexico 87109

USACE Contract No. W912DY-10-D-0014
Delivery Order 0002

Prepared by
Shaw Environmental & Infrastructure, Inc.
7604 Technology Way, Suite 300
Denver, Colorado 80237

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ACRONYMS AND ABBREVIATIONS

AFB	Air Force Base
BTEX	benzene, toluene, ethylbenzene, and xylenes
CFR	Code of Federal Regulations
CHOX	chemical oxidation
CMBST	high-temperature organic destruction
DOT	U.S. Department of Transportation
EPA	U. S. Environmental Protection Agency
IDW	investigation-derived waste
INCIN	incineration
LF	landfill
mg/kg	milligrams per kilogram
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
PCB	polychlorinated biphenyl
PPE	personal protective equipment
RCRA	Resource Conservation and Recovery Act
STABL	stabilization
SVOC	semivolatile compound
TCLP	toxicity characteristic leaching procedure
TPH	total petroleum hydrocarbons
VOC	volatile organic compound
WMP	Waste Management Plan
WWT	wastewater treatment

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1. INTRODUCTION

This document will serve as the Waste Management Plan (WMP) for environmental activities performed at Kirtland Air Force Base (AFB) in support of investigation of the BFF Spill, under U.S. Army Corps of Engineers contract W912DY-10-D-0014, Delivery Order 0002. The WMP governs the minimization, generation, management, storage, and transport and disposal of wastes that are routinely encountered during these environmental activities. The primary focus of this WMP is the management of investigation-derived waste (IDW). Wastes generated during the execution of remedial actions will be governed by this plan to the extent that they can be predicted and easily accommodated with the scope of this WMP.

1.1 Purpose

The purpose of waste management, particularly IDW management, is to leave the site in no worse condition after the implementation of activities than existed before the activities began, and to comply with federal and state waste management regulations and applicable or relevant and appropriate requirements to the extent practicable. These management procedures are directed toward waste minimization to reduce the quantity of waste that will require treatment, storage, or disposal.

1.2 Definitions

Cross-contamination—spread of chemicals from one item to another or from one location to another.

Debris—a solid material exceeding a 60 millimeters particle size that is intended for disposal that can be classified as a manufactured object, plant, or animal matter, or natural geologic material. The following materials are not debris—any material for which a specific treatment standard is provided in Resource Conservation and Recovery Act (RCRA) Subpart D, Part 268; process residuals such as smelter slag and

residues from treatment of waste, wastewater sludges, or air emission residues; and intact containers of hazardous waste that are not ruptured and that retain at least 75 percent of their original volume.

Decontamination Fluids—fluids generated after decontamination of equipment. Fluids include soapy water, rinse water, solvents (e.g., isopropanol), and contaminated media removed from equipment during the decontamination process.

Dewatering Fluids—liquid waste generated from dewatering operations in excavations, retention ponds, and drainage channels.

Disposable Equipment—equipment that cannot be decontaminated at the conclusion of an environmental restoration activity and requires disposal. IDW disposable equipment includes bailers, coliwasas (samplers designed to permit representative sampling of multi-phase wastes from drums and other containerized wastes), jars and containers, plastic sheeting, foil, disposable laboratory equipment, etc. Disposable equipment from remedial activities includes small tools, barrier materials, decontamination pad equipment, hoses, chains, timber, survey stakes, etc.

Free Liquids—liquids that readily separate from the solid portion of a waste under ambient temperature and pressure.

Hazardous Waste—a solid waste is a hazardous waste if it is not excluded from regulation as a hazardous waste and exhibits any characteristic of hazardous waste identified in Subpart C and/or D of 40 Code of Federal Regulations (CFR) part 261.

Mixed Waste—radioactive waste that also contains a hazardous waste component regulated under RCRA (see definition of hazardous waste). Although not strictly a mixed waste, radioactive waste containing

wastes regulated by the Toxic Substances Control Act (e.g., polychlorinated biphenyls [PCBs], asbestos) or naturally occurring radioactive materials are also considered to be a mixed waste under this plan.

Personal Protective Equipment (PPE)—coveralls, gloves, respirator cartridges, tape, boots, etc.

Purge Water—groundwater pumped from a borehole (monitoring well) prior to sampling.

Radioactive Waste—waste that contains higher than background levels of radioactivity, or is otherwise not releasable for use by the general public. Waste that can be disposed of without regard to its radioactivity is not considered radioactive waste.

Remediation Waste—any media or debris resulting from environmental restoration activities that meet the definition of solid waste in 40 CFR Part 261.

Representative Sample—a sample of a universe or whole (e.g., waste pile, lagoon, groundwater) that can be expected to exhibit the average properties of the universe or whole.

Soil Cuttings—excess soil removed by the direct-push and hollow-stem auger drilling techniques.

Special Waste—New Mexico defines "Special Waste" as the following types of solid wastes that have unique handling, transportation, or disposal requirements to ensure protection of the environment and public health and safety:

- Treated formerly characteristic hazardous wastes
- Packing house and killing plant offal
- Asbestos waste
- Ash
- Infectious waste
- Sludge

- Industrial process waste
- Residue from a spill of a chemical substance or commercial product (including contaminated soils)
- Dry chemicals, which when wetted, become characteristically hazardous

The New Mexico Environment Department (NMED) also defines petroleum-contaminated soil as "Special Waste" if the sum of benzene, toluene, ethylbenzene, and xylene (BTEX) isomer concentrations is greater than 500 milligrams per kilogram (mg/kg), with benzene individually greater than 10 mg/kg, and total petroleum hydrocarbon (TPH) concentration greater than 1,000 mg/kg.

1.3 IDW Minimization

A primary goal of the WMP is to minimize, to a practical extent, the volume of waste that will be generated, stored, and removed from the site for disposal. In order to minimize the volume of waste, the following general rules will be applied:

- Do not contaminate materials unnecessarily:
  - Plan work ahead, based on the work procedure to be used.
  - Take only the material (i.e., chemicals) needed to perform the work activity. Additional material can be brought to the work location if it is found to be necessary. Materials can be stored in large containers but the smallest reasonable container will be used to transport the material to the location where it is needed.
  - Maintain cleaning and extra sampling supplies outside any potentially contaminated area to keep them clean and to minimize additional waste generation.
  - Maintain or construct prefabricated materials, barriers, support equipment, etc., outside potentially contaminated areas.
  - Perform mixing of detergents or decontamination solutions outside potentially contaminated areas.
  - Do not place media considered hazardous for different reasons together.
  - Use drop cloths or other absorbent material to contain small spills or leaks.
  - Avoid a bellows effect when double-bagging contaminated materials.
  - Use containers to minimize the spread of contamination.

- Do not place contaminated materials with clean materials.
- Cover wooden pallets inside the exclusion zone with plastic. Decontaminate and re-use material and equipment when practical. Use volume reduction techniques when practicable.
- Verify that waste containers are solidly packed to minimize the number of containers.
- Use only the size of container to meet needs (i.e., do not use a drum or garbage can when a small polyethylene bag will do).
- Use less hazardous substances whenever possible (i.e., bring only the volume of standard solutions needed for testing, use minimal amounts of decontamination water and solvent rinses).
- Use direct-push, hydropunch, or any other waste minimizing sample acquisition techniques whenever possible.

1.4 Regulatory Context

NMED regulates environmental activities in the State of New Mexico. Environmental restoration work at Kirtland AFB is under the jurisdiction of both NMED and the U.S. Environmental Protection Agency (EPA), Region 6. Consequently, the following federal and state regulations form the regulatory context in from which waste management decision making at Kirtland AFB will derive:

- 40 CFR Parts 260 -299, EPA regulations for identification and management of hazardous waste
- 40 CFR Part 761, EPA regulations for management of PCBs
- 49 CFR Parts 100-178, U.S. Department of Transportation (DOT) rules for hazardous materials transport
- 20 New Mexico Administrative Code (NMAC) Chapter 9, New Mexico Solid Waste Management Regulations
- 20 NMAC Chapter 4, New Mexico Hazardous Waste Management Regulations
- 20 NMAC Chapter 5, New Mexico Underground Storage Tanks Regulations
- 20 NMAC Chapter 9, New Mexico Special Waste Requirements Regulations
- 20 NMAC Chapter 6, New Mexico Water Quality Control Commission Regulations

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2. WASTE MANAGEMENT APPROACH

From the time that waste is generated through its ultimate disposal, waste will be managed in compliance with applicable regulatory requirements and in a manner that is protective of human health and the environment. All waste will be managed in compliance with applicable federal, state, local, and Kirtland AFB regulations. A regulatory expert will be actively involved in all planned activities to ensure that the appropriate characterization strategy will be used on a waste-to-waste basis. Furthermore, once characterization data are available, the regulatory expert will interpret the data and in combination with all other associated site history and project circumstance, provide a path forward for managing each waste generated in a timely and compliant manner.

2.1 Project-Specific Wastes

IDW anticipated to be generated during BFF Spill investigation and remediation field activities will consist of contaminated environmental media and associated waste materials from soil (excavation and sampling), drill/soil cuttings (from boreholes and well installation), monitoring well purge and development water, decontamination water, and water generated from pump tests. Waste material associated with these activities includes disposable PPE, disposable sampling equipment (e.g., scoops, bowls), and other inert materials (e.g., plastic, rope, tape, and paper).

2.2 Waste Accumulation and Storage Areas for Containers

Wastes governed by this plan shall be properly managed in an appropriate waste accumulation or storage area from the time it is generated until it is removed from the area (e.g., for disposal or further management). These areas will be, when practical, within the area of contamination at the point of generation. Otherwise waste containers will be staged at strategic and secure areas onsite until waste is properly disposed.

Waste accumulation and storage areas will be kept orderly and clear of non-waste-related items at all times. Minimum standards for the accumulation of waste in containers will be implemented at waste storage areas to ensure that waste is managed in a protective manner. Waste staging areas are not bound by specified time limits as are hazardous waste accumulation/storage areas. Inspections will be required weekly and will included visual confirmation of the following:

- Container is closed securely and/or locked.
- Container is in good condition (i.e., no excessive rust or dents that could compromise container integrity).
- All container labels are legible.
- Pertinent information is marked on drum/label (i.e., site of origin, waste contents, date of generation).
- Waste volume in container has not changed since the last inspection (only for containers where a visual assessment of volume is possible).

2.3 Container Management

IDW may be contained in drums, roll-off boxes, polyethylene tanks, or similar containers. IDW that is placed in a container (i.e., drum, roll-off box) will be managed in accordance with the following practices:

- Containers will be inspected upon receipt and/or before use to ensure the structural integrity of the containers.
- Only DOT-compliant containers will be used to accumulate, store, or transport waste generated at Kirtland AFB.
- Containers used for management of bulk IDW will be secured with a mechanism to prevent tampering. All access points to IDW containers (e.g., drum bungs, roll-off tarps) will be tightened with tools, as necessary, to prevent casual access.
- Once IDW is placed in the container, an appropriate label will be affixed to the container. The label must include the following basic waste identification information:
  - A unique container number
  - Accumulation start date
  - Site identification
  - Contents (e.g., soil, purge water)
  - Emergency contact information

- Drums will be positioned to allow for clear observation of labels and visual inspections for potential leaks. If an aisle is required in the drum storage area in order for a clear visual inspection of the drums, a minimum of three feet aisle space is recommended.
- Containers must always be closed, unless waste is being added to the container.
- Once the waste evaluator has fully characterized a particular waste stream, appropriate label(s) and markings will be placed on the container to reflect the characterization. Any previous labels or markings that were not accurate will be removed.
- Unless special circumstances warrant, IDW from different area of contaminations will not be mixed within a single container.

2.4 Additional Requirements for Hazardous Waste Containers

IDW that has been characterized as hazardous waste will be accumulated or stored in accordance with 40 CFR 262. The following requirements are applicable to only hazardous waste and are in addition to the general container management requirements.

- Containers of fully characterized hazardous waste accumulated in a generator 90-day area will have a hazardous waste label affixed to them and will be marked with the following information:
  - Generator information (name, address)
  - Kirtland EPA identification number
  - Applicable EPA waste number(s) (e.g., D008, F001)
  - Accumulation start date
  - Proper DOT shipping name
  - Appropriate DOT hazard class sticker(s)

In accordance with applicable state and federal hazardous waste and/or DOT regulations additional markings and/or labels may be required in preparation for transport of waste containers off-site.

2.5 Waste Staging Area for Stockpiles

Waste staging areas are defined strictly for the purposes of this plan, as areas within an area of contamination that will be used for the accumulation of stockpiling of soil or water, awaiting further management (e.g., treatment, disposal). Waste staging areas will be established within the boundaries of an area of contamination. Waste staging areas will be established and maintained by the contractor field

team manager. For the purpose of the BFF spill remediation activities, centralized waste staging will be located at the BFF spill site location at Kirtland AFB.

2.6 Waste Characterization

IDW will be characterized using data obtained from the analysis of environmental samples collected during the investigation and quarterly monitoring activity that generated the waste, through analysis of samples collected directly from the waste, through knowledge of waste-generating process, or through a combination of these methods. A hazardous waste evaluation will occur for all waste generated at the site. If a particular waste meets the definition of a solid waste and is not excluded from regulation, it will then be determined if the waste meets the criteria of hazardous (characteristic and/or listed) or non-hazardous.

For the purpose of the BFF project, the Kirtland AFB active onsite landfill (LF-268) will be used for disposal of solid non-hazardous wastes. Kirtland AFB currently requires all waste being disposed at LF-268 to be analyzed for the following list of parameters for submittal in order to obtain approval for disposal at the landfill. The requirements include the following:

- Ignitability characteristic as defined in 40 CFR Part 261,
- Corrosivity characteristic as defined in 40 CFR Part 261,
- Reactivity characteristic as defined in 40 CFR Part 261, and
- Toxicity characteristic as defined by EPA Test Method 1311, toxicity characteristic leaching procedure (TCLP) for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), RCRA l metals, herbicides, and pesticides

Analysis for petroleum hydrocarbons is only required for wastes suspected of having petroleum-based contamination. The required petroleum hydrocarbon analyses include:

- TPH by EPA Test Method 8015B
- BTEX by EPA Test Method 8260B or 8021B

The following Table, Landfill-268 Waste Acceptance Criteria, summarizes acceptable levels that are applicable when utilizing the onsite landfill for waste disposal.

Table 1 – Kirtland AFB Landfill-268 Waste Acceptance Criteria

Constituent	Regulatory Level*	Constituent	Regulatory Level*
Arsenic (D004)	5.0 mg/L	Hexachlorobenzene (D032)	0.13 mg/L
Barium (D005)	100.0 mg/L	Hexachlorobutadiene (D033)	0.5 mg/L
Benzene (D018)	5.0 mg/L	Hexachloroethane (D034)	3.0 mg/L
Cadmium (D006)	1.0 mg/L	Lead (D008)	5.0 mg/L
Carbon Tetrachloride (D019)	0.5 mg/L	Lindane (D013)	0.4 mg/L
Chlordane (D020)	0.03 mg/L	Mercury (D009)	0.2 mg/L
Chlorobenzene (D021)	100.0 mg/L	Methoxychlor (D014)	10.0 mg/L
Chloroform (D022)	6.0 mg/L	Methyl ethyl Ketone (D035)	200.0 mg/L
Chromium (D007)	5.0 mg/L	Nitrobenzene (D036)	2.0 mg/L
o-Cresol (D023)	200.0 mg/L	Pentachlorophenol (D037)	100.0 mg/L
m-Cresol (D024)	200.0 mg/L	Pyridine (D038)	5.0 mg/L
p-Cresol (D025)	200.0 mg/L	Selenium (D010)	1.0 mg/L
Cresol (D026)	200.0 mg/L	Silver (D011)	5.0 mg/L
2,4-D (D016)	10.0 mg/L	Tetrachloroethylene (D039)	0.7 mg/L
1,4-Dichlorobenzene (D027)	7.5 mg/L	Toxaphene (D015)	0.5 mg/L
1,2-Dichloroethane (D028)	0.5 mg/L	Trichloroethylene (D040)	0.5 mg/L
1,1-Dichloroethylene (D029)	0.7 mg/L	2,4,5-Trichlorophenol (D041)	400.0 mg/L
2,4-Dinitrotoluene (D030)	0.13 mg/L	2,4,6-Trichlorophenol (D042)	2.0 mg/L
Endrin (D012)	0.02 mg/L	2,4,5-TP (Silvex) (D017)	1.0 mg/L
Heptachlor (D031)	0.008 mg/L	Vinyl Chloride (D043)	0.2 mg/L
BTEX	50 mg/kg	Benzene	10 mg/kg
TPH	100 mg/kg		

* 40 CFR 261.24, Table 1

In addition to the analytical thresholds, listed, the following LF-268 guidance to generators needs to be adhered to in considering the landfill as a disposal option for IDW.

1. The Kirtland AFB civil engineer and Kirtland AFB Landfill require that soil and/or debris from any restoration site or monitoring well installation have analytical documentation characterizing the waste

prior to consideration for disposal. Analytical requirements will be based on the specific site knowledge of the Restoration project manager and/or site engineer.

2. Minimum analytical requirements necessary for soil and debris characterization derived from restoration site or monitoring well activities are defined above (See Table 1, Landfill-268 Waste Acceptance Criteria). For waste and debris that have been characterized during the completion of site activities, analyses previously generated during the characterization process may be used in determination of suitability for disposal.

3. Soil or debris that has been analyzed for hazardous constituents and does not exceed any RCRA regulatory limits (40 CFR 261.24 Table 1) may be disposed of in the Kirtland AFB landfill. Soil and debris containing hazardous constituents exceeding regulatory limits and/or illustrating hazardous waste characteristics will be disposed of at a facility permitted to accept hazardous wastes following appropriate DOT procedures.

4. Petroleum-contaminated soil that has a total BTEX concentration greater than 50 mg/kg, or a benzene concentration greater than 10 mg/kg, or a TPH concentration greater than 100 mg/kg is considered a special waste. Special wastes will not be disposed of in the Kirtland AFB landfill but will be disposed of at a facility permitted to handle special wastes.

5. Kirtland AFB retains the right to reject all material for disposal into the Kirtland AFB Landfill on a case-by-case basis, even if the waste does not exceed regulatory limitations.

6. If a waste is approved for disposal at the Kirtland AFB landfill, a Kirtland AFB Landfill Pass will be issued to the requestor for the waste hauling vehicle. When using a government vehicle to haul waste to the Kirtland AFB landfill, a waste disposal authorization letter is required but a Kirtland AFB landfill pass is not.

The LF-268 specific waste characterization process and analytical requirements will be sufficient to make a general waste determination and allow for appropriate waste management onsite or off site. If the waste exceeds any of the levels listed in the Table 1, with the exception of the TPH and BTEX parameters, the waste will be considered a hazardous waste. That waste will then have to be profiled, treated, and disposed of offsite as a hazardous waste according to the level and type of contamination indicated in the waste characterization results.

In the event there are other reasons why the waste cannot be disposed of at the onsite landfill and all of the waste acceptance criteria are met, that waste will be managed as NMED special waste and shipped offsite accordingly.

The field team manager will stage IDW pending analysis (i.e., waste that is not fully characterized) at the site of origin pending the receipt of analytical data and subsequent characterization, unless otherwise directed by Kirtland AFB personnel. IDW that is generated outside of the Kirtland AFB installation boundary will not be staged at the site of origin. Such wastes will be staged at a waste staging area within the installation boundary at the BFF site.

2.7 Waste Management Implementation

If it is determined that the LF-268 analytical waste acceptance criteria are satisfied, the following information will be presented in a "waste profile" format that will be used consistently to represent each individual waste stream encountered and considered for onsite disposal.

- Submit a memorandum requesting authorization to dispose of investigative-derived debris to the appropriate Solid Waste program manager.
  - Kirtland AFB Activities: Mr. Steven C. Kitt, 377 MSG/CEANC at 846-9014 or Steven.kitt@kirtland.af.mil
- Include in the submittal the name and phone number of the point of contact overseeing the activity, the location from which the waste was generated/site identifier, waste analytical results, hauling companies to be used to transport the waste to the landfill, roll-off identification numbers, and license plate numbers of transport vehicles, if not using roll-offs for waste containment.

As stated, if for any reason waste is not accepted for onsite disposal, arrangements will be made to manage the waste offsite in a compliant manner. Licensed and/or permitted facilities will be used for the purpose of transportation and disposal of waste from Kirtland AFB, as deemed necessary. Waste profile documentation will be prepared for review and signature by Kirtland AFB before shipment offsite. Upon receipt of the signed profile packages waste removal will be coordinated to ensure proper management of all waste being offered for disposal.

Table 2 lists the projected wastes to be generated during activities and the proposed analytical suite, the means of containerizing, probable waste status determinations and the two most likely methods of treatment and disposal.

Table 2 – Management of Projected Waste Streams

Waste Description	Characterization	Containerization	Waste Status	Treatment/Disposal
IDW Soils	LF 268 Suite	-Roll-off -Drum	Non-Hazardous	Direct Land Disposal 1.) LF268 2.) NMED permitted Subtitle D Landfill
IDW Soils	LF268 Suite	-Roll-off -Drum	Hazardous D004-D011 D018-D043	STABL, CHOX, and Land Disposal 1.) WCS Hobbs, NM 2.) Clean Harbors Deer Trail, CO
IDW Water, well purge water, well development water	-LF268 (exclude BTEX, TPH) -WWT specific parameters as needed	-Drum or bulk storage tank	Non-Hazardous	1.) Discharge to ground surface per approval 2.) On-site WWT
Aviation Fuel	-Total Metals -Total VOCs -Flash Point -pH -PCB	-Drum	Hazardous D018	CMBST, INCIN 1.) Off-site Fuel Blending 2.) Off-site Incineration
Spent Carbon	-TCLP Metals -Total VOCs -Flash Point -pH -PCB	-Drum	Hazardous D018	CHOX, INCIN & Land Disposal 1.) Clean harbors 2.) Rhino Environmental
SVE Condensate	-TCLP Metals -TCLP VOC's -Total VOC's -Flash Point -pH	-Drum	Hazardous D018	CHOX, WWT 1.) Clean Harbors 2.) Safety Kleen 3.) Other off-site WWT
Used Oil	Generator Knowledge	-Drum	NA	Recycled

Based on existing information, this table depicts an anticipated approach to waste streams generated in support of the BFF Spill field activities. However, if circumstances and/or analytical results deviate from the expected, necessary adjustments will be made to onsite waste handling and treatment and disposal selection. All procedures for handling and disposal of wastes, including necessary adjustments, will be in

accordance with applicable federal and state regulations (see Section 1.4). Any significant adjustments to procedures will be transmitted to stakeholders during monthly status meetings, DQCRs, and other ad hoc meeting/conference calls as discussed in Section 5.1 of the work plan.

All documentation generated in managing each waste stream will be kept on file and provided to the appropriate Kirtland AFB environmental staff.

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APPENDIX D

Field Forms

Form 1: Groundwater Purge Log

Form 2: Water Quality Meter Field Calibration Log

Form 3: Analytical Request / Chain-of-Custody Form

Form 4: Groundwater Level Data Form

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Form 1. Groundwater Purge Log

Shaw Environmental, Inc.

GROUNDWATER PURGE LOG

Kirtland Air Force Base, Bulk Fuels Facility Spill

Project Name: _____ **Well ID No.:** _____

Site / SWMU No.: _____ **Date:** _____

Weather: _____ **Time:** _____

Field Crew: _____ **Crew Signature:** _____

Review Signature: _____ **Date Review:** _____

WELL OBSERVATIONS

Protective Casing / Vault: - Intact - Damaged - **Locked:** Yes - No **Well ID Mark**: Yes - No

Notes:

_____

CALCULATIONS

(A) Depth to Well Bottom	ft
(B) Pre-Purge Depth to Water	ft
(C) Water Column Height (A-B)	ft
(D) Casing Factor: 4"=0.65 5"=1.02	
(E) One Well Casing Volume (C x D):	gal
(F) Depth to Top of Screen	ft
(G) Depth to Bottom of Screen	ft
(H) Saturated Filter Pack Length (G –F, or B)	ft
(I) Casing/Borehole Factor 4/10 = 1.2, 5/10 = 1.07, _____	

(J) Filter Pack Volume (H x I)	gal
(K) Min Purge Volume (E + J)	gal
EQUIPMENT / MODEL	**ID NUMBER**
Parameter Meter	
Turbidity Meter	
Pump	
Field Alkalinity	

PURGING INFORMATION

Description first water purged:

_____

Date and / or Time	Gallons Removed	Depth to Ground-water	Temp (°C)	pH	Spec Cond (mS/cm^2)	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Comment

Page 1 of 2

140705

Form 1. Groundwater Purge Log (Continued 2 of 2)

Shaw Environmental, Inc.

Date and / or Time	Gallons Removed	Depth to Ground-water*	Temp (°C)	pH	Spec Cond (mS/cm^2)	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Comment
Values Prior to Sampling									

Field Alkalinity Result _____

Note: For calculations, additional casing factors (D) and casing/borehole factors (I) can be found in the *Groundwater Investigation Work Plan, Part I: Field Investigation Activities.*

Page 2 of 2

140705

Form 2. Water Quality Meter Field Calibration Log

Shaw
Shaw E & I, Inc.

WATER QUALITY METER FIELD CALIBRATION LOG

Project Name: Kirtland AFB Bulk Fuels Facility Spill **Sampling / Monitoring Activity**: _____ Page ___ of ___

Calibration Solutions Lot Numbers and Expiration Dates: _____

_____

_____

Date / Time	Instrument Model / Number	Parameter / Known Value	Initial Reading	Calibrated Reading	Initials	Comments

140705

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Form 3. Analysis Request and Chain of Custody Record

Shaw™
Shaw E & I, Inc.

ANALYSIS REQUEST AND CHAIN OF CUSTODY RECORD

Reference Document No:
Page 1 of 1

Project Number: 140705
Project Name: Kirtland AFB
Sample Coordinator: Mark Lyon
Turnaround Time:

Samples Shipment Date: 01 JAN 2011
Lab Destination: Empirical Laboratories, Inc.
Lab Contact: Kim Kostzer
Project Contact: Pamela Moss
Carrier/Waybill No.: Fed Ex/

Bill To: Shaw Environmental, Inc. - Accounts P
PO Box 98519
Baton Rouge LA 70884

Report To: Pamela Moss
7604 Technology Way, Suite 300
Denver CO 80237

Special Instructions:

Possible Hazard Indentification: Radiological ☐
Non-hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown ☐

Sample Disposal:
Return to Client ☐ Disposal by Lab ☐ Archive (mos.)

1. Relinquished By (Signature/Affiliation)	Date: Time:	1. Received By (Signature/Affiliation)	Date: Time:
2. Relinquished By (Signature/Affiliation)	Date: Time:	2. Received By (Signature/Affiliation)	Date: Time:
3. Relinquished By (Signature/Affiliation)	Date: Time:	3. Received By (Signature/Affiliation)	Date: Time:

Comments:

Sample No	Sample Name	Sample Date	Sample Time	Container	Ctr Qty	Preservative	Requested Testing Program	Sample Vol	Units	Fil	CID	Condition On Receipt

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Form 4. Groundwater Level Data Form

Page ____ of ____

Site: _____ Name: _____

Date: _____ Project: _____

Well ID	Time	Top of Casing	Well Depth (ft)	Depth to Water (ft)	Comments (pH, temperature, specific conductance)

Measurement Reference Point from: ___ Top of Ground or ___ Top of Casing

Weather Conditions:_____

_____

_____

Other Significant Observations:_____

_____

_____

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APPENDIX E

BFF Spill Quality Assurance Project Plan (QAPjP)

(to be provided based on January 6, 2011 meeting with NMED)

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APPENDIX F

Remediation Services International
Operations and Maintenance Manual, Version 8.xx

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REMEDIATION SERVICES, INT'L

Phoenix S.A.V.E.™ System

Operations & Maintenance Manual, Version 8.xx

©2003 Remediation Services, Int'l
4835 Colt Street, Unit D
Ventura CA 93003
Phone 805.644.8382; email: rsi@rsi-save.com

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Chapter

1

SAFETY INFORMATION

Safety Features Of The Model V3/V4

1. High Coolant Temperature Automatic Shutoff set at 220° F
2. Low Oil Pressure Automatic Shutoff set at 20 psi
3. Engine Over-Speed Protection set at 2800 rpm (programmable)
4. Spark and Flame Arrestor
5. Automatic Fire Suppression System with Manual Discharge Feature
6. Automatic Oil Level Regulator
7. Oversize Radiator Coolant System
8. Well Filter Housing High Water Level Shutoff
9. Locking Access and Service Doors
10. Strategically Located Information and Warning Decals
11. Safety Door Interlocks
12. Low/High Battery Voltage Safety Shutdown
13. High Exhaust Temperature Safety Shutdown
14. Vacuum Lockoff on Propane Fuel System
15. Thermal Resistant Ceramic Coated Exhaust System
16. Low “Recirc” Pressure Safety Shutdown on Spray Aeration Option
17. Lower Explosion Limit Monitoring and Safety Shutdown (Optional)

Operator Safety

1. Make sure that all guards, shields and shrouds originally installed on the machine are properly in place and in good working order.
2. Make sure that the fire suppression system is properly charged.
3. The unit is to be operated by one person only. Keep everyone except authorized personnel away, while the machine is operating.
4. Never touch the exhaust system, its support assembly, or the exhaust duct.
5. Keep hands away from moving parts while the unit is running.
6. Operate machine in adequately ventilated areas only. Carbon monoxide is a dangerous gas that can cause serious injuries or death.
7. Use extreme caution when handling Liquid Propane Gas (LPG) fuel and store the LPG in approved containers only.
8. Wear ear protection when operating equipment or in immediate area of the unit.
9. Be sure that the machine housing is bolted to the transporter before moving.

Area Control And General Safety

1. Smoking is prohibited, at all times, in venting area.
2. Start up and maintenance personnel will keep a fire extinguisher readily available at all times.
3. When the machine is being started or being serviced, access to the machine and the work area will be limited to maintenance personnel ONLY in order to reduce the possibility of physical injury to visitors or the public.
4. The operator or maintenance technician is responsible for keeping unauthorized person(s) out of the area. Authorized visitor(s) will be instructed to remain clear of Remediation Unit until they have been briefed on safety.
5. When the unit is operating unattended, it must be secured on all sides by a chain link fence, cement block wall or other security barrier. The door to the area will be securely locked.

In The Event Of An Emergency

REMEDIATION SERVICE, INT'L knows of no circumstance associated with the vapor recovery operations of this device that could result in the need for evacuation of the area, other than an the alternate fuel source leak.. Only occurrences not associated with the vapor recovery operation such as fire in an adjacent building, a nearby automobile collision or a natural disaster might necessitate evacuation.

Maintenance personnel, if present and time allows, shall carry out the following steps in the event of an emergency:

1. Turn off engine ignition.
2. Turn off all electronic monitoring equipment.
3. Close valves on propane tank.
4. Disconnect engine from extraction well.
5. Ensure that the public remains at least 50 feet from area.

Otherwise, follow the steps below:

1. Press the EMERGENCY STOP button.
2. Shut off supplemental fuel (Liquid Propane Gas and/or Natural Gas Lines).
3. Vacate the area.
4. Ensure that the public remains at least 50 feet from area.

In An Extreme Emergency

1. Vacate the area and seek any necessary assistance.
2. Perform the above functions only as the operator's personal safety and the general public safety allow.

Chapter

2

WARRANTY INFORMATION

Limited Warranties

Manufacturer warrants the equipment against defective parts or workmanship for a period of six months from the date of delivery, provided that Buyer engages Manufacturer, at Buyer's own expense, to perform an on-site functional test and user orientation prior to initial system operation. Engines, sparks plugs, wires, filters, catalytic converters, accessory items, etc. may have useful lives that are shorter than the warranty period, depending upon physical conditions which exist during use of the product. Warranty claims for parts, which have failed due to a shortened useful life, will not be honored under this warranty. Manufacturer's liability under this warranty is limited to repairing or, at Manufacturer's sole option, replacing the equipment which meets the defective parts and workmanship criteria. All repairs shall be performed at RSI's office, and Buyer shall be responsible for shipment of the equipment to and from RSI's office. In the event repairs are required during the warranty period as a result of the failure of Buyer to perform the minimum periodic maintenance prescribed by Manufacturer, Buyer agrees to pay for such maintenance service and parts at Manufacturer's then current rates.

This warranty shall be void as to any equipment damaged or rendered unusable by the willful act, negligence, tampering, or modification by persons other than Manufacturer, including such damage caused by the use of auxiliary equipment not provided by Manufacturer. Manufacturer assigns to Buyer the benefits of any warranties or guarantees provided to Manufacturer by the manufacturer(s) of any of the equipment components.

THE FOREGOING WARRANTY IS EXCLUSIVE AND IS IN LIEU OF ALL OTHER WARRANTIES (WHETHER WRITTEN, ORAL OR IMPLIED) INCLUDING WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

Chapter

3

BASE UNIT COMPONENTS

Alternator & Battery

The alternator used on the RSI I.C. engine is a single wire system with an built-in voltage regulator. Because the alternator is such an important component in the electrical system, it is recommended that the performance of the alternator be monitored. At every service, monitor the voltage output of the alternator. If a continuous drop in voltage is noticed, it is recommended that the alternator be replaced. Replacing the alternator prior to failure reduces the risk of damage to other components and unnecessary downtime. The battery installed with your I.C. engine is specified to exceed the requirements of the standard operating parameters of the electrical system.

Note ! The Alternator is manufactured to RSI specifications. Do not replace the alternator with anything except an official RSI Alternator.

MAINTENANCE – SEE PAGE 67
TROUBLESHOOTING – SEE PAGE 42

Automatic Oil Level Regulator

The engine is equipped with a reservoir, and an automatic valve maintains proper engine oil level for extended unmanned operation. The V3 or V4 must be placed in a level position for this component to operate correctly.

MAINTENANCE – SEE PAGE 68
TROUBLESHOOTING – SEE PAGE 43
AND SEE MURPHY SHUTDOWN CONDITIONS, APPENDIX B

Carburetor

The RSI designed Phoenix 1000 carburetor system is controlled by the Phoenix 1000 S.A.V.E. Controller. The carburetor is unique in design in that it allows for two fuel sources and two air sources to be blended in such a way that the engine will always favor the waste stream over the alternate fuel (propane or natural gas) while at the same time maintaining a given RPM and controlling emissions.

MAINTENANCE – SEE PAGE 68
TROUBLESHOOTING – SEE PAGE 44

Catalytic Converter

The catalytic device installed is an automotive type with non-replaceable monolithic elements. This device requires no maintenance; however it will need to be replaced periodically. For example, although the manufacturer states that a 4,000-hour operating life is achievable, replacement may be necessary much earlier due to certain site conditions.

The Catalytic Converter has five distinctive components:

1. Pre-Cat Temperature Gage – This device measures the Exhaust Temperature before the exhaust reaches the Catalytic Converter.
2. Catalytic Converter.
3. Post-Cat Temperature Gage – This device measures the Exhaust Temperature after the exhaust has passed through the Catalytic Converter.
4. Two Pre-Cat Sample Ports – These ports allow for measurement of the Exhaust Pressure and or emissions before the exhaust reaches the Catalytic Converter.
5. Post-Cat Sample Port – This port allows for measurement of the Exhaust Pressure and or emissions after the exhaust reaches the Catalytic Converter.

Recommendations!

RSI suggests monitoring the exhaust temperature, pre and post catalyst, under a "static" condition in order to establish and document the engine's Normal readings.

A "static" condition is defined as:

1. the engine is warmed up and running at the Set Point RPM,
2. the Exhaust Temperature is at its stable operating temperature (greater than 650 degrees °F), and
3. no well gases are being processed. (Insure the RSI V3 or V4 is disconnected from any and all wells before taking readings).

If the Automotive Catalytic Converter is operating properly, the conversion/oxidation of CO, NO_x and VOC from the engine will cause a slight temperature rise across the catalyst. In other words, the temperature at the Post-Cat Temperature Gage will be higher than the temperature at the Pre-Cat Temperature Gage.

MAINTENANCE – SEE PAGE 68
TROUBLESHOOTING – SEE PAGE 47

Controller

The designed Phoenix 1000 Controller is a microprocessor based engine air/fuel ratio controller with data logger and telemetry functions. The engine and all related components and modules are totally controlled by the Controller system.

MAINTENANCE – SEE PAGE 70
TROUBLESHOOTING – SEE PAGE 47
OTHER RESOURCES – SEE \RSI MANUALS\PHOENIX HOST SOFTWARE

Controller Compartment Cooling & Filtering

The controller compartment houses the Phoenix Controller, the Breakout PCB, the optional Modem, cables and other optional electronic components. The compartment is cooled separately from the main engine compartment through the use of a muffin fan. Separate air/particulate filtering is provided by use of a foam automotive style filter.

MAINTENANCE – SEE PAGE 70
TROUBLESHOOTING – SEE PAGE 48

Electronics

Each engine includes a state-of-the-art Phoenix Controller for monitoring and process control of the remediation process. Optional data acquisition and storage, remote valve control, remote start/stop, and remote telemetry features are also available. The interconnect system is comprised of a Breakout PCB and an additional Power Distribution PCB which uses D-connector, keyed power connector and terminal block connections.

MAINTENANCE – SEE PAGE 71

Engine

The I.C. engine is an industrial version 460 C.I.D. Ford Model LSG-875, modified and remanufactured to RSI specifications. The engine is totally controlled by the Phoenix 1000 S.A.V.E. Controller computer system. The engine serves as both a vacuum pump and as a means of destroying hydrocarbon vapors removed from the soil. The internal combustion engine is a specially manufactured industrial type capable of being co-fired by propane or natural gas. Halogenated compounds and chlorinated chemicals are not appropriate for destruction with the RSI I.C.E. The engine is outfitted with an emission control system, including a catalytic converter, fully automated controller/carburetor system with proportioning valves for continuous automated control of well vapors, alternate fuel and dilution air. The engine is equipped with an automotive style muffler for noise control; an automatic oil level device and automotive type cartridge filters.

MAINTENANCE – SEE PAGE 72
TROUBLESHOOTING – SEE PAGE 50

Engine Cooling

Engine cooling is accomplished through the use of an oversized radiator cooling system to insure safety and long life. There is an overflow reservoir installed for checking the coolant level and filling the radiator. A standard 160 degree automotive thermostat comes installed in the engine.

MAINTENANCE – SEE PAGE 74
TROUBLESHOOTING – SEE PAGE 53

Fire Suppression System (Automatic)

One (1) automatic **Kidde IND 21** Dry Chemical Suppression System, with two (2) rate compensated thermostats and manual actuator are included in the Base Model. The Kidde IND 21 Dry Chemical Suppression System includes a standard dual nozzle distribution system.
The system is intended for use as fire suppression equipment on heavy-duty vehicles that are used in both "on-road" and "off-road" applications. The system consists of:

1. one stored pressure cylinder which contains 21 pounds of tri-class (ABC) dry chemical extinguishing agent,
2. manual and electric activating devices for discharge of the agent, and
3. an arrangement of flexible hoses and nozzles which delivers the fire suppressing agent to the engine compartment.

The dry chemical is not toxic. However, combustion gases from fire are poisonous and must not be inhaled. The Dry Chemical Kidde Ind 21 Fire Control system will discharge automatically when specific events occur. For example, the Fire Control system will automatically discharge if the temperature in the Engine Compartment rises faster than the pre-determined rate set in the system or reaches a higher than allowable temperature. However, if a fire is detected anywhere in the unit, do not wait for the internally supplied system to discharge automatically. Pull the safety pin out of the electro-mechanical actuator and strike hard (pushing inward) on the actuator knob. Leave the unit and stand by with a portable extinguisher.

Caution: Do not attempt to open the engine compartment until the Fire Department arrives, or the housing has cooled down and no signs of fire exist.

MAINTENANCE – SEE PAGE 75
TROUBLESHOOTING – SEE PAGE 53
OTHER RESOURCES - \VENDOR MANUALS\KIDDE FIRE CONTROL MANUAL

Flow Measurements

The Phoenix Controller estimates the extracted Well, Dilution Air, and Supplemental Fuel Flow. The Phoenix Controller displays the estimated scfm (standard cubic feet per minute) rate in the status window. A more accurate flow device is available for all process flows as an option. The Velocity Probe Interface Kit and Flow Box are connected between the well and the Phoenix Controller. The actual well volume readings are displayed and recorded in the Phoenix Controller. See Flow Box Manual for complete information.

OTHER RESOURCES - \RSI SOFTWARE\PHOENIX FLOW BOX TECHNICAL MANUAL
- \VENDOR MANUALS\UNITED SENSOR PROBE

Frame And Housing

Unitized frame and housing of heavy gauge sheet metal, with "slide-in/slide-out" engine capability. Cabinetry and certain other components are powder coated for durability and appearance. The cabinets feature large lockable access doors for easy maintenance and operation. The cabinet has been designed to achieve the best balance between service capability, noise reduction and security.

MAINTENANCE – SEE PAGE 76

Propane/Natural Gas Flow Meter

A positive displacement totalizing mechanical flow meter is installed on the unit to mechanically measure fuel usage. An optional Magnetic Reader is also available. This Magnetic Reader electronically senses the fuel flow rate. The information is displayed and recorded in the Phoenix Controller.

Spark And Flame Arrester

A spark arrester is installed on the engine exhaust to protect the well gas source from any flash back from the engine. There is an additional flame arrester pad located in the carburetor adaptor plate located between the carburetor and intake manifold. There are two types used depending upon system configuration. One that is mounted inside the intake manifold adaptor housing which is used for standard units, and the the other that is self-contained and installed in between the intake manifold and the carburetor. The second one is used for units that operate under load (i.e. generator or load modules are installed).

MAINTENANCE – SEE PAGE 79
TROUBLESHOOTING – SEE PAGE 55

Supplemental/Alternate Fuel Control System

The V3 and V4 models are plumbed to use both Propane (LPG) and Natural Gas fuels depending on your preference. . The Phoenix Auto-Fuel Control system is an electro-mechanical system that manages the flow of the fuel and air to the engine. The Phoenix 1000 S.A.V.E. Controller automatically adjusts the supplemental fuel flow to compensate for changing influent hydrocarbon concentrations and maintains an air/fuel ratio at or near stoichiometric combustion. The goal of the Supplemental Fuel Control system is to provide the minimum amount of alternative fuel needed so that the engine favors contaminants drawn from the well.

Supplemental fuel may be either Liquid Propane Gas (LPG), or Natural Gas delivered at 7"-10" H_2O pressure. **Consult RSI for any other type of fuel configurations.**

Liquid Propane Gas (LPG)
Use liquid withdrawal LPG tanks with no pressure regulator. The V3/V4 unit is equipped with a propane regulator/vaporizer system that will convert liquid propane to vapor and reduce pressure to specified operating conditions. Do not draw liquid propane fuel from bottom tank fittings because oil and other contaminants may be present, and may void part or all of the warranty. Insure that propane tank is emptied and cleaned prior to installation. An external 3/8" propane male NPT fitting is provided for ease of connection to a supplemental propane fuel source.
Natural Gas
Natural gas can also be used with RSI V3 and V4 remediation systems. The natural gas fuel is supplied to the RSI V3/V4 engine through an existing 1" female NPT three-way ball valve/engine. The natural gas supply must be regulated to approximately 1/4 psi, or 7" - 10" H2O WC (household) pressure. Flow is controlled by a normally closed solenoid valve. The customer supplies the natural gas and pipe fittings needed to connect to the RSI unit.

Important !
THE PROPANE OR NATURAL GAS SUPPLY LINE MUST BE CLEARED OF ANY AND ALL DEBRIS BEFORE USE. THE LEADING CAUSE OF FAILURE IN THE LPG VAPORIZER IS "DIRTY" FUEL. WHEN SELECTING AN LPG FUEL SUPPLIER, INSIST THAT THE STORAGE TANK BE NEW, OR THAT THE STORAGE TANK BE CLEANED AND FREE OF OIL. THE STORAGE TANK MUST PROVIDE TOP LIQUID DRAW FITTINGS. MAKE SURE THAT THE SUPPLIER DELIVERS LPG FUEL WHICH IS FREE OF OIL. MAJOR ENGINE DAMAGE CAN OCCUR FROM "DIRTY" PROPANE. THE WARRANTY ON THE ENGINE AND RELATED COMPONENTS IS VOID WHEN HEAVY DEPOSITS OF PROPANE OIL ARE FOUND IN THE FUEL SYSTEM.

MAINTENANCE – SEE PAGE 85
TROUBLESHOOTING – SEE PAGE 57
OTHER RESOURCES – \VENDOR MANUALS/IMPCO MANUAL

Well Gas Filter Housing And Water Trap

The system includes a well gas filter and small (1 gallon) water trap with high-level shutoff switch. Larger capacity tanks for Dual-Phase Extraction and condensate knockouts are available as an option. An auto-drain feature is available as an option on all models. For more information, see the section on Optional Components.

MAINTENANCE – SEE PAGE 82
TROUBLESHOOTING – SEE PAGE 58

Well Gas Hose

A 2"x 15' well gas vacuum hose is supplied for connecting the well gas filter housing to the extraction manifold. Hose connection to the well gas filter housing is via a 2" male cam-lock located on one end of the hose. The other hose end is connected to the plumbing manifold supplied by the customer via a 2" female cam-lock connection.

Chapter 4

OPTIONAL COMPONENTS

BASE UNIT/OPTIONS DIMENSIONS	V3		V4	
	SIZE	LBS	SIZE	LBS
Base Unit - Dimensions	13'5"L x 6'4"W x 5'5"H	2260#	17'5"L x 6'4"W x 5'5"H	4420#
With Spray Aeration Module	17'5"L x 6'4"W x 8'0" H	3210#	23'5"L x 6'4"W x 8'0" H	5370#
With Cat Ox Module	17'5"L x 6'4"W x 8'0" H	3245#	23'5"L x 6'4"W x 8'0" H	5405#
With Spray Aeration & Cat Ox Modules			27'5"L x 6'4"W x 8'0" H	6355#
GenSet Module		+ 580#		+ 580#
Load Blower Assembly Module		+ 490#		+ 490#
Stand (If no Transporter is used.)		+ 185#		+ 185#
Transporter, Single Axle	13'L	540#	13'L	540#
Transporter, Dual Axle (Note 1)	17'L	740#	17'L	740#
Transporter, Triple Axle (Note 2)	23'L 27'L	940# 1140#	23'L 27'L	940# 1140#

Note 1: Equipped with either surge or electric brakes
Note 2: Available with electric brakes only

Air Compressor Module

This option is an engine driven air compressor capable of delivering 12.4 scfm of air at 100 psi. This module is commonly used to provide compressed air to downwell pneumatic pumps.

MAINTENANCE – SEE PAGE 67
TROUBLESHOOTING – SEE PAGE 41

Air Injection On/Off Valve Control

This option provides "ON/OFF" valve control using a 12-volt external relay control unit. The option will control up to 16 injection points (wells) and can be controlled either locally or remotely as desired. The user supplies the Solenoid valves.

TROUBLESHOOTING – SEE PAGE 42

Cat-Ox Module

The patented RSI S.A.V.E.™ II high flow catalytic oxidizer module (CAT-OX) is unique in that it uses the waste heat of an internal combustion engine to pre-heat an industrial catalyst for the destruction of hydrocarbon vapors recovered from contaminated soil. This differs from conventional catalytic oxidizer systems, as they require auxiliary fuel for catalyst pre-heating. The engine also provides power for the positive displacement blower and generates electricity for the instrument panel, control valves, and the controller. No outside electrical connections are required to operate the RSI S.A.V.E.™ II high flow CAT-OX.

The S.A.V.E.™ II CAT-OX is an exciting addition to the S.A.V.E.™ family which, under certain conditions, can triple the well flow rate capacity of the base system and increase the destruction rate of hydrocarbons with virtually no additional operating cost. The S.A.V.E.™ II CAT-OX has two oxidizers operating individually and in parallel with each other, not in series (either/or) as conventional thermal/catalytic oxidizers do.

The S.A.V.E.™ II CAT-OX has been designed to mount on the end of the optional dual axle trailer that also houses the base S.A.V.E.™ system. The moisture knockout tank is a stand-alone device and is not mounted to the trailer. It is connected via 3" well gas hose to the intake of the positive displacement blower. The cabinet is built with space needed to mount the additional components necessary in operating the CAT-OX. All new S.A.V.E.™ systems can accept a CAT-OX module and its related components at a later date, if desired.

The S.A.V.E.™ II high flow CAT-OX was developed as an addition to the existing internal combustion engine based vapor recovery and water treatment system known as the S.A.V.E.™ System, and does not operate on a stand-a-lone basis. The patented base S.A.V.E.™ Systems are developed to extract gasoline and its vapors from the soil and groundwater. The four, six or eight cylinder internal combustion engines use recovered gasoline vapors as fuel. If insufficient fuel is available, auxiliary fuel such as propane or natural gas is supplemented to achieve the correct air/fuel ratio for complete combustion to occur. The mechanical work produced by the engine supplies power to all components and produces waste heat utilized by the CAT-OX.

The catalyst used in the S.A.V.E.™II CAT-OX is made up of a high cell density ceramic or metal substrate that has been coated with platinum group metals. The ceramic or metal substrate provides the support and surface area needed by the catalyst to provide high volumetric activity, low-pressure drop, and long service life. The catalyst was designed for high solvent oxidation efficiency with superior resistance to deactivation.

The heat produced by the exhaust of the engine is utilized by the CAT-OX to pre-heat the internal catalyst. The waste exhaust heat mixes with a pre-heated vapor stream extracted from the soil via a positive displacement blower. A heat exchanger pre-heats the incoming vapor using the CAT-OX stack effluent. The combined exhaust and vapor pass through an industrial catalyst where the unburned hydrocarbons are oxidized creating a temperature rise across the catalyst. The products of oxidation, carbon dioxide and water are then discharged to the atmosphere.

The total flow rate through the CAT-OX is a function of the exhaust heat as well as hydrocarbon concentration and its heating values. At a low concentration of hydrocarbons (less than 2% LEL of fresh gasoline) less heat is available from the combustion of the hydrocarbons to pre-heat the inflow vapor stream and maintain required temperature in the CAT-OX, therefore, the total flow must decrease to achieve operational equilibrium. If the hydrocarbon concentration is higher than 25% LEL, then the well flow rates will be reduced to insure over heating conditions do not occur.

Weathered hydrocarbons generally have a lower heating value which, when passed through the catalyst, produces a lower temperature rise than the same concentration of fresh hydrocarbons. The concentration of hydrocarbons and/or flow rate must be decreased when treating a vapor stream with a high heating value, as the post-catalyst temperature may reach its high limit because of a higher temperature rise across the catalyst. This is accomplished automatically using the Phoenix 1000 CAT-OX Controller.

MAINTENANCE – SEE PAGE 69

TROUBLESHOOTING – SEE PAGE 46
OTHER RESOURCES - \VENDOR MANUALS\JOHNSON-MATTHEY

Dual-Phase Extraction (DPE) Autodrain Module

This module is used for projects that require free product and/or groundwater removal in conjunction with high vacuum, Dual-Phase soil venting and groundwater extraction process. This module may also be used to store, and then discharge condensate that accumulates during the normal system operation. The Dual-Phase Extraction/Treatment module consists of a Vacuum Knockout Tank, Discharge Pump, Water Level Controls, and On/Off Relays (Safety Shutoff Switches) for process flow control.

The Dual-Phase Extraction (DPE) module with the auto-drain feature was introduced by RSI as a means to accomplish two separate tasks:

1. First, simply as an auto drain system to remove unwanted condensate from the process automatically. It works by separating entrained liquids that condense from the extracted air/fuel soil vapor during the normal soil vapor extraction (SVE) process. The "vapor phase" is directed into the internal combustion engine (ICE) for oxidation purposes, and the liquids are held inside the holding tank of the DPE module. Once the liquid inside the holding tank reaches a predetermined level, a pump (capable of overcoming the ongoing high vacuum SVE process) is turned on to discharge the liquid to a holding tank or an oil water separator, pending further treatment. If only water is present in the DPE tank, (in other words, no free floating product is present), the DPE module may discharge its contents directly into RSI's Spray aeration module for further treatment. Normally this process creates minimal amounts of liquid, for example 10 to 20 gallons per day.

2. A second use for the RSI DPE module is to purposely remove both liquids and vapors from the subsurface by applying a high vacuum to a one inch (1") diameter or smaller extraction "stinger" pipe located inside a groundwater/vapor extraction well. The high vacuum on the extraction pipe causes an increase in air velocity, which in turn "lifts" the liquid along with the vapor at varying rates, anywhere from 1 gpm (gallon per minute) to 10 gpm depending, upon site conditions and well construction. The "vapor phase" is directed into the internal combustion engine (ICE) for oxidation purposes, and the liquids are held inside the holding tank of the DPE module. Once the liquid inside the holding tank reaches a predetermined level, a pump (capable of overcoming the ongoing high vacuum SVE process and the rate of liquid influx) is turned on to discharge the liquid to a holding tank or an oil water separator, pending further treatment. If only water is present (in other words, no free floating product is present), the DPE module may discharge its contents directly into RSI's Spray aeration module for further treatment. If product is present, it must be removed first (usually by an oil water separator), and then the remaining dissolved contaminants can be treated by the Spray Tank Module.

MAINTENANCE – SEE PAGE 70
TROUBLESHOOTING – SEE PAGE 48

Genset Module

The GenSet Module consists of a direct drive generator powered by the onboard Natural Gas/Propane engine that is in turn controlled by the Phoenix Control System. The Genset Module provides a source of AC power for local and/or distributed power generation.

MAINTENANCE – SEE PAGE 76
TROUBLESHOOTING – SEE PAGE 53
OTHER RESOURCES - \VENDOR MANUALS\MARATHON ELECTRIC

Inlet And Exhaust Flow Measurement

The Phoenix Controller estimates extracted well, dilution air, and supplemental fuel flow and shows estimated scfm (standard cubic feet per minute) rate via the computer/processor display. It does so based on carburetor valve positions in relation to engine manifold vacuum.

A more accurate flow device is available for all process flows as an option and the information is displayed and recorded in the Phoenix Controller. The optional Flow Box module (hardware and software) provides exact measurements of the extracted well flow(s) based on established parameters such as atmospheric pressure, line pressure, temperature and pipe size. The RSI Flow Box hardware, when coupled with the pressure differential velocity probe, provides the ability to:

1. Measure the static line pressure, pressure differential, and temperature in a given flow of gases
2. Compute the flow rate in various sizes of pipe corrected to standard cubic feet per minute (scfm) based on certain constants and measurements taken by the pressure differential velocity probe, and
3. Redefine the parameters/constants such as pipe size, moisture content, molecular weight of the flowing gases, and altitude/elevation for each of the flows monitored by the RSI Flowbox.

The RSI Flow Box Host Software (FBHost Software) provides the ability to:

1. Read process gas flows (in scfm), gas temperatures, line pressures and pressure differential for each flow measured, two per flow box, and
2. Receive and record all pertinent data into the Phoenix Controller for future download via a unique graphical user interface and PHHost Software.

TROUBLESHOOTING – SEE PAGE 54
OTHER RESOURCES - \VENDOR MANUALS\UNITED SENSOR

Load Module

The load module comes in one of three designs: electric (requires generator), air (requires PTO), or hydraulic. The customer need determine which approach is most appropriate. In all forms, its basic function is to add "load", or in other words, make the engine work harder than it does at idle RPM. This results in the engine requiring more fuel, and therefore more air. In general, it increases the system's BTU throughput capacity directly in proportion to how much load is added. The operator has full control over the amount of load that can be added, or taken away.

Electric based load banks consist of the Genset module, plus an electrical automatic load bank. The load bank consists of varying sizes of heating elements, usually placed in front of the engine's radiator fan for cooling purposes. The load bank allows the operator to determine the kW elements that are on at any given time and at the same time will automatically switch off load in favor of demand from another source such as a down well pump or area lighting as the case may be.

Air based units are simply large Roots RAI 68 positive displacement blowers made to discharge air at a high back pressure so as to add mechanical load to the engine.

The Hydraulic Load Module is by far the most favored approach. Loading the system is accomplished by adding a hydraulic pump driven by the existing engine, where hydraulic oil is pumped through a closed loop system consisting of a hydraulic oil reservoir tank, an air to liquid heat exchanger, a filter, a primary control valve and various other control valves. The total number of valves depends upon system configuration. All manually operated valves are preset at the factory for specific operating conditions and should not be adjusted without first consulting the manufacturer for guidance.

OTHER RESOURCES - HYDRAULIC LOAD MODULE/..\VENDOR MANUALS\ROOTS URAI BLOWERS ..\VENDOR MANUALS\MARATHON ELECTRIC

Oil/Water Separator

The Oil/Water Separator module is available on a skid or trailer mounted as a pre-processing stage for the water systems. These are slant ribbed coalescing separator and skimmer units used to remove hydrocarbon based free product from the water stream.

MAINTENANCE – SEE PAGE 76
TROUBLESHOOTING – SEE PAGE 54
OTHER RESOURCES - \VENDOR MANUALS\MILTRONICS
\VENDOR MANUALS\PARKSON SEPARATOR

Positive Displacement Blower Module

Various models of Positive Displacement Blowers capable of injecting/extracting various amounts of air at varying pressures are available. The Positive Displacement Blower requires either the PTO or Genset Module options.

MAINTENANCE – SEE PAGE 79
TROUBLESHOOTING – SEE PAGE 55
OTHER RESOURCES – \VENDOR MANUALS\ROOTS POSITIVE DISPLACEMENT BLOWER

Power Take-Off (PTO)

Power Take-Off units are available with each engine to provide mechanical power to PD blowers, compressors and pumps.

MAINTENANCE – SEE PAGE 79

Project Manager Proportional Valve Control

This option provides Proportional Valve Control for up to 16 extraction points (Wells) and can be either locally or remotely controlled as desired.

TROUBLESHOOTING – SEE PAGE 54

Spray Aeration Module

A specialized groundwater treatment system consisting of a Spray Aeration Tank, Water Circulation Pump, Water Level Controls, Liquid To Liquid Heat Exchanger (Electrical Heating Elements available as an option), Spray Nozzle and On/Off Solenoids for process flow control.

RSI's patented Spray Aeration system uses the same principles as conventional air stripper technologies. However the RSI Phoenix System enhances the stripping process:

1. by maximizing the surface area between groundwater and air using a finely atomized spray, and
2. by the introduction of heat and vacuum.

These improvements greatly enhance RSI's ability to remove contaminants from groundwater.

The Internal Combustion Engine (ICE) generates a vacuum. That vacuum lowers the overall operating pressure and enhances the transfer of organic contaminants from the groundwater to the Air Phase.

The Waste Heat generated by the Internal Combustion Engine (ICE) is used to increase the temperature of the contaminated groundwater. The higher temperature increases the transfer rate of the contaminants from the groundwater to the Air Stream (Air Stripping phase).

Water level in the Spray Aeration tank is maintained between 34 gallons and 55 gallons. The water in the Spray Aeration Tank is constantly re-circulated through a spray nozzle at 70 to 80 gallons per minute (gpm) with a backpressure of 15 to 30 psi. Actual values will depend upon Spray Tank Vacuum while in use.

An example of how a balanced process works is as follows:

1. If the flow rate from the ground is 10 gpm, then statistically the Phoenix unit will process 10 gallons of water 7 to 8 times through nozzle in the Spray Aeration Tank. If the flow rate from the ground is decreased, then the influent (contaminated groundwater) remains in the Tank longer and makes more passes through the nozzle in the Spray Aeration Tank.
2. Therefore, a flow rate of 5 gpm delivery rate will produce 14 to 16 passes through the nozzle in the Spray Tank, a flow rate of 2.5 gpm will allow 32 passes, and at 1 gpm about 64 passes..
3. Water is also discharged from the Spray Aeration Tank using the same pump used for re-circulating the Contaminated Water. Water is discharged from the Spray Tank by opening and closing a Solenoid Valve that is in turn controlled by the Float Control System. When the Solenoid Valve is opened, the re-circulating pump discharges a minimum of 10% of its flow capacity out of the Spray Aeration Vessel while continuing to process the remaining water.

Optimum performance can be achieved if:

- the water temperature is maintained at a minimum of 110 degrees °F,
- the Spray Tank Vacuum is maintained at 12” to 15” Hg, and
- the airflow though the Spray Aeration Tank is maintained at a minimum of 10 scfm.

If more airflow is dedicated to the air stripping process, removal efficiency will increase, but at the same time will limit the amount of process flow from the soil venting process.

MAINTENANCE – SEE PAGE 74
TROUBLESHOOTING – SEE PAGE 156
OTHER RESOURCES – \VENDOR MANUALS\ *****SEE FOLDERS LISTED BELOW***

\ASCO VALVE	**\MURPHY PRODUCTS**
\BETE	**\PERMBERTHY**
\MILTRONICS	**\PRICE PUMP**
\SHERTECH	

Telemetry/Modem

MAINTENANCE - \RSI MANUALS\PHOENIX HOST SOFTWARE
TROUBLESHOOTING MODEM – SEE PAGE 54

Transporter

A specialized heavy tubular frame single axle trailer with 2” ball (5000 lb. rated) and spare tire is available. A dual axle trailer with 2-5/16” ball (7000 lb. rated), with surge or electric brakes, is available as an alternative to the single axle trailer. A triple axle trailer with 2-5/16” ball (10,000 lb. rated) with electric brakes only is also available on special orders.

MAINTENANCE – SEE PAGE 82
OTHER RESOURCES - \VENDOR MANUALS\TRAILRITE MANUAL

Well Gas Condensate Vessel (Larger Capacity Options)

The standard model V3 and V4 systems include a well gas filter and small (1 gallon) water trap with high-level shutoff switch. Larger capacity tanks for Dual-Phase Extraction and condensate knockouts are available as an option. Extra capacity 30 gallon holding tanks which connect to the outlet of the standard well filter via a hose are mounted on a skid, pallet or set onto the ground. Trailer or skid mounted pre-knockout tanks can be installed for water collection before the standard well filter. An auto-drain feature is available as an option on all models.

MAINTENANCE – SEE PAGE 82
TROUBLESHOOTING – SEE PAGE 58

Chapter 5

SYSTEM OPERATION

Phoenix Engine Control System

The operating and maintenance procedures outlined in this manual are intended as guidelines to assist the operating personnel in the day-to-day operation and maintenance of this remediation unit and equipment. Operating personnel should always follow proper safety procedures in accordance with both industry safety standards and their own company safety policies when proceeding with operation, maintenance and repair of the equipment. This manual is neither designed nor intended as a substitute for safe operating procedures which must be followed while implementing the operation procedures outlined in this manual. It is assumed that operation and maintenance personnel are qualified and experienced. The primary responsibility for safety in the operation and maintenance of this system is with the owner-operator and the personnel conducting the maintenance and operation.

Phoenix System Components

The Phoenix Engine Control System consists of the following components:

a. Automatic Carburetor
b. Phoenix 1000 S.A.V.E.™ Controller (Control Panel)
c. Breakout PCB Interface
d. Servo ("Tank") Valve (provided with optional spray aeration tank module)

Overview

The Phoenix Engine Control System (Controller) is designed to optimize cleanup from vapor extraction wells and optimize run time by automatically adjusting alternate fuel, dilution air, and process well valves. In Phoenix Engine Control Systems, which include the spray aeration module, the vacuum applied to the spray aeration tank is also managed by the Controller and the Servo ("Tank") Valve to enhance the water treatment process.

The Phoenix Engine Control System (referred to as "Controller") starts the engine running on a combination of air supplied through the Dilution Air Valve and Alternate Fuel (either LPG or Natural Gas) valve. The Controller continues to provide a mixture of Dilution Air and Alternate Fuel during the idle and warm-up periods. After the warm-up period has passed, and after the pre-cat temperature (the exhaust temperature before entering the Catalytic Converter) reaches 600 degrees °F, the system will automatically switch to "RUN" mode. Once the exhaust temperatures stabilize and a minimum two-minute period has lapsed, the Controller will switch to "O_2" Mode and then automatically begin opening the process/well inlet valve.

The Controller makes whatever adjustments are needed to maintain the set RPM and to hold a near stoichiometric fuel ratio in the engine. This means that while the well/process flow valve is opening, the Controller constantly adjusts the Alternate Fuel Inlet Valve (from the LPG or Natural Gas sources) and the Dilution Air Inlet Valve. If the well is very rich with high concentration of hydrocarbons, the Alternate Fuel Valve (from the LPG or Natural Gas sources) will eventually close to a predetermined minimum valve position. Once the fuel inlet valve reaches its minimum valve position, it causes the Well Valve to stop opening. On the other hand, if the process stream contains only a small amount of hydrocarbons, the Control system will close the Dilution Air Valve to a predetermined minimum valve position where it to will cause the well valve to stop opening. As the well conditions change, the system will continuously adjust the Valves (Well/Tank Valve, Air Fuel Valve and Dilution Valve) to maintain the maximum flow from the Well/Tank source while maintaining a correct air-fuel mixture.

If an optional Spray Aeration Tank (Air Stripping module) has been added to the unit, the Servo ("Tank") Valve must be present.. On these enhanced units, a Servo Valve (labeled "VAC" valve on the controller's display) is connected to the Controller. The quantity of air coming from the Well is controlled in order to maintain a certain vacuum on, and air flow from, the Spray Aeration Tank. The Controller has a "Set Point" value that is entered into the system during the initial start-up or installation of the system. During operation, the system compares the "Set Point" value for the spray tank vacuum stored in the controller with the actual Spray Aeration Tank vacuum reading and will open and close the Spray Aeration Tank valve (Servo Va lve), as needed to maintain tank vacuum at the programmed set point. For more information, refer to Phoenix Set Points.

Servo ("Tank") Valve

The Servo ("Tank") Valve is a standard one-inch gate valve with a box containing a servomotor instead of a manual adjustment handle. The Servo "Tank" Valve is connected to the Controller Electrical Interface panel at the 9-pin connection labeled "Spray Tank Vacuum Control Valve" using a cable with connector as shown in Figure 2. The Servo ("Tank") Valve is installed upstream of any flow/vacuum measuring devices to insure accurate flow and vacuum measurements.

Automatic Carburetor

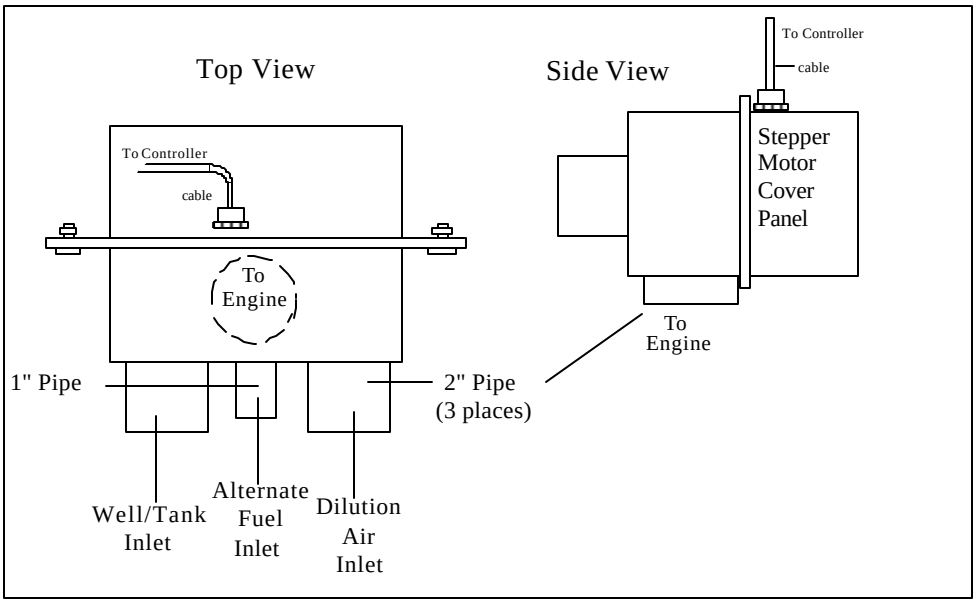


Figure 1. The Automatic Carburetor

Carburetor Interfaces

The automatic carburetor has five connection points: four pipe fittings and an electrical connector.

Hose/Pipe Connections

The carburetor, as depicted in Figure 1, is physically mounted to the Engine Intake Manifold in an upright position as shown in Figure 1 - side view. Three (3) Two -inch (2") pipe fittings are connection to the engine via vacuum rated, gasoline resistant hose at the following points:

- to the carburetor,
- to the Well/Tank
- to the Dilution Air Inlets

A one-inch (1") hose/pipe is used to connect the engine to the Alternate Fuel Inlet using gasoline resistance hose. The carburetor will accept either Propane (LPG) or Natural Gas.

Electrical Connections

There are also three stepper motors that control individual valves at the Dilution Air Inlet, Alternate Fuel Inlet and at the Well/Tank Inlet (process flow). The electrical connection between the Carburetor and the Phoenix Controller is a hard-wired pigtail cable with a 15-pin male connector and a separate ground wire that grounds the shielded cable. The cable is connected to the controller as shown, and the ground should be connected to the chassis of the controller to insure any electrical "noise" from the ignition system is filtered and sent to ground. The Carburetor is connected to the Controller Electrical Interface panel at the 15-pin connection labeled "Carburetor" as shown in Figure 2.

Phoenix 1000 S.A.V.E.™ Controller

The Phoenix 1000 S.A.V.E.™ Controller ("Controller") can be viewed from two perspectives.

1. The Controller Electrical Interface board at the bottom of the Controller is depicted in Figure 2.
2. The Controller Front Panel on the face of the Controller is depicted in Figure 3.

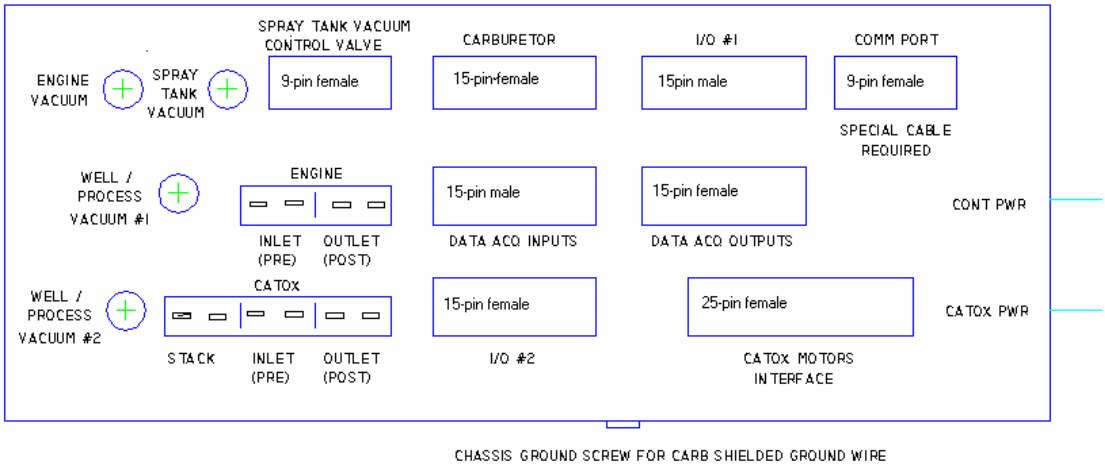


Figure 2. Controller Electrical Interface (bottom view)

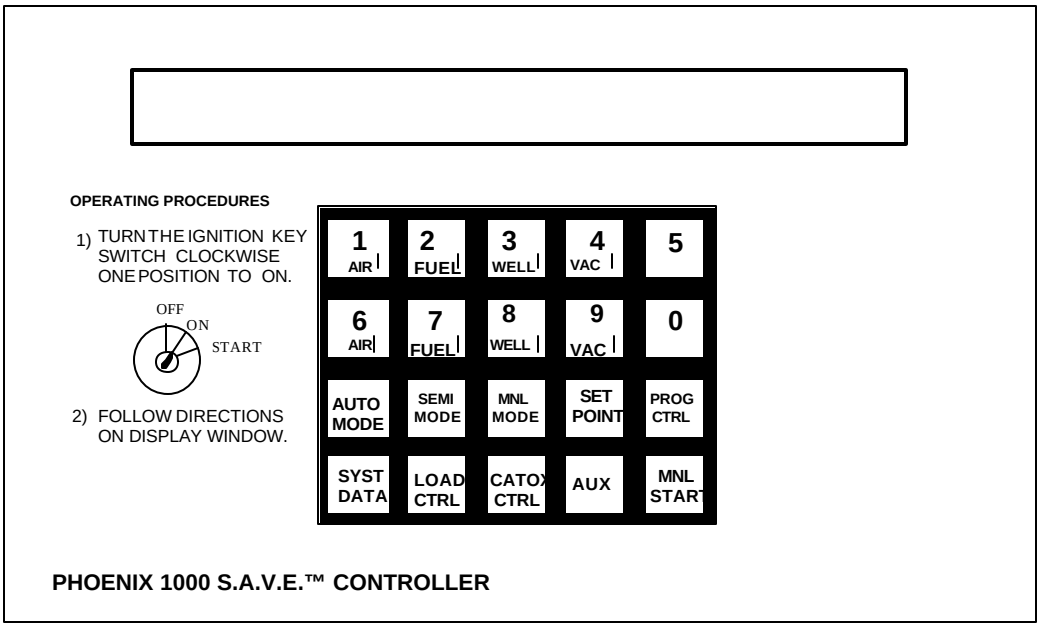


Figure 3. The Controller Front Panel

Controller Interfaces

The following are the standard interfaces normally found on the Controller Electrical Interface.

1. One power cable connection to the breakout board
2. Two type K thermocouple connections
3. Three vacuum hose interfaces
   a. Well Gas Filter housing for measurement of the well vacuum
   b. Engine Manifold vacuum
   c. Spray Aeration Tank vacuum
4. Six serial cable interfaces to the breakout board
5. Carburetor
6. Modem or Data Transfer Port

Enhanced Controller Electrical Interface

Enhanced Controllers include additional interfaces as follows:

a. One additional power cable with connection to the breakout board,
b. Two additional serial cable interfaces to the brake out board,
c. Three additional type K thermocouples, and
d. One additional vacuum hose interface.

Breakout Board

The Breakout Board routes most all wiring to the appropriate devices. Please refer to the “Breakout Board Drawing” in the section #8 for complete details. All cable connector interfaces should be mechanically secured by tightening the two threaded fasteners. The controller power connector(s) are connected to the Breakout Board as labeled.

System Start-Up

Following are the recommended start-up instructions:
The Phoenix Controller Front Panel includes a two line - forty-character Text Display Window and a 20-key entry pad (refer to Figure 3) above. The Text Display Window on the Phoenix Controller Front Panel shows system status and key operating parameters while the system is running. The keypad is used to make system Mode changes and to change critical operating parameters (See Set Point Mode and Program Control).

Note: Normal operation, including Murphy safety switch shut down, is suspended while the system is in Set Point or Program Mode. The system must be returned to one of the three operating modes (Automatic, Semi-Automatic and Manual) for continued operation. The system will automatically default to the previous operating Mode if an operating mode is not selected within 1 minute. For safety purposes, the system will automatically default to AUTO Mode after two minutes if system is left in Manual or Semi Automatic Mode.

Daily Power Up

Follow these steps if the default Set Points has not been previously entered or if changes to those Set Points are required.

1. To turn the system on, turn the key switch clockwise one position to "ON" (refer to Figure 4 above.). The initial display will show the following message:

   PLEASE ENTER ACCESS CODE _ _ _ _ (four-digit)
   To Continue With System Operation

2. Enter the Operator Pass Code or Project Manager Pass Code to proceed. The operator's pass code default is 1234 unless changed by the Project Manager. The display will briefly show the following message:

   PHOENIX S.A.V.E. CONTROLLER
   SERIAL #xxx VERSION #8.xx DATE xx/xx/xx

3. If a modem is not connected to the controller, the display will show:

   Modem not connected or not turned on
   Press 0 to skip or any key to retry

4. If a modem is connected, or the "0" key is depressed as described above, the display will show:

   S.A.V.E. System Controller
   TURN KEY TO START or SELECT FUNCTION

   Note: If this is initial start up, please push the "SET POINT" button to input operating parameters (refer to section V following).

5. If ready to begin operation, turn the key to the "START" position as shown in figure 3.. This will cause the normal Engine Start Sequence. The key will spring back to the "ON" position similar to a normal vehicle ignition switch. On initial power up, the system must calibrate to set the proper valve positions. During calibration, the following message will show:

   Calibration in Progress.....
   Please Wait ...20…19...18...17... all the way to 0
   (Enhanced controllers start counting down at 40 seconds instead of 20 shown)

> **Note:** Enhanced controllers require an additional 40 seconds to initialize valve positions after calibration.

6. The controller will then briefly display:

Calibration Complete

> **Note:** System Status Message may not be visible in all instances due to the controller's upgraded processing speed.

7. If all access doors equipped with Safety Door Interlocks are not closed, the controller will display:

Please Check Engine Compartment Doors
Press Any Key To Continue

8. After all necessary access doors are closed, and a key is depressed, the start-up process will resume.

The system will attempt to start the engine a selectable number of times. Usually the engine will start on the first attempt. While cranking, the following display will show:

CAUTION	**STARTING ENGINE**	**CAUTION**
CAUTION	**Attempt #1**	**CAUTION**

If the engine starts, the display will switch to the normal AUTO display screen (shown below), the status will be "IDLE", and then display "Run" when running rpm and other predetermined criteria are met. If it fails, the system will repeat the start sequence the selected number of times.

Operation

Following is information that is important to the on-going operations of the unit:

Modes of Operation

Automatic Mode

The Automatic Mode will maintain the engine RPM and hold the proper air/fuel ratio for steady running. The system always defaults to the automatic mode during system start up. If the mode was changed to another setting, the system can be re-set to Automatic Mode by pressing the "Auto Mode" button on the keypad as shown in Figure 2. If the key is turned to "start" as described in the Start-Up section of the manual, the unit will automatically start in the "Auto Mode".

In the Automatic Mode and after a predetermined warm up period, the well valve continuously attempts to open to a maximum position that will allow smooth running. This takes place after "O2" mode is reached (when proper exhaust temperatures are achieved) and the baseline "snapshot" is saved into memory. As the Well Valve opens, the air and fuel valves open or close as necessary to maintain engine RPM and a stoichiometric air fuel ratio.

> **Note:** System Status Message may not be visible in all instances due to the controller's upgraded processing speed.

IMPORTANT: The Well Valve will not open if:

a. The RPMs are oscillating beyond the predefined RPM
b. The Engine Manifold Vacuum is below the predefined Manifold Vacuum Set Point (see Program Control Menu)
c. The Valve positions are beyond the predefined Minimum or Maximum Set Point (see Program Control Menu)
d. The exhaust temperature for the pre-cat is below the predefined Minimum Set Point for the pre-cat temperature of 600 degrees °F (see Set Point Menu)
e. Either temp probe is above the predefined limit of 1100 degrees °F (see Program Control Menu), or is not reached a stable condition, or
f. The Well Vacuum has reached the Maximum Set Point (see Set Point Menu).

The Automatic Mode display window shows the status for the key parameters sample shown below:

RPM	AUTO	Flow	AIR	FUEL	WELL	Evac	W/Vac
xxxx	02	scfm	xxx	xx.x	xxx	xx.x	xxx

All estimated flows are expressed in "SCFM", Well Vacuum is expressed in inches of water (H_2O), and Engine Manifold Vacuum is expressed in inches of mercury (Hg). If flow box is installed, the well flow measurement is actual and not estimated.

The Murphy safety inputs are fully functional in the Auto Mode. If a Murphy input shuts the system down, the appropriate Murphy message will appear in the STATUS display of the Control Panel and the system will not attempt to restart the engine. In the Auto Mode, spontaneous engine failures that are not associated with a known fault will initiate the restart sequence. For a description of fault conditions, see "Murphy System Shutdown Conditions/Status Display in the Appendix. For a description of the Restart Sequence, please refer to Start-Up procedures.

Semi-Automatic Mode

IMPORTANT: The "SEMI" mode key should only be used for troubleshooting the system by a qualified RSI technician. Units left to operate in any mode other than "AUTO" are subject to damage and may cause injury. The Controller will automatically switch back to Auto Mode after two minutes of no activity.

The Semi-Automatic Mode is identical to the Automatic Mode except that the Well Valve is operated manually from the Controller Front Panel. The Semi-Automatic Mode is selected by pressing the "Semi Mode" button on the Controller Front Panel keypad as shown in Figure 2 above. The Semi-Automatic mode shows the following typical display:

RPM	SEMI	FLOW	AIR	FUEL	WELL = xxx	TANK = xxx
xxxx	RUN	Scfm	x.x	x.xx	(3? ,8?)	(4? ,9?)

The well valve is gradually opened by pressing the "3" key and gradually closed by pressing the "8" key. Air and fuel valve positions are adjusted by the system to achieve the optimum setting given a fixed well position. The Murphy system is functional during operation in the Semi-Automatic mode.

Manual Mode

IMPORTANT: The "MANUAL MODE" key should only be used for troubleshooting the system by a qualified RSI technician. Units left to operate in any mode other than "Auto" are subject to damage and may cause harm. The Controller will automatically switch back to AUTO Mode after two minutes of no activity.

The Manual Mode of operation is selected by pressing the "MNL MODE" button on the keypad of the Phoenix Controller Front Panel as shown in Figure 3 above and allows the user to operate the valves manually. This offers the greatest flexibility for defining Setup and Operating parameters. However the "MNL MODE" is very sensitive to prevailing conditions because it is unable to compensate for variations. The manual display is as follows:

RPM	AIR= xxx	FUEL= xxx	WELL= xxx	VAC= xxx
xxxx	(?1 ,6?)	(?2 ,7?)	(?3 ,8?)	(?4 ,9?)

The 1, 2, 3, and 4 buttons increase (open) valve positions for air, fuel, well, and tank/vac valve respectively while the 6, 7, 8, and 9 buttons decrease (close) the valve openings.

Starting the Unit in Manual Mode

For trouble shooting purposes, the unit may be started in the "manual mode". To do so, repeat steps one through four as described above in "Daily Power up". When reaching the screen/prompt:

S.A.V.E. System Controller
TURN KEY TO START or SELECT FUNCTION

Press the "MNL MODE". Another screen prompt will follow saying:

System not calibrated
TURN KEY TO Continue

The system will then begin its calibration sequence as describe above, however the system will not attempt to start at the end of the calibration countdown.

Once the system is done calibrating, press the number "5" key on the keyboard. This will command the air and fuel valve to open to their predetermined position. Then, by pressing and holding down the "MNL START" key on the controller, the engine will begin to turn over and start, providing the initial air and fuel positions are set correctly and the system is in good working order. Once the system is running at or near its programmed RPM, press "AUTO MODE" and the controller will take over future operation.

IMPORTANT: Stop pressing the MNL START key after 5 seconds or after the engine starts, which ever occurs first, otherwise damage to the starter and or battery will occur. The Controller will automatically switch back to Auto Mode after two minutes of no activity.

Load Ctrl

The "LOAD CTRL" button is not functional at this time.

Cat Ox Ctrl

The "CAT-OX Ctrl" button is functional if a CAT-OX module is present and if the Phoenix Controller is the "Enhanced" model. See the separate "CAT-OX Operations Manual" for more details. If an Enhanced Controller is installed, but no "CAT-OX" module is present, some data fields are still displayed such as temperature readings, vacuum readings, LEL readings and certain valve positions. The display screens are as follows:

Cat-Ox Main Screen

1 = CatOx AUTO	3 = CatOx MNL
2 = CatOx Data	4 = Reserved

Cat-Ox Option 1 Auto

AIR = xx.x%	WELL = xx.x%	BBP = xx.x%	HBP = xx.x%
LEL = xx.x%	IN = xxxxF	OUT = xxxxF	STACK = xxxxF

Cat-Ox Option 2 Data

Well Flow = xxxscfm		Well Vacuum = xxx in H20	
LEL = xx.x%	IN = xxxxF	OUT = xxxxF	STACK = xxxxF

Cat-Ox Option 3 Manual

AIR = xx.x%	WELL = xx.x%	BBP = xx.x%	HBP = xx.x%
(?1 . 6?)	(?2 . 7?)	(?3 . ,8?)	(?4 . 9?)

Aux Button

Main Menu

1 = Run Summary	3 = Set Time	5 = Time Code
2 = CLR History	4 = Set Date	6 = Tare Flow

The "**AUX**" button is used to:

1. **Run Summary**. Selecting "1" on the Main Menu causes the following information to be displayed: last fault, number of system stalls from last start up and display elapsed time of controller.

Fault: xxx	#Stalls:xxx
Elapsed Time: xxx:xx:xx	

a. **Clear History**. Selecting "2" on the Main Menu causes the following information to be displayed.

Press DATA Key to Clear History Data Press Any Key to Continue

b. **Set Time**. Selecting "3" on the Main Menu causes the following information to be displayed.

Enter Current 24 hr Time (hh : mm)

c. **Set Date**. Selecting "4" on the Main Menu causes the following information to be displayed.

Enter Current Date (mm – dd – yy)

d. **Enter Time Code**. Selecting "5" on the Main Menu causes the following information to be displayed. Contact RSI for assistance if prompted by the Phoenix Controller for data entry.

Contact RSI For Time Extension Code

e. **Flow Tare functions**. Selecting "6" on the Main Menu causes the system to automatically tare the Flow Box (for use with RSI Flow Box option).

Sys Data

The "**SYS DATA**" button is used to select one of eight menu choices as follows:

1 = Valve	3 = Eng/Batt	5 = Flow/VAC	7 = Water
2 = Well	4 = Temp/O_2	6 = Proj Mgr	8 = History

a. Valve. Selecting "1" on the SYS DATA Menu causes the following information to be displayed. The information is the same as "Auto" mode, except the window also displays Air, Well and Fuel Valve positions, Engine Manifold Vacuum and Well Vacuum settings which are used to estimate the corresponding displayed flows when not measured by the optional RSI flow box.

mode	AIR = xxx	FUEL = xxx	WELL = xxx	WVAC = xxx
xxxx	cfm = xxx	xx.x	xxx	EVAC = xx.x

Note: The number values for valve positions do not relate to any operating parameters other than the trend of valves opening and closing. For example: At sites with tight soils, the Well Valve may read 300 because of high vacuum, whereas at a sandy site the Well Valve position may be displayed as 100. Regardless of the readying, both valve positions may be providing the same flow rate. Computed Flow rates are based upon the valve opening and pressure differential. As a result, RSI recommends the use of independent measurements devices supplied by others, or recommends the RSI Flow Velocity Probe and Flowbox Interface option.

b. **Well**. Selecting "2" on the SYS DATA Menu causes the following information to be displayed. The display provides estimates of BTU/Hr and the ppmV of the extracted process stream gasses, and provide cumulative volumes of processed Dilution Air and processed Extracted Vapor from the process stream, and cumulative volumes for Supplemental fuel.

TOTAL WELL	Gas:xxxx00	BTU/Hr: xxxx00	ppmV
VOLUME	x100 : AIR = XXXX	FUEL = XXXX	WELL = XXXX

BTU 1/hr. Estimate:
To estimate the BTU/Hr content in the well, the system first measures the Supplemental Fuel usage (energy in BTUs) while the engine is running at its nominal operating condition with the well/process valve completely closed. Under this condition, all of the energy must be coming from the makeup/alternate fuel source which is either LPG or Natural Gas. The BTU/Hr content of the makeup/alternate fuel can be measured with reasonable accuracy because the energy content per cubic foot of propane and natural gas are well known. For Propane, we use 2520 BTU per cubic foot at atmospheric pressure and room temperature. Natural Gas values vary by region, however, we use 1000 BTU/cubic foot is as an average. This measurement will be labeled "snapshot" in the system's Datalogged information.

Note: To insure an accurate "snapshot", it may be necessary to disconnect the Well Hose and drain the Moisture Knockout Tank to make sure no well gas is being processed by a leaky Valve in the carburetor.

As the well/process valve opens, combustible gasses begin to feed the engine while the required alternate fuel adjusts. The only two sources of energy to run the engine are the alternate fuel and the well. Therefore, any BTU/Hr content not being supplied by the makeup/alternate source must be coming from the well. The estimated BTU/Hr from the well is simply the initial BTU/Hr measurement (adjusted for increased/decreased energy demand due to load changes and or inert gasses in the extracted process gasses simulating a load change), less the present makeup fuel flow, in scfm, multiplied by its BTU per cubic foot content.

PPMv Estimate:
The estimate of ppmV equivalent gasoline in the well flow is the BTU/Hr well content divided by the BTU's per cubic foot of vaporized fresh gasoline (to get cubic feet of gasoline per hour), divided by the total well flow, in cubic feet per hour (to get the fuel to air ratio), multiplied by one million.

Note: The system does not estimate ppmV below 2000 because estimation error increases as the well combustible contents decrease. In particular, the estimate becomes very sensitive to the initial engine starting condition.

a. **Eng/Batt**. Selecting "3" on the SYS DATA Menu causes the following information to be displayed: Oil Pressure, Battery Voltage and Coolant Temperature;

Oil Pressure = xxx psi	Battery = xx.x V
Coolant Temp = xxx deg	Reserved

b. **Temp/O2.** Selecting "4" on the SYS DATA Menu causes the following information to be displayed: Pre and Post Temperature of automotive catalyst and filtered/unfiltered O2 sensor feedback data;

Pre – CAT Temp = xxx deg F	O_2 SENSOR = xxxx
Post CAT Temp = xxx deg F	O_2 SENSOR = xxxx

c. **Flow/VAC**. Selecting "5" on the SYS DATA Menu causes the following information to be displayed: Vacuum and Flow data from optional velocity probes/Flow Interface Option Box.

scfm	F2 = xxx	F3 = xxx	F4 = xxx	F5 = xxx	F6 = xxx
Inches H_20	V2 = xxx	V3 = xxx	V4 = xxx	V5 = xxx	V6 = xxx

d. **Project Manager.** Selecting "6" on the SYS DATA Menu causes the following information to be displayed.

Select Project Manager Manifold Manifold # = _

1. Typing a "1" in the window displayed above will cause the following new display. Project Mgr Display – Main 1.

Project Manager	1 = Valve Positions
Manifold #x	2 = Solenoid Operation

2. Project Mgr Display – Main 2

PROJ MGR #1 = xxx	#2 = xxx	#3 = xxx	#4 = xxx
MNFLD 3x (?1 . 6?)	(?2 . 7?)	(?3 . ,8?)	(?4 . 9?)

3. Project Mgr Display – Option 1, Positions

Project Manager #x	Solenoid: xxx
Project Manager #x	Solenoid: xxx

4. Project Mgr Display – Option 2, Solenoid Operations

e. **Water**. Selecting “7” on the SYS DATA Menu causes the following information to be displayed. The Display Water treatment system data, including recirc (recirculation) pressure, recirc(recirculation) water temperature, S.A.V.E.™ System Tank Vacuum and Tank Valve positions, and cycle counts for Spray Aeration and DPE processes.

Water: Press = xxx	Temp = xxxF	TANK VALVE = xxx
Cycle Cnt: #1 = xxx	#2 = xxx	Tvac = xx.x in Hg

f. **History**. Selecting “8” on the SYS DATA Menu causes the following information to be displayed. Manually insert current system data and status into Datalogger memory to record a specific event at a specific date and time.

Save Current State in History? Press 1 for YES, Any other key to SKIP

Set Point Mode

The Set Points listed below are numeric parameters that effect the system operation and are adjustable by the user. They are saved in the Phoenix Controller memory even when the power is off so that there is no need to enter the menu unless a change in setup is required.

Note: Normal operation is automatically suspended while you are in the Set Point menu.

To change the Set Point selections/options:

a. Upon providing power to the controller, follow the on screen instructions until display reads “Turn Key to Start, or select function”. When this is displayed, press the "SET POINT" button on the Phoenix Controller Front Panel. The Controller Text Window will display the first Set Point “Running RPM” followed by a number of underscores.

Note: Pressing the "SET POINT" button without entering information will cause the Controller to display the next Set Point setting without changing the value of the current "SET POINT".

b. Using the keypad, type or enter a number with the correct number of digits to change the current Set Point setting. Leading zeros must be entered to complete an input.

Note: If an error is made during entry, press the "SET POINT" button to erase the entry and try again.

c. When all digits are input, the new number will be saved automatically and the display will automatically move to the next Set Point setting.
d. Continue to press the “SET POINT” button to loop through all of the menu selections.
e. To exit the menu, press any other Mode button. The System must be returned to one of the three operating modes (Automatic, Semi-Automatic or Manual) for continued operation.

Note: The system will automatically return to the previous operating mode if there is no keypad activity for one (1) minute.

Set Point Function and Normal Values

The following paragraphs describe the function of each set point and offers normal values.

Running Rpm

Default Settings	***Comments***
1800 to 2000 RPM	4-digits, all numeric are required. Always restart the system when changing this setting.

The Running RPM Set Point is the RPM that the system will normally operate at. Higher settings will increase total flow slightly. However, too high a Set Point could decrease engine life while too low of a Set Point value may cause carbon build up on the heads and result in bad emissions. A typical setting is 1800 to 2000 RPM. Units equipped with generators must be operated at 1800 RPM.

Note: Always restart the system when changing this setting. Changing this setting after the system has gone into O_2 mode without restarting the engine will negatively affect the BTU/PPMv estimates.

Max Engine Well Vacuum (In H_2O)

Default Settings	Comments
300 inches of H_2O	3-digits, all numeric are required. Setting this parameter at "300" inches H_2O effectively means there is "no upper limit" on the Well Vacuum..

The *Max Engine Well Vacuum* sets the maximum limit for the vacuum pressure applied to the Well stated in inches of water. The default setting is 300 inches of H_2O. This value is beyond the system's vacuum capacity; the setting of 300 for this parameter value effectively means "no upper limit". This feature is used when it is necessary to control the amount of vacuum placed on the wells, for example, to control groundwater upwelling or mounding.

Max Cat-Ox Well Vacuum (In H_2O)

Default Settings	Comments
180 inches of H_2O	3-digits, all numeric are required. Setting this parameter at "180" effectively means there is "no upper limit" on the Blower Vacuum..

The *Max CatOx Well Vacuum* sets the maximum limit for the vacuum pressure applied to the Well from the CatOx module in inches of water. The default setting is 180 inches of H_2O. This value is beyond the blower's vacuum capacity. Therefore, setting the CatOx Well Vacuum at 180 effectively means "no upper limit". This feature is used when it is necessary to control the applied blower vacuum placed on the well because of groundwater upwelling.

Data Save Interval (Minutes)

Default Settings	Comments
60 minutes	All numeric entry are required. This setting instructs the system to save data at specific intervals specified in minutes.

The *Data Save Interval* is the frequency in minutes that data is recorded to the Datalogger feature of the Phoenix Controller. The Datalogger will store a maximum of 700 recorded events. This includes "sample" events along with scheduled intervals. A normal setting is 60 minutes, which allows for approximately one month of data to be stored (prior to overwriting the oldest data) when operating 24/7.

Program Control

The Program Control settings are Pass Code protected and cannot be changed unless the appropriate Security Access Code has been entered. The default pass code is 5, 6, 7, 8, and along wit the system access code, is changeable by project manager.

Generally speaking, the Program Control Set Points are not changed unless load, elevation, climate conditions, or other variables are causing difficulty starting the engine. Changes to Program Control settings should be made only by an authorized service contractor or by RSI personnel. Program Control Set Points should be recorded for future reference.

For more information on acceptable Program Control settings, see Phoenix 1000 Menus and Default Programming Values.

Program Control Mode

The Program control settings listed below are numeric parameters that effect the system operation and are adjustable by the user. They are saved in the Phoenix Controller memory even when the power is off so that there is no need to enter the menu unless a change in setup is required.

> **Note:** Normal operation is automatically suspended while you are in the Program Control Mode.

To change the Program Control selections/options:

a. Upon providing power to the controller, follow the on screen instructions until display reads "Turn Key to Start, or select function". When this is displayed, press the "PROG CTRL" button on the Phoenix Controller Front Panel. The Controller Text Window will display the first setting called "Selected Data Set" followed by a number of underscores.

> **Note:** Pressing the "PROG CTRL" button without entering information will cause the Controller to display the next setting without changing the value of the current entry.

b. Using the keypad, type or enter a number with the correct number of digits to change the current PROG CTRL setting. Leading zeros must be entered to complete an input.

> **Note:** If an error is made during entry, press the "PROG CTRL" button to erase the entry and try again.

c. When all digits are input, the new number will be saved automatically and the display will automatically move to the next PROG CTRL setting.
d. Continue to press the "PROG CTRL" button to loop through all of the menu selections.
e. To exit the menu, press any other Mode button. The System must be returned to one of the three operating modes (Automatic, Semi-Automatic or Manual) for continued operation.

> **Note:** The system will automatically return to the previous operating mode if there is no keypad activity for one (1) minute.

Program Control Set Points/General Programming

Selected Data Set = _ (Single-Digit Entry)

Selected Data Set: This heading refers to pre-defined groups of values that have been grouped together in sets for ease of programming.

Data Set values:

0 = No default parameter values are written. Each parameter value must be manually set.
1 = Use when process flow inlet concentrations exceed 60,000 ppmV.
2 = Use when process flow inlet concentrations are between 30,000 ppmV and 60,000 ppmV.
3 = Use when process flow inlet concentrations are less than 3,000 ppmV.
4 = Use when RSI S.A.V.E™ Spray Aeration module is in use.

> **Note:** This change does not take effect until the Controller is turned off and then back on.. Re-start the system by following Shutdown procedures and then re-starting the unit using the Start-Up procedures. After initial reboot, return the *Selected Data Set* parameter value to 0. The changes made by changing the data set value will remain. For more information on acceptable Program Control settings, see Phoenix 1000 Menus and Default Programming Values.

Idle RPM = _ _ _ _ (Four-Digit Entry)

Idle RPM is the target RPM value for normal engine operation during idle period. Changes to this value may require changes to the Air Initial Position valve setting and the Fuel Initial Position Valve settings as described below. For more information on acceptable Program Control settings, see Phoenix 1000 Menus and Default Programming Values.

Air Initial Position = _ _ _ (Three-Digit Entry)

Air Initial Position describes the actual incremental air valve opening value of the carburetor for the starting sequence. This setting is automatically increased by 25% of its previous setting when choosing the natural gas option (see below) instead of propane (default). This setting is rarely changed, unless idle RPM as described above is changed, or a major shift in elevation takes place.

Fuel Initial Position =_ _ _ (Three-Digit Entry)

Fuel Initial Position describes the actual incremental fuel valve opening value of the carburetor for the starting sequence. This setting is automatically increased by 25% of its previous setting when choosing the natural gas option (see below) instead of propane (default). This setting is rarely changed, unless idle RPM as described above is changed, or a major shift in elevation takes place.

For more information on acceptable Program Control settings, see Phoenix 1000 Menus and Default Programming Values.

Min Tank Vacuum (Inches Hg) = _ _ (Two-Digit Entry)

Min Tank Vacuum should be set at 12 inches Hg (Mercury) if the S.A.V.E spray aeration module is present, otherwise this parameter should be set to 22 inches Hg. This value is beyond the system's vacuum capacity; the setting of 22 for this parameter value effectively means "no limit". If a water treatment system is present, the setting of 12 maintains the spray aeration tank vacuum at or about 12" Hg. It does so by opening and or closing the spray tank VAC valve as necessary to maintain the tank vacuum at the desired set point. The spray tank VAC valve is connected to the vapor flow from the extraction process. The maximum amount of vacuum that can be placed on the soil venting extraction process is limited to the spray tank vacuum set point. In the default setting of 12, this means a maximum of 12 inches of Hg of applied engine vacuum can be placed on the SVE and/or SAVE processes. The spray tank vacuum will stabilize prior to allowing any SAVE process to begin. Default is for the standard (base) model is 22 inches Hg (Mercury). Default for the Min Tank Vacuum with S.A.V.E.™ Spray Aeration module option is 12 inches Hg (Mercury).

Target Oxygen (Target O_2) = _ _ _ _ (Four-Digit Entry)
Target Oxygen is a factory preset value performed at time of initial start-up. Consult RSI before changing this value. Minor changes to this setting will increase or decrease the effluent emissions depending on specific site conditions. Default value is 1800.

KFRRunO_2 = _ _ _ (Three-Digit Entry)
KFRRunO_2 is a factory preset value performed at time of initial start-up. Consult RSI before changing this value. Default value is 35.

Number Of Restart Attempts = _ (Single-Digit Entry)
Number of Restart Attempts establishes the number of times that the engine will try to start following an engine stall or when the key is first turned on and moved to the start position. This input will normally be set to 0, therefore disabling this feature. Please check with local governing agency to determine if automatic restart is acceptable prior to engaging this option. Default value is "0".

Remote Start= _ ("1"=Enable, "0"=Disable) = _ (Single Digit Entry)
Remote Start feature may be enabled or disabled with this parameter setting. Consult local governing agency to determine if remote start is acceptable prior to enabling this option. Default value is "0".

Fuel Ratio Loop= _ ("0"=Demod, "1"=O2 At T) = _ (Single Digit Entry)
Fuel Ratio Loop is a factory preset value performed at time of initial start-up. Consult RSI before changing this value. Default value is "1".

Fuel Type= _ ("1"=Natural Gas, "0"=Propane) = _ (Single Digit Entry)
Fuel Type tells the controller which fuel source you are using. Default value is "0".

Modem Speed= _ ("0"- 2400, "1"=4800, "2" =9600)=_ (Single Digit Entry)
Modem Speed 0 = 2400; 1 = 4800; 2 = 9600 -- Default setting is 9,600. This sets the speed at which the controller communicates with the target modem. Slower setting may be required for cellular connection or bad landline phone lines.

Number Of Cylinders= _ ("4", "6", "8") = _ (Single Digit Entry)
The *Number of Cylinders* is set to match the number of cycles in the engine, 4, 6 or 8.

Emergency Phone Field #1 - Area Code= _ _ _ (Three-Digit Entry)
Emergency Phone field #1- Area Code is the area code for the 1st telephone number to be contacted should the RSI system stall or go off-line. Enter 000 for a local call in lieu of the area code.

Emergency Phone Field #1 - Prefix = _ _ _ (Three-Digit Entry)
Emergency Phone field #1 - Prefix is the prefix for the 1st telephone number to be contacted should the RSI system stall or go off-line. Enter 000 to disable this feature.

Emergency Phone Field #1 = _ _ _ _ (Four-Digit Entry)
Emergency Phone field #1 - 4 Digits is the remainder of the 1st telephone number to be contacted should the RSI system stall or go off-line.

Emergency Phone Field #2 - Area Code = _ _ _ (Three-Digit Entry)
Emergency Phone field #2 - Area Code is the area code for the 2nd telephone number to be contacted should the RSI system stall or go off-line. Enter 0 for a local call in lieu of the area code.

Emergency Phone Field #2 - Prefix = _ _ _ (Three-Digit Entry)
Emergency Phone field #2 - Prefix is the prefix for the 2nd telephone number to be contacted should the RSI system stall or go off-line. Enter 0 to disable this feature.

Emergency Phone Field #2 - = _ _ _ _ (Four-Digit Entry)
Emergency Phone field #2 - 4 Digits is the remainder of the 2nd telephone number to be contacted should the RSI system stall or go off-line.

System Access Code= _ _ _ _ (Four-Digit Entry)
System Access Code is the Pass Code required to gain access to system for routine operation. *The default value is 1234.*

Control Menu Access Code = _ _ _ _ (Four-Digit Entry)
Control Menu Access Code is the Pass Code required to gain deeper access to the system for changing Control Menu parameter values. During system Set-Up, the Access is normally changed to another, unique code for Supervisor Access only. This change is to protect the Program Code for basic system settings from accidentally being changed. See your System Administrator/System Supervisor or an RSI Technician to make changes to this Access Code or related changes to its sub-menu of options.

For additional details, see Phoenix Host Software manual
and Flow Box manual

Phoenix 1000 Menus and Default Programming Values – Version 8.XX

Set Point Menu Options

Phoenix 1000 Set Point Menu	8-Cyl	6-Cyl	4-Cyl	DESCRIPTION / NOTES
SET POINT MENU				Requires Menu Access or Customer Override Code
Running RPM	1800	1800	2000	Changing this setting may affect system performance unless other settings are modified.
Max Engine Well Vacuum (in H_20)	300	300	300	Well valve will not open past H2O set point
Max CatOx Well Vacuum (in H_20)	190	190	190	Well valve will not open if Well VAC is above the set point
Data Save Interval (minute)	60	60	60	Data save at 60 will save 27 days of data. Clear History before changing this setting.
Total for Menu				

Program Control Menu

CONTROL MENU	8-Cyl	6-Cyl	4-Cyl	Requires Menu Access or Customer Override Code
Selected Data Set	0	0	0	0=none, all custom; 1=Data Set 1, 2=Data Set 2, etc.
Idle RPM	1800	1800	1800	Changing this setting may also affect initial air and fuel valve positions described below
Air Initial Position	90	50	40	Adjust to site specific conditions, i.e. climate, elevation, load and fuel type.
Fuel Initial Position	85	55	35	Adjust to site specific conditions, i.e. climate, elevation, load and fuel type.
Min Tank Vacuum (inches Hg)	23	23	23	Set at 14 if water treatment system is present
Target O_2	1800	1800	1800	Should always remain at factory settings if present in programming
KFRRun O_2	35	35	35	Should always remain at factory settings if present in programming
Number of Restart Attempts	1	1	1	Automatic restart or remote start feature is subject to local governing agencies.
Remote Start Enable / Disable	0	0	0	Change as required
Fuel Ratio (0=Demod, 1=O2 @ Temp)	1	1	1	Should always remain at factory settings if present in programming
Fuel Type (0=Propane, 1=Natural Gas)	0	0	0	Set to appropriate setting
Modem Speed (0=2400, 1=4800, 2=9600)	2	2	2	May need to reduce modem speed for cellular. Must be at 9600 for DSD 1000 transfer
Number of Cylinders (4,6,8)	8	6	4	Set to appropriate setting
Emergency Phone #1 Area Code	0	0	0	Change as required, 0 for area code means local call
Emergency Phone #1 Prefix	0	0	0	Change as required, 0 for prefix means don't dial
Emergency Phone #1 4 Digits	0	0	0	Change as required
Emergency Phone #2 Area Code	0	0	0	Change as required
Emergency Phone #2 Prefix	0	0	0	Change as required
Emergency Phone #2 4 Digits	0	0	0	Change as required
System Access Code	1234	1234	1234	Change as required to protect entry into system operation
Control Menu Access Code	xxxx	xxxx	xxxx	Change as required to protect entry into customer access control menu

Phoenix-1000 Default Settings 7.xx and earlier releases

Series 7.xx Set Point Menu

START OF SET POINT MENU	Scale Factor	8-Cylinder	6-Cylinder	4-Cylinder
Idle RPM	1 bit / RPM	1800	1800	1800
Idle Time (sec)	1 bit / sec	60	60	60
Running RPM	1 bit / RPM	1800	1800	2000
Warm-up Time (sec)	1 bit / sec	60	60	60
Max Well Opening (%)	1 bit / %	100	100	100
Tank Vacuum (inches Hg)	1 bit / in. Hg.	10	10	10
Manifold Vacuum (inches Hg)	1 bit / in. Hg.	12	12	12
Engine Cranking Time (sec)	1 bit / sec	7	7	7
Number of Cylinders (4,6,8)	1 bit / Cyl	8	6	4
Max RPM Shutdown/Restart	1 bit / RPM	3000	3000	3000
Printer Enable (0=Off, 1=On)	0 = off, 1 = on	0	0	0
Fuel Type (0=Propane, 1=Natural Gas)	0 = Pro, 1 = NG	0	0	0
END OF SET POINT MENU				

Series 7.xx Program Control Menu

START OF PROGRAM CONTROL MENU	Scale Factor	8-Cylinder	6-Cylinder	4-Cylinder
Modem Speed (0=2400, 1=4800, 2=9600)	N/A	2	2	2
Data Save Interval (minute)	1 bit / min	60	60	60
Data Print Interval (minute)	1 bit / min	10	10	10
Number of Restart Attempts	1 bit / attempt	1	1	1
Air Initial Position	1 bit / step	90	50	40
Fuel Initial Position	1 bit / step	85	55	35
Fuel Max Start Position	1 bit / step	95	65	45
Startup Fuel Valve Step Rate	1 bit / step	20	20	20
Well Valve Increment (steps)	1 bit / step	20	20	20
Max AIR Opening	1 bit / step	150	150	150
Max FUEL Opening	1 bit / step	150	150	150
Delta RPM Limit for Well Dec	1 bit / RPM	100	100	100
Max DRPM for Well Valve Dec	1 bit / RPM / sec	600	300	150
Max VAC Opening	1 bit / step	300	300	300
KRPM	gain	125	125	125
KDRPM	gain	50	50	35
KVacuum	gain	10	10	10
Target Air/Fuel Mix	1 bit / %	100	100	100
Demodulator Amplitude	1 bit / step	2	2	1
Emergency Phone #1 Area Code	N/A	0	0	0
Emergency Phone #1 Prefix	N/A	0	0	0
Emergency Phone #1 4 Digits	N/A	0	0	0
Emergency Phone #2 Area Code	N/A	0	0	0
Emergency Phone #2 Prefix	N/A	0	0	0
Emergency Phone #2 4 Digits	N/A	0	0	0
Emergency Phone #3 Area Code	N/A	0	0	0
Emergency Phone #3 Prefix	N/A	0	0	0
Emergency Phone #3 4 Digits	N/A	0	0	0
Access Code	N/A	1234	1234	1234
Access Code (Verify)	N/A	1234	1234	1234
END OF CUSTOMER ACCESS CONTROL MENU				

Chapter

6

TROUBLESHOOTING

Overview
This guide is not intended to solve problems down to the lowest level, but rather to get to the basic sub-component or engine part that is replaceable in the field. Solving problems is generally best accomplished by the "divide and conquer" approach; that is to systematically rule out the largest system elements first and then work down to smaller and smaller sub-components until you get to a part that can be replaced. As a basic example, suppose that the controller and carburetor have been replaced and the same problem remains. You must now look at the engine and its systems. The battery, starter, and starter solenoid can be quickly ruled out as the problem if the engine cranks during the start sequence or when the "start" button is pressed. Similarly, low engine oil is easily identified as the problem if the system shows an "oil pressure" alarm and the dipstick shows no oil. This is a very simple case, but remember that it often pays to eliminate the obvious things first.

For testing and troubleshooting, always disconnect the soil venting extraction (SVE) hoses from the well gas filter housing (allowing fresh air to enter the carburetor) and discontinue all other treatment processes (i.e. water treatment, Dual-Phase extraction, etc.). In other words, take away all variables so that we are strictly testing the engine and the Phoenix Control System under static conditions.

Some problems with proper operation could be the result of auxiliary equipment connected to the system. Power take off (PTO) driven components may cause erratic loading, or rapidly changing well flow concentration may also cause unstable conditions. Systems with large generators and switching loads could cause large RPM transients or even engine stalls. Remove or disengage these pieces of auxiliary equipment before proceeding with testing.

> **Note:** First determine the unit ID #, and the software version and serial number of the controller. The Phoenix Controller at power up will display its software version and serial number. The unit ID # is located on the cabinet. Record this information for future reference. Be prepared to give information to RSI service technician when asked.

Air Compressor Module

The compressor is producing excessive noise:
1. Shut I.C. engine off.
2. Check compressor pulley to ensure tightness of drive belt and to find excessive movement in pulley drive shaft.
3. Check inlet filter for oil or moisture damage.
4. Disconnect oil return hose from compressor at the engine block. Inspect the return port on the engine block to see if the port appears blocked. Place loose end of return hose into a container that is secured and away from the engine block or any moving parts.
5. Start the I.C. engine while monitoring the container fed by the oil return hose. Let the I.C. engine run for 15 to 30 seconds and then turn it off.
6. If oil has moved through the compressor and started to fill the container, the lubrication system is operational.
7. The compressor needs to be rebuilt.

The air output pressure is low:
1. Check the pressure relief valve located on the output manifold of the compressor. If this check valve has been activated, reset and check output pressure again.
2. Check inlet filter for oil or moisture clogging.
3. Disconnect the hose from the output of the compressor. Connect a new or known good in-line pressure gage to the output of the compressor and reattach the output hose to the outlet of the pressure gage.
4. Compare the pressure readings to previous low readings.
5. If pressure is still low, the compressor needs to be rebuilt.

The air output of the compressor has excessive oil:

1. Disconnect the output hose, holding tank and any other down line components from the output of the compressor.
2. Attach a new, clean hose to the compressor and install an in-line filter to the other end of the hose. Be sure that the filter doesn't restrict air enough to trigger the compressor's pressure relief valve.
3. The outlet of the filter can be left open or reattached to the rest of the air system. Start the I.C. engine and run for 30 to 60 minutes.
4. Inspect the in-line filter for oil contamination

   Note: All Bendix air compressors will have some oil contamination, even when new.
5. If the filter has excessive oil contamination, the compressor needs to be rebuilt.
6. If the filter doesn't exhibit excessive oil contamination, the oil contamination may be in existing lines or holding tank. Inspect all components of the air system for an oil source.

Air Injection On/Off Valve Control

The air injection valve fails to operate when given a command:

1. Disconnect the non-operational valve from the control circuit.
2. Attach the valve leads to another control circuit and test that circuit control to see if the valve is operating correctly.
3. If there are two valves attached to the control circuits, and one is operational and the other not, exchanging the connections of the two valves with one another and testing both valves, will indicate whether the problem is in the valve or the control circuit.
4. Inspect the Air Injection Control PCB and cable for any damage or broken wires. If damage is found and is repairable by a company technician, repair and retest circuit.
5. If no damage is found or the damage is too extensive for on-site repair, the control circuit must be sent to RSI for repair or replacement.

Alternator & Battery

The most obvious and frequent problem associated with the battery and alternator charging system is the engine will not turn over when given a start command. This can occur because the battery is dead due to internal failure associated with the construction of the battery or it can occur due to a failed charging system. All batteries installed by RSI into remediation systems are sealed, heavy-duty commercial grade batteries that do not require fluid refills.

The engine fails to turn over when given a start command mode. (See also: Engine in this Troubleshooting section.)

1. Check the battery voltage in the controller display to ensure it is 12.4 volts DC to 13 volts DC.
2. Attach a voltmeter to the terminals of the battery and try to start the I.C. engine. Check the voltmeter to see if the voltage drops below 11 volts while a load is being applied.

   Note: A weak battery will not necessarily indicate a low voltage until a load is applied to the output.
3. Replace the battery with a known good battery with full charge.
4. Try to start the I.C. engine with the new battery. If the I.C. engine starts and runs well, this indicates that the battery was low but further tests can be performed to determine what may have caused this condition.

The engine fails to turn over when given a start command after the battery has been replaced:

1. Monitor the starter located at the rear of the engine to see if the starter is getting any current. The starter may vibrate, hum, emit smoke or some other indication that shows current is flowing to it. Carefully check to see if the casing is getting hot.
2. Using a clamp-on ammeter, measure the current draw through the starter cable. The current draw through this circuit should be 300 amps DC +/- 10%.

3. If the current draw is higher than normal, the starter motor is probably damaged and should be replaced. Step #5 can still be performed to ascertain whether the I.C. engine is the problem.
4. If the current draw is lower than normal the starter windings are open and the motor must be replaced.
5. If the starter is trying to turn but can't turn the engine over, the starter is failed and needs to be replaced. There is a minor chance that the I.C. engine itself is frozen and will not allow the starter motor to turn it. This can be determined by removing the starter from the I.C. engine and grounding the starter chassis to the engine through the use of a jumper cable and trying to start the engine again. If the starter motor turns freely there may be a problem in the engine. It is still possible that the starter is failed and doesn't have the power to turn the engine over as it should. Using a clamp-on ammeter during this test will indicate whether the starter is fully operational or not (see step #2 above).

   Caution: The amount of current drawn from a battery to start the I.C. engine has the ability to burn skin and cause cardiac arrest. Do not allow persons to contact electrical wires or contacts while troubleshooting these circuits.
6. Install a known good starter and retest the system by starting the I.C. engine once again.
7. If the starter is not showing indications of trying to turn the engine over, the problem could be either the starter motor or the starter solenoid.
8. Connect the positive probe of a voltmeter to the output terminal of the starter solenoid. (This is the terminal that connects to the starter motor.) Connect the negative probe of the voltmeter to chassis ground and try to start the engine. When the start signal is applied to the starter solenoid, the voltmeter should indicate approximately 12 volts DC is being applied to that terminal through the solenoid.
9. Voltage at the output of the solenoid indicates that the solenoid is operational and the starter motor has failed. No voltage at the output of the solenoid indicates that the solenoid has failed. Replace the appropriate components and retest the system to see if the I.C. engine will start.

Testing the alternator charging system:

1. Attach a voltmeter to the terminals of the system battery and check voltage. The charging voltage from the alternator should be 13.7 volts DC, approximately 1 volt DC above a static battery voltage reading.
2. Using a clamp-on ammeter, check the charging current in the lead between the alternator and the battery. The charging current should be 25 amps DC.
3. If the voltage or current readings are low from the alternator, the alternator should be replaced.

Automatic Oil Level Regulator

The I.C. engine crankcase is running out of oil and the oil reservoir is not refilling it automatically through the automatic oil level regulator.

1. Verify that the oil in the crankcase is a minimum of one quart below the full mark on the dipstick.
2. Verify that there is oil in the reservoir feeding the automatic oil level regulator.
3. Verify that the PCV system is operating correctly.
4. Loosen the mounting bolts on the regulator mounting bracket and slowly move the regulator upwards. Oil should flow through the regulator when it senses a low level condition.
5. If oil does not flow, remove the automatic oil level regulator assembly from the engine compartment, taking care not to release oil from the reservoir. Clean regulator and hoses or replace as necessary.
6. Reinstall the assembly and retest. If the automatic system doesn't fill the engine crankcase, replace the oil regulator and retest.

Carburetor

In order to properly troubleshoot the carburetor, it is important to understand the system's program. The Phoenix Controller and carburetor start the engine running on dilution air and alternate fuel through an idle and warm-up period. After the predetermined warm-up period and after the pre-cat temperature reaches 600 degrees °F, the system will automatically switch to "O_2" mode (from it's start-up mode referred to as "De mod" mode). Then, after exhaust temperatures stabilize, it will slowly begin opening the well/tank valve connected to the process flow.

As the well/tank valve is opening, the controller constantly adjusts all of the other carburetor valves to maintain the set RPM and to hold a near stoichiometric fuel ratio in the engine. The system continuously increases the well/tank valve while adjusting the alternate fuel and dilution air inlet valves as necessary. If the well is very rich (high concentration of hydrocarbons), the alternate fuel valve will eventually close to a **minimum valve position**, causing the well valve to stop opening. Or in the case of a process stream with minimal hydrocarbons, the control system will close the dilution air valve to a predetermined minimum valve position, again, stopping the well valve from opening further.

The well/tank valve will continue to open until one of several possible events occurs. For example, either the alternate fuel or the dilution valves completely opens or closes beyond a predetermined set point, the RPM strays too far from the set point, the engine vacuum drops below its set point, or the rate of change of the RPM exceeds a predetermined level. As the well conditions change, the system will continuously adjust to maintain the maximum flow from the well/tank while maintaining proper air-fuel mixture.

IMPORTANT:

The well valve will not open if:

1. RPMs are oscillating beyond the predefined "hard-coded" amount;
2. The engine manifold vacuum is below the predefined "hard-coded" manifold vacuum set point;
3. The valve positions are beyond the predefined "hard-coded" minimum or maximum set point;
4. The exhaust temperature for the pre-cat is below the predefined "hard-coded" minimum of 600 degrees °F;
5. Either temp probe is above the predefined "hard-coded" limit of 1150 degrees °F;
6. The maximum well vacuum is reached as programmed (see set point menu).

Carburetor Test Methods

There are three methods for testing the carburetor, assuming that the controller is operational. Method 1 should be used if the engine is running or can be started in spite of the suspect carburetor. If the engine will not run, use either Method 2 (if the engine has a hard time turning over - low battery) or Method 3 (if the engine still cranks OK).

Method 1 (engine running):

1. Place the controller in the Manual mode and note the engine RPM. Note the Air, Fuel, and Well valve positions.
2. Increase the Air valve position up to 20 counts, then step it back. Note the RPM fluctuation.
3. Increase the Fuel valve position up to 5 counts, then step it back. Note the RPM fluctuation.
4. Increase the Well valve position up to 40 counts, then step it back. Note the RPM fluctuation.

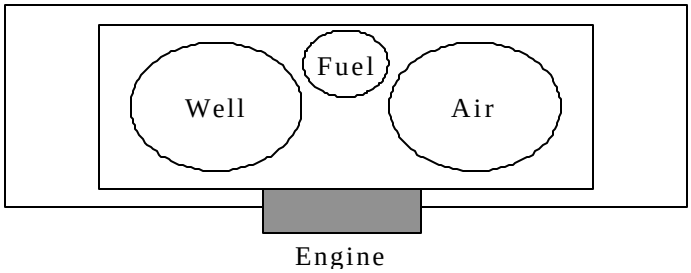
   In each of the three valve movements, the engine RPM should change, either up or down, but return to the original RPM when the valve is returned to its original position. If no change is observed on one or more of the three valves, the carburetor is likely at fault. Remove the carburetor and verify the fault by testing again using Method 2, below:

Method 2 (engine off, controller on):

1. Turn off the makeup fuel source.
2. Place the controller into the Manual Mode.
3. Remove the flex hose from the carburetor inlets (three).
4. Observe the valves either visually or by feel by placing a pencil or rod on the ball.
5. One at a time, open and close the three valves. If any one of the three valves shows no movement, the carburetor is probably at fault. Remove the carburetor and repeat the test to visually confirm results.

Please keep in mind that valve movement is in very small increments and difficult to detect.(see below values for each step).

6. If the valves move, repeat step 5 above, however place a slight load on the valve (finger pressure is fine) to see if the valves can move under load. This will simulate 20" Hg (Mercury) vacuum load on the valve when the engine is running. If valve clicks, but does not move, replace carburetor.



Drawing of valve orientation

- Expect the Air valve to move 1/8" for a valve position change of 128 increments.
- Expect the Well valve to move 1/16" for a valve position change of 128 increments.
- Expect the Fuel valve to move 1/32" for a valve position change of 128 increments.

Method 3 (engine turning over, controller on):

1. Turn off the makeup fuel source.
2. Remove the flex hose from the fuel inlet or from the fuel solenoid.
3. Place the controller into the Manual Mode.
4. Close all three valves by pressing the "0" key to Calibrate.
5. Crank the engine (use manual start key) for three seconds and note the engine vacuum (approx. 12 inches Hg).
6. Open the Air valve to a position around 100.
7. Crank the engine for three seconds and note a lower engine vacuum (< 3 inches Hg).
8. Again, Calibrate the three valves by pressing "0" key.
9. Open the Well valve to a position around 200.
10. Crank the engine for three seconds and note a lower engine vacuum (< 3 inches Hg).
11. Again, Calibrate the three valves by pressing "0" key.
12. Open the Fuel valve to a position around 400.
13. Crank the engine for three seconds and note a lower engine vacuum (< 5 inches Hg).

Note: If any of the above steps do not result in the described outcome, the carburetor will need to be removed. With the carburetor in hand, repeat the "Method 2" tests described above to be certain of the fault.

Cat-Ox Module

The patented RSI S.A.V.E.™ II high flow catalytic oxidizer module (CAT-OX) is unique in that it uses the waste heat of an internal combustion engine to pre-heat an industrial catalyst for the destruction of hydrocarbon vapors recovered from contaminated soil. This differs from conventional catalytic oxidizer systems, as they require auxiliary fuel for catalyst pre-heating. The engine also provides power for the positive displacement blower and generates electricity for the instrument panel, control valves, and the controller. No outside electrical connections are required to operate the RSI S.A.V.E.™ II high flow CAT-OX.

The S.A.V.E.™ II CAT-OX is an exciting addition to the S.A.V.E.™ family which, under certain conditions, can triple the well flow rate capacity of the base system and increase the destruction rate of hydrocarbons with virtually no additional operating cost. The S.A.V.E.™ II CAT-OX has two oxidizers operating individually and in parallel with each other, not in series (either/or) as conventional thermal/catalytic oxidizers do.

The S.A.V.E.™ II CAT-OX has been designed to mount on the end of the optional dual axle trailer that also houses the base S.A.V.E.™ system. All new S.A.V.E.™ systems can accept a CAT-OX module and its related components at a later date, if desired.

A complete manual exists for this module, however some of the features may be used to record data during operation of the standard V3 and V4 units. As such, the following is a brief troubleshooting guide for some of the operating functions of the Cat-Ox Module. Please refer to the complete manual for additional information.

Do not attempt to change the program or set points of any components unless authorized by RSI. For more detailed direction when working on each component, please refer to the individual operator/owners manuals.

LEL Sensor (Optional)
Displaying A Negative Number:

1. Calibrate the sensor following the procedure outlined in the GasTech Calibration Kit.
2. Replace catalytic bead detector as per GasTech Operations manual.

Displaying Questionable Values:
To calibrate the existing controllers if displayed values are questionable, connect thermocouples to another temperature recording device and observe the reading. Make sure that the second recording device can accept a type K thermocouple.

1. If no correlation in values exists, the problem is in the controller. Contact RSI.
2. If values correlate, change thermocouple probes and again measure temperature with the existing controller and confirm with the second recording device.

Sporadic, Jumpy, Or Below Normal Temperature Displays:
This may indicate a short in the thermocouple wires. The temperature displayed on the thermocouple will occur at the short.

Caution: It is imperative that this is corrected or the controllers will not operate under actual temperatures measured in the CAT-OX resulting in the overheating and/or sintering of the catalyst.

1. Disconnect the thermocouple wires from the probe and the controller and check for continuity. If the wires have no continuity then a short is not present. Repair or replace the wire if a short is found

Catalytic Converter

There are three methods to help identify a problem with the automotive Catalytic Converter.

1. If the Post-Cat Temperature Gage reading is the same or lower as the Pre-Cat Temperature Gage, the automotive Catalytic Converter may need to be replaced. If the Automotive Catalytic Converter is operating properly, the conversion/oxidation of CO, NOx and VOC from the engine will cause a temperature rise across the catalyst. In other words, the temperature at the Post-Cat Temperature Gage will be higher than the temperature at the Pre-Cat Temperature Gage once the pre-cat temperature reaches a minimum of 600 degrees F.
2. The pressure drop across the Catalytic Converter can be measured. To determine whether there is a problem with the exhaust pressure, subtract the Post-Cat pressure reading from the Pre-Cat pressure reading.

   Pre-Cat pressure reading (xx psi)
   -- Post-Cat pressure reading (xx psi)
   Pressure drop >1.5 psi

   If the pressure differential between the Pre-Cat pressure reading and the Post-Cat is more than 1.5 psi , the converter is clogged and needs to be replaced.

   Note: Let the engine warm-up prior to testing.
3. It is also helpful to compare current operating parameters to previously taken measurements ("baseline" or "snapshot" samples taken under static conditions). If these readings are taken (and recorded) at regular intervals, it will be easier to see what, if any, changes have taken place over time. Use the chart below to establish baseline values for the Catalytic Converter during operation.

Controller

Checking the Phoenix-Controller:

1. Turn off the alternate fuel source.
2. Power up the controller by turning the key switch.
3. The "S. A. V. E. System" - - "title message should appear for about 5 seconds.
4. If no modem is detected, another message will show - press the "0" key…" to go on.
5. After pressing The "Turn key to start or select function" message should appear.
6. Press the "Set Point" key.
7. Check the values in the Set Point menu by pressing the "SET" key and stepping through the programming options. Review the entries against the default values listed in the operations manual. If any of the values are wildly different for unexplained reasons, the controller may have experienced a low battery problem that scrambled its memory. Try resetting the original values and running the system.
8. Check the values in the control menu by pressing the "PROG CTRL" key and stepping through the programming options. Review the entries against the default values listed in the operations manual. If any of the values are wildly different for unexplained reasons, the controller may have experienced a low battery problem that corrupted the memory. Try resetting the original values and running the system.
9. Disconnect the system carburetor connector from the controller. Using another carburetor or a carburetor simulator, individually operate the Air, Fuel, and Well valves assuring that each one moves. If one or more of the valves does not operate, the controller has a fault and will need to be replaced.

If no test carburetor is available, the test will have to be run with the system carburetor using one of the methods listed in the following section. If the system carburetor is all that is available and it does not pass on all three valves, it may not be possible to determine which of the two components has failed. It is much more likely that a single nonmoving valve is a carburetor fault than a controller fault. If, on the other hand, none of the valves move, it is much more likely a controller fault.

Note: FOR ALL OTHER SYMPTOMS, PLEASE CONTACT RSI FOR SERVICE.

Controller Compartment Cooling & Filtering

The compartment is excessively hot:

1. Check the muffin fan to verify that it is operational.

2. If it is non-operational:
   a. check for broken wires or connections.
   b. Remove the muffin fan and test operation by connecting to a 12 volt DC power source with a minimum 1 amp rating.
   c. If the fan operates on this power supply, the problem is the supply to the fan in the cabinet. The fan is supplied 12 volts DC from the Project Manager connections on the system Breakout PCB located in the control cabinet. The ignition key must be on and the system in "Run" mode to test the voltage on the Breakout PCB.
   d. Using a voltmeter, check the voltage at the Project Manager's voltage terminals on the Breakout PCB, ensuring the polarity of the probes are correct. The voltage should be 12 volts DC.

      Caution: Ensure that the probes do not touch each other or in any way "short out" original the voltages on the Breakout PCB as this could damage the controller or other parts of the system.

   e. If the voltage is correct, the connection between the muffin fan and the PCB are not making connection. Replace the wires to the fan and reconnect or replace the muffin fan.
   f. If the voltages are less than 12 volts DC, there is a problem on the Breakout PCB and it should be replaced or sent to RSI for repair.
3. If the fan is operational:
   a. Remove the air filter at the air inlet to the control cabinet and inspect for excessive dirt buildup. Replace or clean the filter as necessary and replace.
   b. Monitor the temperature in the cabinet while the filter is out to see if the temperature drops significantly. If the temperature in the cabinet remains high without the filter in place, the internal cabinet temperatures and ambient air temperatures must be evaluated to determine if there is anything that can be done to cool the controller cabinet without using refrigerated air.
   c. If the temperature drops while the filter is out of the system and increases significantly once it is put back in place, the filter should be replaced with a new one and the control cabinet monitored again.

Dual-Phase Extraction (DPE) Autodrain Module

The Dual-Phase Extraction (DPE) module with the auto-drain feature was introduced by RSI as a means to accomplish two separate tasks:

1. First, simply as an auto drain system to remove unwanted condensate from the process automatically. It works by separating entrained liquids that condense from the extracted air/fuel soil vapor during the normal soil vapor extraction (SVE) process. The "vapor phase" is directed into the internal combustion engine (ICE) for oxidation purposes, and the liquids are held inside the holding tank of the DPE module. Once the liquid inside the holding tank reaches a predetermined level at the sensor, a pump (capable of overcoming the ongoing high vacuum SVE process) is turned on to discharge the liquid to a holding tank or an oil water separator, pending further treatment. If only water is present in the DPE tank, (in other words, no free floating product is present), the DPE module may discharge its contents directly into RSI's Spray aeration module for further treatment. Normally this process creates minimal amounts of liquid, for example 10 to 20 gallons per day.
2. A second use for the RSI DPE module is to purposely remove both liquids and vapors from the subsurface by applying a high vacuum on a small diameter (1" or less) extraction "stinger" pipe located inside a groundwater/vapor extraction well. The high vacuum on the extraction pipe causes an increase in air velocity, which in turn "lifts" the liquid along with the vapor at varying rates, anywhere from 1 gpm (gallon per minute) to 10 gpm depending, upon site conditions and well construction. The "vapor phase" is directed into the internal combustion engine (ICE) for oxidation purposes, and the liquids are held inside the holding tank of the DPE module. Once the liquid inside the holding tank reaches a predetermined level, a pump (capable of overcoming the ongoing high vacuum SVE process and the rate of liquid influx) is turned on to discharge the liquid to a

holding tank or an oil water separator, pending further treatment. If only water is present (in other words, no free floating product is present), the DPE module may discharge its contents directly into RSI's Spray aeration module for further treatment. If product is present, it must be removed first (usually by an oil water separator), and then the remaining dissolved contaminants can be treated by the Spray Tank Module.

The major components of the Dual-Phase Extraction (DPE) Module are as follows:

- Holding Tank (aka) Vacuum Vessel, Knockout Tank
- Water Discharge Pump
- Float/Water Level Switches
- Safety Shutdown Switch
- Strainer

DPE tank does not automatically drain:

1. Verify that the Milltronics Probe has power (green light on). If not, trace power supply back to its source. If 12 volts present at source and no fuses are blown inline, then replace probe.
2. Verify that there is water/product above the Milltronics Probe sensor level.
3. Verify that the Milltronics Probe is detecting water/product (yellow light on). If not, and water/product is present, clean probe with mild acid wash solution and repeat test. If it still doesn't sense the water/product, check the sensitivity switch (see Milltronics Probe manual for greater detail). If that doesn't work, replace probe.
4. If the probe appears to be functioning fine, verify that the Milltronics Probe is closing its relay (red light on).
5. If so, verify that the Milltronics Probe's closed relay is allowing 12-volt signal to pump control relay.
6. Check for 12-volt power at pump control relay. It should be energized if Milltronics Probe relay is allowing 12-volt signal. If 12 volts are present before and not after, the pump control relay is not engaged under this condition, replace the relay.
7. If the pump control relay is energized, check the pump starter relay to verify that it is engaged. If not, replace pump starter relay.
8. If pump starter relay is engaged, check pump for correct operation. (See pump manual for complete information).
9. If motor turns, but no water flow, check for obstruction is the suction side of the line (most likely the strainer), or check for broken pump shaft or broken impeller. Repair or replace as needed.
10. If pump motor is not on and power is present, repair or replace pump motor.
11. Check the Dip Switch settings on the probe to ensure that the program settings are correct.

DPE tank air flow is obstructed:

1. Ball float check valve located inside well gas filter housing located on top of DPE tank is obstructing flow. Drain water or take assembly apart, clean and return to normal operation.
2. Replace well gas filter housing filter.

> **Note:** The discharge line from the DPE pump should be plumbed so as to always allow at least three feet of head. This will stop the pump from cavatating when first turned on as caused by pockets of air in the pump housing. Because the DPE tank is under vacuum while in operation, the pump is off. It is possible that a "leaky" check valve will allow air to enter the pump housing from the discharge line when not plumbed as described, therefore causing the pump to cavitate.

Engine

Controller will not turn on

1. Check fuses on the breakout board.
2. Check for a good ground connection between the black ground wire and the negative terminal with a voltmeter.

3. Check for a 12-volt signal coming into the controller via the red power wire with a voltmeter.

The controller will not go into the "caution starting engine" mode even when the key is fully turned:

1. Check the connections on the wire from the ST terminal on the ignition key switch to the breakout board, pin # 14, “key turned in”. If no voltage is being sent, the ignition key switch is faulty. Insure the ignition key is in the “On” position.

The controller has power, but will not turn over the engine when in the "caution starting engine" mode (See also: Alternator & Battery in this Troubleshooting section)

1. Measure the battery voltage before trying to start. If it is less than 12 volts, the battery is not in good condition. If the battery drops below 11 volts or the engine starts turning but can’t turn over normally, the battery needs to be charged or needs to be replaced. The system will reset to the beginning menu if voltage drops below 8 volts.
2. Check for 12 volts at the starter solenoid port on the breakout board (pin # 9) and at the starter solenoid. If 12 volts are being sent to the starter solenoid, the problem is either the solenoid or the starter, not the controller. If 12 volts are not present, put the controller in the Manual Mode and check the voltage at the fuel solenoid coil or on the breakout board when the “mnl start” button is pressed. The voltage should match the battery voltage. If no voltage is present, check the fuses at the breakout board and check the controller fuel output as described in the “Checking the Phoenix Controller” section of this document.
3. If the battery voltage does not drop when the engine is trying to start and the engine has no response, something is wrong with the starter system. Put the controller in the Manual Mode and check the voltage at the solenoid coil when the “mnl start” button is pressed. This is done with a voltmeter. The voltage should match the battery voltage. If it does, the problem is in the solenoid or the starter motor, or the battery ground wire to chassis. If no voltage appears at the solenoid, check the fuses on the breakout board.

Engine Turns Over, But Will Not Start

1. Check fuel supply.
2. Check that all valves are open and adequate fuel supply is present. Check the propane tank or loosen the natural gas fitting (with everything turned off) to hear the gas flow. This is the most likely problem.
3. Check the fuel solenoid valve for proper operation.
4. Check the voltage at “fuel solenoid” on the breakout board, pin # 8. 12 volts should be evident at the solenoid during operation. If 12 volts are not present, put the controller in the Manual Mode and check the voltage at the fuel solenoid coil or on the breakout board when the “mnl start” button is pressed. The voltage should match the battery voltage. If no voltage is present, check the fuses at the breakout board and check the controller fuel output as described in the “Checking the Phoenix Controller” in Chapter 5 of this document.
5. Check the propane regulator and propane regulator safety vacuum lock-off for proper operation.
6. Check for incorrect initial carburetor valve positions (air/fuel mixture).

> **Note:** Go to the Checking The Phoenix Controller - Manual Mode section of the document and experiment with a variety of valve positions for air and fuel. If a successful start occurs, note the valve positions on the display and consider resetting initial air position and initial fuel position as described in Program Control above. Climate or system load may affect initial start positions, but if system has been operating properly and no site conditions have changed, the problem probably lies elsewhere. If further troubleshooting is required, go to the “Checking the Phoenix 1000 Carburetor” section of this document to isolate this potential problem. Use method 3 if possible as it is the easiest and quickest test.

7. Check for Electrical/Ignition problems -(i.e. no spark) bad coil/breakout board voltage or bad distributor. Check for correct rotation. The simplest and quickest way to check the ignition is with a timing light. As the engine cranks, the light should flash regularly. If it doesn’t flash, check power to the ignition.
8. Check distributor, cap, rotor or spark plug wires.
9. Check for vacuum leak or pinched vacuum line to propane regulator lockout.

10. Check fuel solenoid valve for correct operation (you may temporarily bypass this solenoid valve in the event propane is the alternate fuel source and a propane regulator equipped with a vacuum lock off safety device is present).
11. Check for bad coil and/or ignition module (change both items as a set).
12. Check to insure there are no intake manifold or other vacuum leaks upstream of the automatic carburetor.
13. Check the air to the engine. Ensure that there are no blockages to air passage such as a very dirty air cleaner or flame arrester. Check the carburetor air valve as described in the "Checking the Phoenix 1000 Carburetor" section of this document. Use method 3 if possible as it is the quickest.

Engine is running, but not correctly or Engine runs rough, stalls after startup, or can not obtain idle RPM:

1. Check for loose, cracked, or broken spark plug wire(s).
2. Check for fouled/broken spark plug(s).
3. Check for bad distributor, cap, or rotor.
4. Check for plugged catalytic converter.
5. Check for plugged flame arrestor.
6. Check for Fuel supply contamination or restriction.
7. Check for bad propane regulator.
8. Check for vacuum hose leak (loose fitting) at propane regulator vacuum lock off safety device.

Engine Is Stalled With No Fault Indication And Will Not Restart:

1. Check the battery. Measure the battery voltage before trying to start. If it is less than 12 volts, the battery is not in good condition. If the battery drops below 11 volts or the engine starts turning but can't turn over normally, the battery needs to be charged or needs to be replaced. The system will reset to the beginning menu if voltage drops below 8 volts.
2. Check the Ignition. The simplest and quickest way to check the ignition is with a timing light. As the engine cranks, the light should flash regularly. If it doesn't flash, check power to the ignition.
3. Check the Fuel to the Engine. By whatever means appropriate, make sure the alternate fuel source is available. Check the propane tank or loosen the natural gas fitting (with everything turned off) to hear the gas flow. This is the most likely problem.
4. Put the controller in the Manual Mode and check the voltage at the fuel solenoid coil or on the breakout board when the "MNL start" button is pressed. The voltage should match the battery voltage. If no voltage shows, check the fuses at the breakout board, check the "fuel" relay on the breakout board, and check the controller fuel output as described in the controller section below.
5. If the fuel source is there and the solenoid is operating, the problem may be in the carburetor fuel valve. Go to the carburetor check section below to isolate this potential problem. Use method 3 if possible it is the easiest and quickest test.
6. Check the Air to the Engine. Make sure that there are no blockages to air passage such as a very dirty air cleaner, plugged catalytic converter or flame arrestor. Check the carburetor air valve as described in the carburetor check section below. Use method 3 if possible it is the easiest and quickest test.

Engine Stalled with no Fault indication, but restarts and runs normally:

1. The most likely cause for this problem is the lack of makeup fuel (propane or natural gas). If the system had plenty of fuel at the time of the stall, the situation may be difficult to diagnose. A few things to look for and consider are listed below:
2. Consider a sudden change in well conditions - use the "Get History" option in the host software and then "Get Fast Buffer 1&2" data, to look at what led up to the event.
3. Check for intermittent electrical connections.
4. Check for loose screw terminals or loose wires in lugs.
5. Check for cables not well seated or not screwed to the controller.
6. Check for excessive corrosion or dirty connectors.
7. Frozen fuel, air or well lines.
8. Air cleaner has become blocked or clogged.
9. Catalytic Converter is plugged.

Engine Stalled with a "STATUS" indication:

1. Note the display/fault indication and check the appropriate engine or system fault. If auxiliary systems can be disabled without causing damage to the system, try disconnecting them and their auxiliary Murphy input and restart the engine. If the unit runs fine with the suspect system disabled, that system is likely at fault.
2. Please see "System Shutdown Conditions/Phoenix Controller Status Displays" chart in the Appendix B at the end of this document.

The Engine runs but will not achieve idle speed:

1. Check for any restriction in the fresh airflow into the automatic carburetor (dirty air cleaner, etc.). There should be no restriction in any of the plumbing upstream of the automatic carburetor in the fresh air, fuel or well lines.
2. Check for any vacuum leaks in the system.
3. Check for exhaust back-pressure. (Catalytic Converter is plugged.)
4. Check for clogged intake spark arrestor.

Engine Cooling

The cooling system for the I.C. engine consists of the radiator, hoses and the thermostat located in the engine block. Most of the systems have coolant routed to the propane lockout unit mounted on the firewall. There is an in-line thermostat mounted on the feed hose to the lockout. Some systems have coolant routed to a Spray Aeration tank mounted on the trailer. Neither the propane lockout nor the Spray Aeration tank will affect the operation of the cooling system for the I.C. engine.

If the engine temperature is suddenly reading high, there are a few possible problems that could be the cause.

1. Inspect the radiator, engine and area underneath the system for evidence of leaks. Check the coolant level in the radiator by visually checking the plastic coolant reservoir. If no leaks are found but the reservoir is low, fill to 40% full with a mixture of 50% coolant and 50% water. Restart engine and monitor temperature.
2. The radiator could be clogged internally or externally. Inspect the surface of the radiator for foreign material that could cut down the cooling capability of the radiator. Internal clogging generally does not cause the temperature to increase quickly unless the radiator has been operating in a clogged condition and suddenly can't achieve cooling capacity due to temperature changes or load changes. If internal clogs are suspected, have the radiator pressure washed and flushed. Restart engine and monitor temperature.
3. The thermostat could be stuck in the closed position. Replace the thermostat and restart engine and monitor temperature.
4. The engine could have a damaged head gasket or crack in the block or a head.
5. The engine could also be operating at a higher than normal temperature because of distributor timing. Generally the I.C. engine will not operate correctly if the timing is not adjusted correctly but if the engine has jumped time or the distributor has been adjusted for any reason, the temperatures could be above normal. This can be ascertained by the use of a timing light or emissions analyzer. Contact the RSI service department before adjusting the timing on any RSI system.

Fire Suppression System (Automatic)

There are no user serviceable components in the automatic fire suppression system. After a fire, follow the instructions found in the Walter Kiddee Fire Control System Maintenance and Service documentation available on the Product Support CD supplied with this manual. If the automatic fire suppression system failed to activate during a fire in the RSI system, contact the RSI service department immediately.

Genset Module

Caution: THE GENSET MODULE OUTPUT CAN HARM OR KILL A PERSON. PLEASE TAKE ALL PRECAUTIONS WHEN PERFORMING TROUBLESHOOTING OR TESTING SYSTEM!

For troubleshooting information concerning the Genset Module, please refer to the Troubleshooting section in the Marathon Electric Maintenance and Service documentation available on the Product Support CD supplied with this manual.

Inlet And Exhaust Flow Measurement/Flow Interface Box

The RSI Flow Box Host Software Version 2.xx ("FBHost") is another powerful software program in the suite of software programs available through RSI. (See literature and documentation regarding other software products available from RSI.) The RSI Flow Box hardware, when coupled with the pressure differential velocity probe, provides the ability to:

- Measure the static line pressure, pressure differential, and temperature in a given process flow,
- Compute the flow rate in various sizes of pipe corrected to standard cubic feet per minute (scfm) based on certain constants and measurements taken by the pressure differential velocity probe, and
- Redefine the parameters/constants such as pipe size, moisture content, molecular weight of the vapor stream, and altitude/elevation for each of the flows monitored by the RSI Flowbox..

The RSI Flow Box Host Software (FBHost Software) provides the ability to:

- Read process gas flows (in scfm) and gas temperatures, line pressures and pressure differential for each flow measured, two per flow box, and
- Receive and record all pertinent data into the Phoenix Controller for future download via a unique graphical user interface and PHHost Software.

See the Troubleshooting section in the Flow Box Interface documentation available on the Product Support CD supplied with this manual

Modem

If the modem doesn't work, replace with new. This must be purchased from RSI as it is a modified US Robotics Sportster Modem, Model 00568603 designed to run off of 12 volts DC.

Oil/Water Separator

See the Troubleshooting section in the Parkson Maintenance and Service documentation available on the Product Support CD supplied with this manual.

Project Manager Proportional Valve Control

The Project Manager valves are operated through an on-board multiplexer PCB. If one or more PM valves are not operating correctly, the problem is in the PCB or the motors that open and close the valves. If all of the valves are non-operational, the problem may be in the interconnect cable or the controller.

From the controller, try to operate each of the valves independently to decide if the problem is with all valves or not. If the system has more than one Project Manager on the system, test the second Project Manger using the controller. A failed cable between the controller and the first Project Manager could keep all valves on all Project Manager units from operating. Remove the first cable connected between the controller and the first Project Manager and swap the cables

from any other Project Manager into that position and retest. If the valves begin to work, the problem is in the cable. If the Project Manager is still non-operational, the problem is either in the controller or the first Project Manager. Each Project Manager is switch selected as the first, second and so forth in the system. Contact the RSI service department for instructions on changing the switch settings in the Project Managers.

Positive Displacement Blower Module

Positive displacement blowers generally fail in only two modes. The first is when the PD blower is seized after not being operated for some time or serviced correctly by changing the fluid per the recommended schedule. The second failure mode is over-heating during operation.

The PD blower is seized:

1. Disconnect the drive belt or coupling to the PD blower. Disconnect any pipes or hoses attached to the inlet or outlet of the PD blower.
2. Try to turn the shafts of the blower by hand or with a wrench, taking care to protect the shaft from damage from the wrench.
3. If the shaft will not turn, spray a light oil such as WD-40 or Liquid Wrench into the inlet and outlet of the blower. Lightly tap on the end of the shafts with a hammer or mallet to free any rust or deposits hampering the PD blower from rotating. Repeat step 2 again to see if the blower has freed itself.

The PD blower is operating at high temperature:

1. Disconnect any pipes or hoses attached to the inlet or outlet of the PD blower.

   Caution: It is imperative that anyone near the system be equipped with hearing protection!

2. Start the I.C. engine and operate the blower without any restriction on the inlet or outlet ports.
3. Monitor the temperature of the PD blower while operating without restriction. If the temperature of the PD blower is in the normal range, inspect all parts and equipment on the inlet and outlet circuits of the blower to locate blockages or restrictions.

   Note: The restriction doesn't need to be complete to cause overheating. Even a slight restriction on either side of the blower will cause a problem.

4. Fix or replace suspected components that are causing a blockage or restriction and reassemble the blower system. Operate the PD blower, monitoring the temperature for overheating.
5. Check the oil level.

Spark And Flame Arrester

Spark Arrester (located on the exhaust system)
If the back pressure in the system's exhaust is excessive and not allowing the I.C. engine to breathe correctly and tests have been performed on the catalytic converter, the problem may exist in the spark arrester. If the pressure drops across the catalytic converter indicate that it is operating correctly, remove the Spark Arrester from the catalytic converter to determine if this part is at fault..

Flame Arrester (located between the engine intake manifold and the Phoenix carburetor)
If the engine is not performing correctly and there is indication that the I.C. engine is starving for air and/or fuel, the flame arrester may be fully or partially clogged. It is possible to clean this component well enough to reinstall and test the engine. If the I.C. engine operates better and doesn't starve for air or fuel after cleaning, plan on replacing the flame arrester as soon as possible.

Caution: Never operate the I.C. engine without this safety component in place!

Spray Aeration Module

The Water Sys (Water Systems) Tab in the host software or the System Data 7 in the controllers menu provides the ability to view the status of both the Spray Aeration Vacuum Extraction (S.A.V.E.™) module and the Dual-Phase Extraction module if either or both optional modules are present in the Phoenix Unit.

Vapor and/or liquids are pulled into the Dual-Phase Extraction unit by a vacuum applied to the Well. The Dual-Phase Extraction unit separates the vapor from the liquid. Depending on your configuration, the vapor is forwarded directly to the Internal Combustion Engine (ICE) where the Volatile Organic Compounds (VOC) are burned. Also depending on your configuration, the liquid in the Dual-Phase Extraction unit is either pumped to a separate storage tank or the liquid is sent to an Oil-Water Separator.

Both the optional Dual-Phase Extraction (DPE) process and the optional Spray Aeration (Air-Stripping) process are diagrammed on the Water System tab. Both the Dual-Phase Extraction module and the Spray Aeration module provide the ability to take polluted groundwater (also known as "influent") and separate the water from volatile organic compounds (V.O.C.). Both modules take the volatile organic compound (V.O.C.) vapors to the Internal Combustion Engine (I.C.E.). The I.C.E. burns and destroys the vapor containing the V.O.C. The Water Sys tab displays a diagram of both the Spray Aeration module and Dual-Phase Extraction module. Data that reflects the status of each system is presented in text boxes adjacent to the respective features as shown in the on-screen piping and instrumentation diagram. Units of measure are indicated next to the data windows. Flow arrows and descriptive notes are presented as an aid to understanding system operation.

The RSI S.A.V.E.™ (Spray Aeration Vapor Extraction/Air Stripping) module provides the ability to separate dissolved contaminants from the groundwater and treat these contaminants as a vapor that can be burned by the I.C.E.

The Spray Aeration/Air Stripping module uses a vacuum to draw the liquid into a Spray Aeration Tank. Once inside the S.A.V.E.™ Chamber, the liquid is heated using a liquid-to-liquid heat exchanger and/or optional electric heating elements. The heated liquid is then atomized under pressure using spray nozzles. Volatilization helps the water give up the contaminant. The vapor that is produced is sent to the I.C.E. where it is burned.

A re-circulating water pump and a jet pump work together to continue circulating the liquids in the Spray Aeration Chamber. To enhance and balance the process, ambient air (clean air from the surrounding area) may be added to the Spray Aeration Chamber through an Air Inlet Valve. Internal limit switches such as the High Water Level and Low Water Level switches monitor the liquid level in the Spray Aeration Chamber and provide feedback to the Phoenix Controller. The Phoenix controller is responsible for tank filling and draining sequences.

Spray Aeration Process Does Not Allow Water To Enter The Spray Aeration Tank:

1. The controller has not yet reached O_2 mode.
2. The Spray aeration tank has not yet reached it programmed vacuum set point (process will not begin until set point is reached).
3. Although the spray tank reached its vacuum set point, it has now dropped below that set point turning the water treatment system off.
4. Inlet filter to the spray tank is clogged.
5. Inlet solenoid valve is not receiving 12 volt power.
6. Inlet solenoid valve is clogged with debris.
7. Actuator on the solenoid valve needs to be replaced.

Spray Aeration Process Does Not Allow Water To Discharge From The Tank:

1. The controller has not yet reached O2 mode.
2. The Spray aeration tank has not yet reached it programmed vacuum set point (process will not begin until set point is reached.
3. Although the spray tank reached its vacuum set point, it has now dropped below that set point turning the water treatment system off.
4. Discharge filter to the spray tank is clogged.
5. Discharge solenoid valve is not receiving 12 volt power.
6. Discharge solenoid valve is clogged with debris.
7. Actuator on the solenoid valve needs to be replaced.
8. Pump pressure has dropped below 15 psi.

Water Pressure From The Re-circulation Pump Does Not Build Up:

1. There is no water in the spray tank, or the water level isn't at the minimum water level point.
2. There is air in the pump line and it needs to be bled out of the pump.
3. The motor isn't turning the pump shaft.
4. The pump shaft is broken.
5. The impeller is broken.
6. Pressure sender isn't working.

Vacuum Does Not Build Up In The Spray Aeration Tank

1. Vacuum set point is set too low or at zero.
2. Spray Tank is allowing air to enter from point other than Visi-Flow gage (rotometer).
3. Spray Tank Vac Valve is not 100% closed.
4. Well valve on the carburetor has not yet opened to apply vacuum.
5. Well valve hasn't opened to a point to allow enough air flow to create vacuum.

Jet Pump Doesn't Appear To Be Removing Condensate From Various Sources Causing The System To Shut Down To High Water Alarm:

1. Jet pump requires cleaning.
2. Discharge filter is causing too much of a pressure drop therefore jet pump will not work, replace/clean discharge filter.

Supplemental/Alternate Fuel Control System

Although there are two different alternate or supplemental fuels used with the RSI system, problems with the supplemental fuel control system are generally identified by troubleshooting from the carburetor back through the system. When troubleshooting a fuel supply problem, check the system in the following manner:

1. Ensure there is natural gas (7" to 10" H_20) or liquid-draw propane available at the three-way valve mounted below the propane regulator/lockout assembly. Ensure the procedure used to verify fuel is in keeping with accepted safe practices.
2. Check the fuel safety cutoff solenoid to ensure that it is operating. The solenoid is opened while the system is calibrating or operating. It is possible to ascertain if the solenoid is operating by holding the solenoid and turning the ignition key to "Calibrate" position. An audible "thunk" or "click" should be heard and the solenoid will vibrate as the plunger moves to open the passageway.
3. If there is doubt the solenoid is operational, it can be removed from the system and tested by applying 12 volts DC to the lead wires of the solenoid. It is possible to see if the plunger is operating inside the solenoid housing.

When natural gas is used as an alternate fuel:

1. Ensure the three-way valve mounted below the propane regulator/lockout assembly is positioned correctly for natural gas operation.

2. While the I.C. engine cranking to start, monitor the movement of the meter on the gas meter located inside the engine compartment. The dial should be rotating as fuel moves through the meter. Lack of movement on the meter face indicates that there is a blockage at the carburetor, the fuel safety cutoff solenoid or the three-way valve.
3. Review the troubleshooting instructions for the carburetor in this section. Disassemble the fuel feed circuit to locate the blockage in the fuel system if required.
4. Ensure proper line pressure and size.

When propane is used as an alternate fuel:

1. Ensure the three-way valve mounted below the liquid-draw propane regulator/lockout assembly is positioned correctly for propane operation.
2. Ensure the propane regulator and lockout are not frozen. This is usually obvious because the assembly will be covered in frost due to the temperature of the propane. A frozen condition indicates that the coolant from the engine is not keeping the assembly at a constant temperature. If the assembly is frozen, remove the thermostat from the coolant lines and reconnect.
3. While the I.C. engine cranking to start, monitor the movement of the meter on the gas meter located inside the engine compartment. The dial should be rotating as fuel moves through the meter. Lack of movement on the meter face indicates that there is a blockage at the carburetor, the fuel safety cutoff solenoid, the three-way valve or the propane regulator/lockout assembly.
4. Review the troubleshooting instructions for the carburetor in this section. Disassemble the fuel feed circuit to locate the blockage in the fuel system if required. Instructions for disassembling the propane regulator and lockout are located in the Troubleshooting section in the Impco Maintenance and Service documentation available on the Product Support CD supplied with this manual.

Well Gas Filter Housing And Water Trap

Housing Will Not Drain:

1. Ensure there is enough water in the housing to test the drain outlet.
2. Disconnect all of the connections attached to the drain outlet of the tank. If water flows out of the tank, there is a blockage in the fittings or hoses attached to the outlet bung of the housing.

The Optional Tank High Level Switch Will Not Activate A High Water Shutdown:

1. Inspect the wires connected to the optional high-level switch, looking for broken wires or connections.
2. Disconnect the wires that are connected to the questionable switch at the furthest connection point from the switch.
3. Using an ohmmeter, connect the probes of the meter to the ends of the wires.
4. Remove the switch from the tank and activate that switch while watching the ohmmeter. The meter should indicate continuity through the circuit. If it does show continuity, the problem is in the connection between those wires and the controller, including the Breakout PCB or any other wiring harness in the circuit.
5. If the ohmmeter doesn't indicate continuity, remove the probes from the wires and connect them directly to the terminals of the high level switch.
6. Reactivate the switch and watch the ohmmeter for an indication of continuity. If the switch shows continuity, the problem is in the wiring and the switch is functional.
7. If the ohmmeter doesn't show continuity, the switch is bad and should be replaced.

Water Is Drawing Through The Well Filter Housing Into The Engine:

1. Inspect the filter inside of the housing for damage to the sealing surface or the filter substrate material. Damage anywhere on the filter allows water and particulates to move through the housing without being filtered.

Well Vacuum Is High And Air Flow Through The Filter Housing Is Low:

1. Inspect the filter inside of the housing for excessive contamination that would restrict airflow. Replace if necessary.

2. Inspect inlets and outlets of filter housing for blockages. Use compressed air to blow through all ports to verify that they are clear of debris and blockages.
3. Disconnect hose to well and retest system for vacuum and flow. If the system is operating normally, the problem is in the hose or the well.

Well Gas (Larger Capacity Options)

Tank Will Not Drain:

1. Ensure there is enough water in the tank to test the drain outlet.
2. Disconnect all of the connections attached to the drain outlet of the tank. If water flows out of the tank, there is a blockage in the fittings attached to the outlet bung of the tank.

The Optional Tank High-Level Switch Will Not Activate A High Water Shutdown:

1. Inspect the wires connected to the optional high-level switch, looking for broken wires or connections.
2. Disconnect the wires that are connected to the questionable switch at the furthest connection point from the switch. This switch may be connected in parallel to the high level switch located in the well gas filter housing located on the V-3 or V-4 unit or it may be connected directly at the Breakout PCB located in the controller cabinet.
3. Using an ohmmeter, connect the probes of the meter to the ends of the wires.
4. Remove the switch from the tank and activate that switch while watching the ohmmeter. The meter should indicate continuity through the circuit. If it does show continuity, the problem is in the connection between those wires and the controller, including the Breakout PCB or any other wiring harness in the circuit.
5. If the ohmmeter doesn't indicate continuity, remove the probes from the wires and connect them directly to the terminals of the high level switch.
6. Reactivate the switch and watch the ohmmeter for an indication of continuity. If the switch shows continuity, the problem is in the wiring and the switch is functional.
7. If the ohmmeter doesn't show continuity, the switch is bad and should be replaced.

Troubleshooting Tables

Standard Controller Shutdown Alarms

Alarm Display	Full Name	Description	Cause	Controller Board	Source/ Pin#
H_2O_S	High Water Level Safety Switch grounded	Dedicated high water level switch	Ground pin for 5 sec	Cont I/O	24
AUX2	Ground signal from undefined component	Undedicated system shutdown for customer use	Ground pin for 5 sec	Cont I/O	25
FIRE	Fire, shutdown	Dedicated Fire suppression system activated	Fire sensor switch closed	Cont I/O	Software
ENG_T	Engine Coolant Temp Over Limit	Dedicated Coolant temperature monitor	Engine temperature > 210 F	DAQ Input	38
OIL_P	Low Oil Pressure	Dedicated Pressure Sender Engine oil pressure monitor	Engine oil pressure < 20	DAQ Input	39
E_CAT	Engine Post or Pre Cat Temp Over Limit	Dedicated Engine pre or post Cat temperature	Temperature > 1350 deg F	DAQ Therm	Software
V_LMT	Air or Fuel Valve Over Limit	Dedicated Valves remain above maximum level Set Point	Valve positions > switch setting	Cont I/O	Software
RPM	RPM Over Speed Over Limit	Dedicated Engine RPM exceeded Set Point	RPM > switch setting	Cont I/O	Software
REC_P	Low Recirculating Pump Pressure	Dedicated Pressure Sender Recirculating Pressure Monitor	Recirculating pressure < 3psi	DAQ Input	58
SPR_T	Spray Tank Temperature Over Limit	Dedicated Temp Sender Spray Tank Temperature Monitor	Spray Tank Water Temp > 160 F	DAQ Input	59
STALL	Engine Stalled	Engine stalled for no apparent reason	Unknown	Cont I/O	Software

Additional inputs for Enhanced Controller Only

Alarm Display	Full Name	Description	Cause	Controller Board	Source/ Pin#
BLO_T	CatOx Blower Temp	Dedicated Thermal Sender CatOx blower	Ground pin for 5 sec	CatOx I/O	54
LEL	LEL	Dedicated LEL sensor monitor	LEL > (Set Point + 10%)	CatOx I/O	53,12
C_CAT	CatOx Inlet or Outlet Temp	Dedicated CatOx inlet or outlet temperature	Temperature > 1250 deg F	CatOx Therm	Software
P1/P2	Pressure Switch	Dedicated Pressure Sender on Filters	Ground pin for 5 sec	CatOx I/O	57

Murphy System Shutdown Conditions Description & Troubleshooting

Display	Name	Description; Troubleshooting
AUX_V	AUX Volt	Auxiliary Voltage (generator)
AUX2	Aux2 Murphy	Undedicated system shutdown. This fault condition is caused by a ground-switch being activated. Check all external switches connected to pin # 25 on the breakout board to make sure none are activated/switched. Replace or repair as necessary. (pin # 25 is normally 8-9 volts DC when not grounded on the break out board).
BATT	Battery	System Battery Voltage. This fault condition is caused by a hard coded software limit being exceeded, usually caused by the alternator, voltage regulator & coil (change as a set), or other electrical problem.
BLO_T	CatOx Blower Temp	Thermal switch on CatOx blower. This fault condition is caused by a ground-switch being activated. Check all external switches connected to pin # 54 on the breakout board to make sure none are activated/switched. Replace or repair as necessary. (pin # 54 is normally 8-9 volts DC when not grounded on the break out board).
C_CAT	CatOx Outlet Temp	CatOx outlet temperature. This fault condition is caused by a hard coded software limit being exceeded. Assuming the fault is not due to CAT-OX overheat, check type K thermal wire(s) and connector(s) that is(are) connected to controller and to the type K temp probe(s) on the CAT-OX to make sure wire is securely fastened at both locations and no shorts exist. Replace probe(s) or repair wiring/wiring connections as necessary.
COMP_R	Compress Press	Compressor Pressure Low
E_CAT	Post Cat Temp	Engine post Cat temperature. This fault condition is caused by a hard coded software limit being exceeded. Assuming the fault is not due to automotive catalyst overheat (i.e. unburned hydrocarbons coming from the engine due to spark plug(s) fouled, spark plug wires malfunctioning, ignition timing, faulty carburetor, faulty controller, bad engine, etc.), check type K thermal wire(s) and connector(s) that is(are) connected to controller and to the type K temp probe(s) on the automotive catalyst to make sure wire is securely fastened at both locations and no shorts exist. Replace probe(s) or repair wiring/wiring connections as necessary. Also, make sure temp probes are not grounded out to exhaust system.
ENG_T	Engine Temp	Coolant temperature monitor. This fault condition is caused by a hard coded software limit being exceeded. Assuming the fault is not due to engine overheat (i.e. bad thermostat, bad water pump, clogged radiator, etc.), check wire connected to pin # 38 on the breakout board and the temp sender on the engine to make sure wire is securely fastened at both locations. Replace sensor or repair wiring as necessary.
FIRE	Fire Murphy	Fire suppression system activated. This fault condition is caused by the automatic fire extinguisher system being activated. Refer to manual for service information.

Display	Name	Description; Troubleshooting
H_2O_S	Aux1 Murphy	Undedicated system shutdown. A high-level float switch activation causes this fault condition. Check all float switches to verify none are activated or switched. Replace or repair as necessary. Float switches exist in the well gas filter housing, the spray aeration tank, the DPE tank, and are wired in series to pin # 24 (normally 8-9 DC volts when not grounded) on the break out board.
LEL	CatOx LEL	LEL sensor monitor. This fault condition is caused by a hard coded software limit being exceeded. Assuming the fault is not due to high LEL, check wire connected to pin # 53&12 on the breakout board and the LEL sender in the engine compartment to make sure wire is securely fastened at both locations. Replace sensor or repair wiring as necessary. See GASTECH LEL service manual for further information.
OIL_P	Oil Pressure	Engine oil pressure monitor. This fault condition is caused by a hard coded software limit being exceeded. Assuming the fault is not due to engine low oil pressure (i.e. bad oil pump, kinked oil line, clogged oil cooler, bad engine, etc.), check wire connected to pin # 39 on the breakout board and the pressure sender on the engine to make sure wire is securely fastened at both locations. Replace sensor or repair wiring as necessary.
P1/P2	Delta P1/P2	Pressure switch on water filters. This fault condition is caused by a ground-switch being activated. Check all external switches connected to pin # 57 on the breakout board to make sure none are activated/switched. Replace or repair as necessary. Pin # 57 is normally 8-9 VDC when ungrounded on the breakout PCB.
RECIR	Recirc Press	Recirculation Pressure Low. This fault condition is caused by a hard coded software limit being exceeded. If it happens during the initial starting sequence, it is generally a lack of pressure in the re-circulation pump. During normal operation, this is generally due to no water in the spray aeration tank caused by a faulty level probe or faulty solenoid valve, an air leak in the suction side of the pump or the pump seal is damaged. Turning the water treatment system off, via the toggle switch on the front panel, will override this input. If no spray aeration tank is present, yet problem persists, then pin #26 on the breakout PCB may be mistakenly grounded.
RPM	High RPM	Engine RPM monitor. This fault condition is caused by a hard coded software limit being exceeded, usually caused by major air fuel ratio changes due to site specific conditions.
STALL	Stalled condition	System unable to start. This fault condition is caused by a hard coded software limit being exceeded. If it happens during the initial starting sequence, it is probably due to the engine being cold. During normal operation, this is generally due to an interrupted fuel supply, faulty gas solenoid valve, propane lock off malfunction (vacuum hose came loose), or oil in the propane.
TIME	Time's up	Operational Time has expired
Vlim	Valve limit	Valve runaway. This fault condition is caused by a hard coded software limit being exceeded. Assuming the fault is not due to the engine not being able to breath (usually caused by automotive catalyst plugging causing back pressure in excess of 1.5 psi or the intake spark arrestor being plugged), ignition timing, faulty carburetor or faulty controller, then the problem probably is with the fuel supply. Check Propane for excessive oil, check vacuum hose connected to vacuum safety lock off to make sure it is securely connected, check 1" solenoid valve for correct operation.
WTEMP	Water Temp	Spray Tank Water Temp High

Phoenix-1000 Default Settings 8.xx releases

SET POINT MENU	8-Cyl	6-Cyl	4-Cyl	Description / Notes
				Requires Menu Access or Customer Override Code
Running RPM	1800	1800	2000	Changing this setting may affect system performance unless other settings are modified.
Max Engine Well Vacuum (in$H_2$0)	300	300	300	Well valve will not open past H2O set point
Max CatOx Well Vacuum (in$H_2$0)	190	190	190	Well valve will not open if Well vacuum is above the set point
Data Save Interval (minute)	60	60	60	Data save at 60 will save 27 days of data. Clear History before changing this setting.
Total for Menu				

CONTROL MENU	8-Cyl	6-Cyl	4-Cyl	Description / Notes
				Requires Menu Access or Customer Override Code
Selected Data Set	0	0	0	0=none, all custom; 1=Data Set 1, 2=Data Set 2, etc.
Idle RPM	1800	1800	1800	Changing this setting may also affect initial air and fuel valve positions described below
Air Initial Position	90	50	40	Adjust to site-specific conditions, i.e. climate, elevation, load and fuel type.
Fuel Initial Position	85	55	35	Adjust to site-specific conditions, i.e. climate, elevation, load and fuel type.
Min Tank Vacuum (inches Hg)	23	23	23	Set at 14 if water treatment system is present
Target O_2	1800	1800	1800	Should always remain at factory settings if present in programming
KFRRun O_2	35	35	35	Should always remain at factory settings if present in programming
Number of Restart Attempts	1	1	1	Automatic restart or remote start feature is subject to local governing agencies.
Remote Start Enable / Disable	0	0	0	Change as required
Fuel Ratio (0=Demod, 1=O_2 @ Temp)	1	1	1	Should always remain at factory settings if present in programming
Fuel Type (0=Propane, 1=Natural Gas)	0	0	0	Set to appropriate setting
Modem Speed (0=2400, 1=4800, 2=9600)	2	2	2	May need to reduce modem speed for cellular. Must be at 9600 for DSD 1000 transfer
Number of Cylinders (4,6,8)	8	6	4	Set to appropriate setting
Emergency Phone #1 Area Code	0	0	0	Change as required, 0 for area code means local call
Emergency Phone #1 Prefix	0	0	0	Change as required, 0 for prefix means don't dial
Emergency Phone #1 4 Digits	0	0	0	Change as required
Emergency Phone #2 Area Code	0	0	0	Change as required
Emergency Phone #2 Prefix	0	0	0	Change as required
Emergency Phone #2 4 Digits	0	0	0	Change as required
System Access Code	1234	1234	1234	Change as required to protect entry into system operation
Control Menu Access Code	xxxx	xxxx	xxxx	Change as required to protect entry into customer access control menu

Phoenix-1000 Default Settings 7.xx and earlier releases

START OF SET POINT MENU	Scale Factor	8-Cyl	6-Cyl	4-Cyl
Idle RPM	1 bit / RPM	1800	1800	1800
Idle Time (sec)	1 bit / sec	60	60	60
Running RPM	1 bit / RPM	1800	1800	2000
Warm-up Time (sec)	1 bit / sec	60	60	60
Max Well Opening (%)	1 bit / %	100	100	100
Tank Vacuum (inches Hg)	1 bit / in. Hg.	10	10	10
Manifold Vacuum (inches Hg)	1 bit / in. Hg.	12	12	12
Engine Cranking Time (sec)	1 bit / sec	7	7	7
Number of Cylinders (4,6,8)	1 bit / Cyl	8	6	4
Max RPM Shutdow n/Restart	1 bit / RPM	3000	3000	3000
Printer Enable (0=Off, 1=On)	0 = off, 1 = on	0	0	0
Fuel Type (0=Propane, 1=Natural Gas)	0 = Pro, 1 = NG	0	0	0
START OF CONTROL MENU	**Scale Factor**	**8-Cyl**	**6-Cyl**	**4-Cyl**
Modem Speed (0=2400, 1=4800, 2=9600)	N/A	2	2	2
Data Save Interval (minute)	1 bit / min	60	60	60
Data Print Interval (minute)	1 bit / min	10	10	10
Number of Restart Attempts	1 bit / attempt	1	1	1
Air Initial Position	1 bit / step	90	50	40
Fuel Initial Position	1 bit / step	85	55	35
Fuel Max Start Position	1 bit / step	95	65	45
Startup Fuel Valve Step Rate	1 bit / step	20	20	20
Well Valve Increment (steps)	1 bit / step	20	20	20
Max AIR Opening	1 bit / step	150	150	150
Max FUEL Opening	1 bit / step	150	150	150
Delta RPM Limit for Well Dec	1 bit / RPM	100	100	100
Max DRPM for Well Valve Dec	1 bit / RPM / sec	600	300	150
Max VAC Opening	1 bit / step	300	300	300
KRPM	gain	125	125	125
START OF CONTROL MENU	**Scale Factor**	**8-Cyl**	**6-Cyl**	**4-Cyl**
KDRPM	gain	50	50	35
KVacuum	gain	10	10	10
Target Air/Fuel Mix	1 bit / %	100	100	100
Demodulator Amplitude	1 bit / step	2	2	1
Emergency Phone #1 Area Code	N/A	0	0	0
Emergency Phone #1 Prefix	N/A	0	0	0
Emergency Phone #1 4 Digits	N/A	0	0	0
Emergency Phone #2 Area Code	N/A	0	0	0
Emergency Phone #2 Prefix	N/A	0	0	0
Emergency Phone #2 4 Digits	N/A	0	0	0
Emergency Phone #3 Area Code	N/A	0	0	0
Emergency Phone #3 Prefix	N/A	0	0	0
Emergency Phone #3 4 Digits	N/A	0	0	0
Access Code	N/A	1234	1234	1234
Access Code (Verify)	N/A	1234	1234	1234

Chapter 7

MAINTENANCE

Air Compressor Module

The air compressor modules are air-cooled systems driven from the engine crank pulley or a rear mounted PTO. These modules are lubricated with the engine oil lubricating system through feed and return hoses which attach at the base of the compressor. The air output attachment is made from the manifold located at the top of the compressor.

The compressor module should be inspected every 360 hours of operation for oil leaks, output pressure and oil contamination in the air output. The oil hoses should be inspected for cracks, abrasions and cuts. The hose clamps should be inspected for tightness. Vibration during operation can cause the compressor to become loose on the mounting bracket or the components of the compressor assembly to become loose enough to seep oil and leak air. All components of the compressor should be checked to ensure that bolts and screws are tightened sufficiently to prevent any such leakage.

The pressure relief valve mounted should be tested monthly to ensure safe operation of the system. This is achieved by closing the output line of the air compressor with a valve while watching a pressure gauge attached to the same output line. The pressure relief valve should release pressure at approximately 110 psi.

Alternator & Battery

It is also helpful to compare current operating values against previously taken measurements ("baseline" or "snapshot" samples taken under static conditions). If these readings are taken (and recorded) at regular intervals, it will be easier to see what, if any, changes have taken place over time. Use the chart below to establish baseline values for the Alternator during operation.

ALTERNATOR BASELINE CHART

Baseline	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Voltage												

Automatic Oil Level Regulator

The Automatic Oil Level Regulator is a self-contained assembly that only needs to be kept level with respect to the engine block and at the correct height in reference to the specified oil level within the engine oil pan. It is recommended that the face of the regulator be cleaned with glass cleaner as necessary to provide visual verification of operation.

Note: Do not attempt to adjust this device without contacting the RSI service department first.

Carburetor

The carburetor should be visually inspected monthly to ensure that the control cable is not bound, pinched or burnt. The hoses and clamps that secure the hoses to the carburetor should be checked monthly to ensure there is no leakage to the carburetor. If the carburetor has an air filter installed, the air filter should be replaced every 4000 hours of operation or sooner as required.

Catalytic Converter

The catalytic converter has no maintenance that needs to be performed, but monitoring of the efficiency is critical to the performance of the IC engine and the emissions of the entire system. A baseline chart for monitoring the operation and performance is included below.

Baseline		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature	Pre-Cat												
	Post-Cat												
Pressure	Pre-Cat												
	Post-Cat												
Gases	CO												
	NOx												
	VOC												

Cat-Ox Module

100 Hour Maintenance Checks:

1. Check blower drive belt tension and wear.
2. Lubricate PTO bearings at all fittings.
3. Lubricate blower and check oil levels.
4. Check pipe mounts, brackets, and connections for security - loose piping will allow the piping to vibrate resulting in excess noise and damage.
5. Check hoses and piping for signs of wear or damage - replace if necessary.
6. Check for excess moisture accumulation in the moisture knockout tank - drain if necessary.
7. Check for excess moisture accumulation in the blower silencer - drain if necessary.
8. Check all air filter-silencer elements for particulate clogging - replace or clean elements if necessary.

Monthly Maintenance Checks:

1. Check operation of Murphy Switch - simulate over limit conditions of temperature controllers, LEL sensor, and pressure switch to shut down the machine. Ensure that programmed settings and contacts are set correctly. Only check programmed set points; do not change. If programmed set points are not correct, contact RSI.
2. Check electrically actuated valves for correct position under simulated and/or operating conditions.
3. Check component-mounting bolts for security - tighten as required.
4. Check operation of all moving parts to ensure they are free to operate and that belts are tight.
5. Check operation of the automotive catalytic converter - measure emissions reduction and temperature rise across the converter. Replace converter if not operating efficiently.
6. Check for system vacuum or pressure leaks.
7. Calibrate and adjust LEL sensor with GasTech 81-0260-02-calibration kit. Refer to Safe T Net manual for calibration description and procedure.

Note: Calibration should be performed more often if necessary.

Other Maintenance Guidelines:

1. Catalyst - Refer to the Johnson Matthey Oxidation Catalyst (OR EQUAL) Operations Manual for catalyst description, operation and maintenance.
2. Heat Exchanger - Refer to Exothermic-Eclipse Stainless Air to Air Heat Exchangers, Installation/Operation & Maintenance Guide.
3. Wiring - Check for instrument panel wiring that may have vibrated loose. The vibration of the S.A.V.E.™ System may cause wiring connections to work loose and eventually disconnect, resulting in system failure and/or electrical shorts. Thermocouple wires should also be checked for shorts and/or discontinuity. A short in thermocouple wiring can result in incorrect temperature measurement, as the controller will measure the temperature at the short.
4. Natural Gas Fuel Leaks - Natural gas or propane leaks should be avoided by checking the integrity of all piping through the application of soapy water to all joints and fittings. If a natural gas or propane odor is detected, the S.A.V.E.™ System should be immediately shut down and the source of the leak determined through the application of soapy water to the piping system. System leaks require immediate repair, as the fuel system is under constant pressure regardless of whether the S.A.V.E.™ System is operating or not. Do not attempt to determine the source of leak through the use of an open flame. If a leak is suspected or detected, properly ventilate the area prior to beginning repairs; do not turn electrical switches either on or off. Do not use electric fans or power tools and do not attempt to restart the engine until the repairs are complete and the area has been properly ventilated.
5. Gasoline Fuel Leaks - The source of vagrant gasoline vapors will usually relate to leaks within engine compartment, CAT-OX, or the connections within the manifold piping. Gasoline vapors are not prone to leaking from well connections when the S.A.V.E.™ System is operating because the system operates under vacuum. Gasoline vapors are heavier than air and will drop to the lowest possible level. Any source of ignition can cause an explosion. If a leak is suspected or detected follow the same procedures mentioned in item 4.
6. Automotive Catalytic Converters – The automotive catalytic converter located in the engine enclosure should be replaced when worn out or after 4,000 hours of operation. Proper operation of the converters may be checked by measuring the temperature differential of the sample ports located in the engine exhaust piping before and after the converter. A temperature rise should occur after the converter due to conversion of NOx, CO, and unburned hydrocarbons. If the outlet temperature is lower than the inlet, it may indicate a problem. An engine exhaust analyzer is recommended to determine whether a converter is functional by measuring the decrease of NOx CO or hydrocarbons through the converter. The converters can also be checked for excessive pressure. If there is a pressure drop across the catalyst greater than 1.5 psig at 2000 RPM it is recommended that the converters be replaced.

> **Note:** When burning vapors from leaded fuel, converter life is shortened and should be checked at least every 500 hours. Automotive catalytic converters are readily available from RSI.

Controller

The controller should be kept as dry as possible at all times. The front panel membrane should be cleaned periodically with window cleaner to keep the membrane free of contaminants that may permeate the plastic and cause damage. When a controller is being removed or installed into a V-3 or V-4 system, the technician handling the controller should be grounded to the cabinet of the system or to an earth ground.

> **Note:** Never touch the connectors directly unless grounded correctly.

Controller Compartment Cooling & Filtering

The controller compartment needs to stay as cool as possible during storage and operation. A muffin fan is installed in the controller compartment to move air across the controller enclosure and the breakout PCB. An air filter is mounted at the fresh air inlet to the compartment. The muffin fan should be inspected for operation every 2500 hours. Excessive noise, erratic rotation or non-operation is cause for immediate replacement. The fresh air filter should be replaced every 1440 hours.

Dual-Phase Extraction (DPE) Autodrain Module

The outside of the DPE vessel is powder coated to match the base system. The inside is coated with a 3M epoxy compound to protect the tank from rust and other contaminants. The tank is normally filled by vacuum as provided by the engine intake manifold. A periodic cleaning will keep this vessel in good working order.

A 12-volt circuit normally powers the water discharge pump. A 220 three-phase model is available on request. Discharge pressure should be monitored to determine if downstream blockages are occurring. Monitor the check valve on the discharge side of the pump and replace o-ring when necessary. Check the strainer on the suction side of the pump and clean when necessary.

> **Note:** It is very important that all connections to and from the pump are tight and allow no leakage. Any leak will cause air to enter the pump, causing it to become air-bound (cavitate). Leaks will eventually destroy the pump. The discharge from the pump should always be plumbed into the bottom portion of the holding tank. This will insure that a constant head pressure is present on the discharge stream of the pump.

The safety shutdown switch shuts down the entire process if it is activated for more than five continuous seconds. This event is usually caused by high water conditions. The safety shutdown switch should be tested routinely for correct operation and replaced when malfunctioning. The float/water level switches control the process flow. These switches should be removed prior to any acid washing of the tank, and re-installed when acid wash is complete. The strainer should be disassembled and the filter elements cleaned (or replaced) periodically.

Dual-Phase Extraction (Autodrain) Module Maintenance

See operating description in Phoenix Host Software section. For discharge pump maintenance, see manufacturer's instructions included in RSI Operations Manual. The major components of the Spray Aeration Module are as follows:

Holding Tank/Vacuum Vessel

The outside of the DPE vessel is powder coated to match the base system. A periodic cleaning will keep this vessel in good working order. The tank is normally filled by vacuum as provided by the engine intake manifold.

Water Discharge Pump

The water discharge pump is normally 12 volt, (or 220 three phase on request). Discharge pressure should be monitored to determine if downstream blockages are occurring. Check the strainer on the suction side of the pump and clean when necessary. Check the check valve on the discharge side of the pump and replace o-ring when necessary.

> **Note:** It is very important that all connections to and from the pump are tight and allow no leakage. Any leak will cause air to enter the pump, causing it to cavitate and eventually destroy the pump. The discharge of the pump should always be plumbed into the bottom portion of the holding tank to insure constant head feet of pressure is always present on the discharge stream of the pump.

Float Level Switches

The float level switch controls the process flow. These switches should be removed prior to any acid washing of the tank, and re-installed when acid wash is complete.

Safety Shutdown Switch

The safety shutdown switch shuts down the entire process if it is switched for more than 5 continuous seconds, usually caused by high water conditions. This switch should be tested routinely for correct operation and replaced when malfunctioning.

Strainer

This should be disassembled and the filter elements cleaned (or replaced) periodically.

Electronics

All electronics within the RSI V-3 and V-4 should be kept as moisture free and dust free as possible. Every three months all electrical circuitry and systems should be inspected for moisture and particle contamination. Warm, dry and oil free, compressed air blown across the circuitry should remove any moisture, dust and particles that could cause short circuits and damage. Products made specifically for keeping electrical circuits water resistant are available at most electronics stores. Contact the RSI service department if you have questions concerning the use of a specific product.

Engine

After initial start up (and after a lengthy storage), visually check the unit inside and out on a weekly basis until the first scheduled maintenance. Although certain maintenance requirements can be limited to two visits per 720/hrs, it is strongly recommended that the unit be visited every week as complications, other than maintenance, can arise from system operation. Air Quality Monitoring may be required in more frequent intervals as permit conditions dictate. Catalytic converters and filtration components may need replacement more frequently than noted, depending on site conditions.

Maintenance Schedule	Frequency
Check All Fluid Levels	Each visit
Check Battery and Battery Connections	Each visit
Check and Drain Moisture Knockout Tank	Each visit
Check Emergency Contact Switches	Each visit
Check Belts & Hoses	Each visit
Exhaust and Intake Manifold Bolts Tightened (Check torque req.)	Once at 360 hours
Oil Change/Replace Oil Filter	Every 180 to 360 hours
Spark Plugs Replaced (or sooner if fouling occurs)	Every 720 hours
Fresh Air and Well Gas Filter Replaced	Every 720 hours
Rotor & Cap Replaced	Every 2160 hours
PCV Valve Repair or Replaced	Every 2160 hours
Radiator Pressure Washed and Degreased	Every 2160 hours
Check Propane Filter	Every 2160 hours
Spark Plug Wires Replaced	Every 2160 hours
Flame Arrester Serviced or Replaced	Every 2160 hours
Coolant Changed & Radiator Flushed	Every 4320 hours
Catalytic Converters & O_2 Sensor Replaced (or sooner if fouled or plugged)	Every 4320 hours
Ignition Module and Coil Replaced (both as a set)	As needed

Note 1. See torque specifications in Operators Manual. Perform only when engine is cold.

*UPON INITIAL START-UP (AND AFTER A LENGTHY STORAGE) RSI ADVISES THAT THE USER VISUALLY CHECK THE UNIT MORE OFTEN THAN SCHEDULED MAINTENANCE EVENTS DICTATE. AIR QUALITY MONITORING AND/OR WATER DISCHARGE SAMPLING MAY BE REQUIRED IN MORE FREQUENT INTERVALS AS PERMIT CONDITIONS SPECIFY.

IMPORTANT: CERTAIN SITE CONDITIONS, SUCH AS LEADED FUELS, EXCESSIVE DUST AND TEMPERATURE EXTREMES MAY REQUIRE MORE FREQUENT SERVICING OF COMPONENTS THAN OUTLINED ABOVE. THIS MAINTENANCE SCHEDULE IS INTENDED TO PROVIDE GENERAL MAINTENANCE ADVICE AND MAY REQUIRE MODIFICATION TO FIT ACTUAL SITE CONDITIONS.

RSI SYSTEMS ARE DESIGNED TO OXIDIZE PETROLEUM HYDROCARBONS [NON-CHLORINATED HYDROCARBONS] IN THE NORMAL COMBUSTION PROCESS OF AN INTERNAL COMBUSTION ENGINE. ANY COMPOUNDS PRESENT IN THE EXTRACTED AIR STREAM OTHER THAN PETROLEUM HYDROCARBONS OR ATMOSPHERIC CONSTITUENTS MAY CAUSE DAMAGE TO THE ENGINE.

Engine Maintenance

Before working on any part in the engine compartment, turn the unit off and wait until the engine and exhaust system has cooled down sufficiently. As with any machine, care should be taken when making any check, doing any maintenance, or making any repair to avoid being injured. Improper or incomplete service could also result in the machine not working properly, which may result in personal injury or damage to the machine or its equipment. If you have any questions about carrying out any service, contact **REMEDIATION SERVICE INT'L**.

Caution: Shut off engine before adjusting, repairing, cleaning, or servicing any components. Under no circumstances should the operator or maintenance personnel attempt to clean or service the unit or its ducting system (vacuum) while the engine is running. The only exception is the performing of an ignition timing check.**

****ONLY AUTHORIZED AND TRAINED PERSONNEL are allowed to perform this task.**

Engine Oil

REMEDIATION SERVICE INT'L MODEL V3/V4 is equipped with an automatic oil level regulator and an oil reservoir.

The oil level regulator is PRESET at the factory to maintain the oil in the engine at the proper operating level. DO NOT attempt to adjust this device as overfilling or low oil level can occur.

When checking the oil level before start up, check both the dipstick and the reservoir level. Make sure the reservoir is filled cold to the proper level.

Never overfill the oil reservoir. Heat expansion may cause oil to overflow. Never fill the crankcase over the proper level indicated on the dipstick as overheating can occur.

IMPORTANT: Turn the reservoir valve "off" when changing oil or transporting. Make SURE the valve is "open" for normal engine operation.

CAPACITIES: **RESERVOIR – 8 or 12 QTS.**
CRANKCASE – 10 QTS without oil filter.*

*For good engine life and extended servicing periods, your **MODEL V3/V4** is equipped with one oil filter mounted on the block. After oil changes, run the engine for a short time and check the oil level in the reservoir to insure proper oil level.

APPROVED ENGINE OIL is a **LOW** ash oil. Some low ash oils are as follows

CHEVRON U.S.A.-		Delo 400 15W40
EXXON-		XD-3 Extra 15W40
MOBIL OIL	-	1300 Super
SHELL OIL	-	Rotella T 15W40
TEXACO INC	-	URSA Super Plus 15W40
UNION OIL	-	Guardol 15W40
VALVOLINE FLEET		15/W40

Change oil when engine is **WARM**. The oil can only be checked accurately when the machine is leveled. Do not check the oil immediately after stopping the engine, as the oil in circulation takes a few minutes to drain down into the sump. The oil should be in the "SAFE" area on the dipstick, but never below the "ADD" or above the "SAFE" mark.

The oil is to be changed according to the maintenance schedule found elsewhere in this manual.

Engine Spark Plugs

For replacement use resistive spark plugs. Proper plug gap is .040 TO .045. See Maintenance Schedule for proper intervals.

The spark plugs are to be changed according to the Maintenance Schedule found elsewhere in this manual.

Note: Some engine blocks/heads require a larger size plug with the same specification. Please verify size before replacing.

Engine Spark Plug Wires

For replacement. use resistive spark plug wires.

The spark plug wires are to be changed according to the Maintenance Schedule found elsewhere in this manual.

Engine Timing

36° BTDC (below Top Dead Center) at 1800 RPM (36° advanced).
See Maintenance Schedule for ignition timing check interval.

Engine Intake Manifold

Tighten bolts with torque wrench to 35 foot-pounds.
See Maintenance Schedule for maintenance interval

Engine Exhaust Manifold

Tighten bolts with torque wrench to 30 foot-pounds.
See Maintenance Schedule for maintenance interval

Engine Oil Filters

See Maintenance Schedule for replacement intervals

Note: One (1) filter is required at each oil change

Engine Drive Belts

Check monthly to make sure all drive belts are tight and in good condition. See Maintenance Schedule for replacement intervals.

Note: Two (2) drive belts are required to keep the water pump and fan from slipping. Always replace both belts at the same time.

Engine Air Cleaner

If the engine air cleaner is removed during repair or maintenance, make sure that it is replaced before start up to prevent engine damage.

See Maintenance Schedule for maintenance interval.

Engine Well Gas Filter

If the engine well gas filter is removed during repair or maintenance, make sure that it is replaced before start up to prevent engine damage.

See Maintenance Schedule for maintenance interval.

Engine Cooling

The radiator and hoses should be checked each time the system is started. Cracks, punctures or obvious leaks indicate the hoses should be replaced immediately. Check the hose clamp for proper tightness. The hoses and thermostat should be replaced each year as part of a preventative maintenance program. The radiator should be drained and flushed after every 4000 hours of operation. If replacing, the thermostat, it is necessary to drill two (2) $^{1}/_{8}$" holes in the thermostat. Please see the original thermostat for location.

Note: When adding or replacing coolant, use a mixture of 50% approved coolant and 50% water. Never add water or pure coolant to the system.

Fire Suppression System (Automatic)

Caution: THE SQUIB CARTRIDGE, WHICH AUTOMATICALLY ACTIVATES THE SYSTEM, IS AN <u>EXPLOSIVE DEVICE</u>. SEE THE MATERIAL SAFETY DATA SHEET MATERIAL DATA SHEET - CARTRIDGE), AND THE WALTER KIDDE INSTRUCTION MANUAL FOR IMPORTANT SAFE HANDLING INFORMATION.

AFTER FIRE CONTROL SYSTEM DISCHARGE

1. Find the cause of the Fire Control release.
2. Arrange to have the necessary corrections and repairs made.
3. Call a qualified fire equipment distributor and have the system recharged and reset into a normal operating condition.
4. Contact Remediation Service Int'l to reset fire shutdown settings in computer.
5. Clean the dry chemical residue by washing (cleaning) exposed surfaces thoroughly with clean, dry, low-pressure compressed air.

Note: The dry chemical agent used in this system may corrode metal surfaces. It is important to clean and remove any residue from metal surfaces as soon as possible. This compound can cause skin irritation or burns.

INSPECTION AND MAINTENANCE

Caution: THE BATTERY SHOULD BE DISCONNECTED WHEN WORKING ON THE FIRE CONTROL SYSTEM.

MONTHLY

1. Check all parts of system for physical damage, corrosion, or for loose parts and fittings.
2. Inspect the fire sensors. If they are coated with mud, grease or dirt, wipe with a clean, dry cloth. If foreign matter cannot be removed, the sensor must be replaced with a new sensor with the same rating.
3. Inspect the cylinder and gauge. The cylinder should not show any signs of mechanical damage, rust or corrosion. The nameplate must be legible. The pointer on the gauge should point to the green "Service Pressure" area on the gauge face. If the system fails to pass any of these checks or inspections, call a qualified, licensed, fire equipment service agency immediately for maintenance service.

SEMI-ANNUALLY

The following procedures must be accomplished every six months by a qualified fire protection service agency or a factory-trained representative, in accordance with the detailed procedures specified in the Factory Instruction Manual. It is the owner's responsibility to arrange and schedule these required procedures on a semi-annual basis.

1. The cylinder and valve must be disconnected from the system. The flexible piping or hoses are then blown out only with clean, dry air or nitrogen to verify that these lines are clean and free of obstruction.

2. The Nitrogen Actuation Cylinder must be removed and inspected for physical damage, rust and corrosion. It must be weighed and its weight must be within 1/2 ounce of the weight stamped on the cartridge. If the cartridge does not meet these inspection requirements, it must be replaced.

EVERY SIX YEARS
The dry chemical agent in the cylinder should be discarded and replaced with a fresh recharge of the same agent in accordance with the instructions on the nameplate of the cylinder. A qualified fire equipment distributor should only do recharging.

EVERY TWELVE YEARS
The cylinder containing the dry chemical agent must be hydro-tested by a qualified fire equipment distributor for compliance with National Fire Protection Association (NFPA) pamphlet 17. The hydro test procedure used must comply with the Compressed Gas Association (CGA) pamphlet C-6, "Standards for Visual Inspection of Compressed Gas Cylinders", and C-1, "Methods for Hydro Testing of Compressed Gas Cylinders".

If the cylinder is mechanically damaged, or has any signs of rust or corrosion, then the cylinder must be inspected and tested, as outlined above before the twelve-year interval.

Frame And Housing

The frame and housing need very little maintenance. The condition of the powdercoating should be inspected semiannually to locate areas of rust that can be cleaned and repainted. RSI carries touchup enamel that can be applied in the field to maintain protection for the metal housing. Stress fractures and cracks should be looked for during the inspection process.

Genset Module

Caution: THE GENSET MODULE OUTPUT CAN HARM OR KILL A PERSON. PLEASE TAKE ALL PRECAUTIONS WHEN PERFORMING MAINTENANCE OR SAFETY CHECKS!

The Genset module should be inspected every 360 hours. The Marathon Genset unit should be kept dry and free of dust. It is advised that the Genset unit be blown off with warm, dry oil-free compressed air if moisture or excessive dirt or dust is found on unit during inspection.

Voltage and current output should be tested per the Marathon Electric Maintenance and Service documentation available on the Product Support CD supplied with this manual. All other maintenance and service should be performed in strict adherence with that document to provide employees and service personnel with detailed safety instruction. The Marathon Electric Maintenance manual will describe the schedule and method necessary to keep the Genset module operating to specification.

Note: The Genset module must be operated at the correct RPM rating during operation, troubleshooting and maintenance checks.

Oil/Water Separator

Note: Please review all safety practices listed in section one before proceeding. This equipment must be operated and maintained only by authorized personnel who have read and understand the operator's manual, have been trained in its use, and following any and all applicable safety procedures.

Tankage
Inspect the integrity of all gaskets around the lids. Any signs of deterioration or undesired leakage should be attended to at once. Ensure that all gasket materials on flanges are in good condition to prevent any leakage problems.

Oil Removal
Oil should be drawn off regularly and not allowed to accumulate. If left unattended, the accumulated oil volume will increase to a point where it will begin to interfere with the operation of the coalescer pack.

A simple method to determine a schedule for oil removal is outlined below:

1. Determine the oil capacity of the unit.
2. Allocate an area/tank for storing and decanting the accumulated oil.
3. Arrange for the proper disposal of the oil, either by further treatment or by having a service dispose of the waste.
4. Oil is designed to flow by gravity. Check to make sure the oil can freely drain from the equipment. If the outlet gets plugged, the oil will flood the separation chamber and begin to seep into the effluent chamber.

Oil Skimmer (Sleeve Type)
Every six months (or as needed) remove and clean the oil skimmer assembly as follows:

1. Parkson recommends replacing the 0-rings every time you disassemble the oil skimmer.
2. Slide the sleeves (X2) toward the middle of the oil skimmer pipe just enough to clear the end of the wall pipe.
3. Remove the oil skimmer from the unit.
4. Slide the sleeves off the oil skimmer pipe.
5. Remove and inspect the 0-rings (X4) from the sleeve. Replace if necessary.
6. Wipe a little (sparingly) grease on the 0-rings.
7. Slide the sleeves toward the center of the oil skimmer pipe so the sleeves are even with the end of the skimmer pipe.
8. Install the oil skimmer back in the unit and line up with the wall pipe. Slide the sleeves back over the wall pipe so that the center of the sleeve is in the middle of the wall and skimmer pipe joint.
9. The oil skimmer is now ready for service.

Effulent Quality
Regularly monitor the quality of the effluent leaving the separator. If any loss in effluent quality is observed, steps should be taken to correct the problem immediately.

Coalescer Pack
Frequency of cleaning will be dependent on the characteristics of the wastewater being processed by the media. Periodic visual Inspection will determine the frequency of cleaning.

Monitor the quality of the effluent water. If the quality starts to deteriorate, this is an indication that the media may need replacement or cleaning.

Clogged Solids In The Tank
Clogged solids may be due to inert debris or biological growth within the tank. If it is biological, shock-dose the system with a chorine or biocide product. Expose the media to this solution for a reasonable amount of time to eradicate the growth. Following the biocide application, use a water stream to loosen and remove the debris from the media. If flushing in place is not enough, remove the media from the tank. Use ordinary hose to create a pressure stream. The maximum pressure so as not to damage the media is 20 psi. After biological growth has been eradicated, remove the media from service. Cleaning compounds can then be used to remove debris and hydrocarbon film that retains solids trapped in the openings. Spray the cleaning compounds directly on to the packs.

> **Note:** While the packs are out of service or being reinstalled, take precautions so as not to damage them. Mechanical damage is a result of mishandling or accident. Take extra care in handling the media.

Media Damage In The Tank
Replacement is generally recommended when the media is physically damaged or when the media openings have been plugged by sludge to the point that it is difficult or impossible to clean them. It is also prudent to investigate the cause of media damage -whether it is mechanical or chemical and to take corrective actions.

Chemical Damage In The Tank
Chemical damage is a result of the introduction of harmful chemicals in the Influent water or cleaning compounds that may have been used to flush the media of debris or clogged solids. Selected solvents harmful to the media include: benzene, toluene and chlorinated substituted organics.

The maximum tolerable temperatures of the wastewater for the following types of media are:

Media	Temperature
PVC	130^0F (60^0C)
CPVC	200F (93^0C)
Polypropylene	160F (71 C)

When replacement is required, remove the media logs from the equipment.

The slant rib coalescing media is a standard product of GLE. This is available In PVC, CPVC, polypropylene, polyethylene, carbon steel or stainless steel. When ordering, specify:

a. the material
b. the plate spacing
c. the size of the logs
d. the number of logs required

Dense Pack (If Provided)
The dense pack assembly is comprised of a 6-inch polyester reticulated foam with 20 pores per inch. The foam has a life expectancy of about 13.5 years under normal conditions. However, exposure to high temperature (150 degrees Fahrenheit or more) will degrade the foam at a much faster rate. The foam is also vulnerable to water at a high pH (10.5 and higher).

Because the openings in the foam are so fine, any solids trapped in the orifices will deteriorate the performance of the dense pack. The presence of any solids in the dense pack is in itself an indication that something is not right. Check the quality of the wastewater. There should be minimal solids carry-over by the time the water reaches the dense pack. High viscosity oils (90-150 SSU) in time will also cause clogging of the pores.

Deterioration in the quality of the effluent might be caused by the degradation of the dense pack. Check the integrity of the foam. If the foam has eroded away to a point where it is impractical to dean, replacement is the solution. If cleaning is an option, spray the foam using high-pressure clean water. If this is still not sufficient, soaking the foam in any kerosene-based solution might free any viscous oil dogging the pores of the foam.

Full preventative maintenance and service instructions are found in the Parkson Maintenance and Service documentation available on the Product Support CD supplied with this manual.

Positive Displacement Blower Module

Proper lubrication is the single most important consideration in obtaining maximum service life and satisfactory operation from any positive displacement unit. Unless operating conditions are severe, a weekly check of oil level and necessary addition of fluid should be sufficient. During the first week of operation, check the oil levels in the sumps about once a day. Check for leaks at all seams and openings.
The oil should be changed after the initial 100 hours of operation. At operating temperatures of 200 degrees F. or less, the life expectancy of high quality petroleum based oil is 2000 hours. Consistent operating temperatures above 200 degrees F. reduce the life of the lubricant by half for every 20 degrees F. above 200 F. In extremely dusty environments the oil should be changed more often.

Full preventative maintenance and service instructions are found in the Dresser/Roots Maintenance and Service documentation available on the Product Support CD supplied with this manual.

Power Take-Off (PTO)

It is important to grease (heavy bearing grease) the PTO shaft. This prevents the bearings (oil impregnated type) from drying out.

Spark And Flame Arrester

The spark arrester requires no maintenance but should be replaced after every 4000 hours of operation. The flame arrester should be checked for cleanliness every 2160 hours of operation. The flame arrester can be cleaned with a solvent or petroleum based product but the flame arrester must be blown dry before reinstallation. It is recommended that the flame arrester be replaced once it has been cleaned instead of continuing to clean and reinstalling.

Spray Aeration Module

The outside of the spray vessel is powder coated to match the base system. The inside is coated with a 3M epoxy compound to protect the tank from rust and other contaminants. The tank is normally filled by vacuum as provided by the engine intake manifold. A periodic cleaning will keep this vessel in good working order.

Inlet and outlet filters should be checked every 180 hours of operation or sooner depending upon the specific site water conditions. Depending on the type and volume of contamination, the filters may be cleaned or replaced as needed to keep the system fully operational.

> **Note:** It is very important that all connections to and from the water re-circulation pump are tight and allow no leakage. Any leak will cause air to enter the pump, causing it to become air-bound (cavitate). Leaks will eventually destroy the pump. The discharge from the pump should always be plumbed into the bottom portion of the holding tank. This will insure that a constant head pressure is present on the discharge stream of the pump.

On the units equipped with a spray aeration tank, the Servo Valve (labeled “vac” valve) is connected to the controller. The quantity of air coming from the well is controlled in order to maintain vacuum and air stripping flow from the spray tank. The spray tank valve (“vac” valve) will open and close based upon the actual spray tank vacuum as compared to the “set point” vacuum.

Maintenance Requirements for Hard Water Scaling Problems

Water with high amounts of total dissolved solids (TDS), such as iron, calcium, manganese, and other minerals, flocculate or “come out” of solution when using air-stripping technology causing certain maintenance conditions that need to be addressed for this pump and treat processes. This problem has been a challenge to the environmental industry since the inception. We will address one method that we are most familiar with, and that is filtration as it applies to the RSI spray aeration/air-stripper system.

RSI's spray aeration process is, for all practical purposes, an air-stripper. RSI has made several enhancements to its water treatment process over the past years, to include the minimization of the effects of TDS in the extracted groundwater. In many instances the system can be used "as is" with no additional filtration (other than provided) with simple preventative maintenance, (i.e.) quarterly mild acid baths of the various components. Other sites require more frequent maintenance intervals, and some sites must have additional filtration and/or water pretreatment, or they won't run at all. The untreated TDS interferes with the design process. On sites such as these, site-specific solutions must be considered.

If it becomes necessary to add components to the process, RSI will assist you in implementing your final design into our process. We will help in anyway possible, but are hesitant to provide an engineered solution as this is outside the realm of our expertise. It has been our experience that high TDS sites may require site-specific solutions.

Maintenance intervals are dependent upon the severity of the hard water problem. Please do not hesitate to call RSI should you have any questions or require further information.

Major Components of Spray Aeration Module

The major components of the Spray Aeration Module are as follows:

Spray Tank/Vacuum Vessel

The inside of the spray aeration vessel is coated with a 3M^{tm} "non stick" epoxy. The outside is powder coated for all weather conditions. A periodic mild acid wash will keep this vessel in good working order.

> **Note:** All process airflow from the Spray Aeration Tank to the engine must be turned off prior to commencing with the acid wash process.

Water Pump

The water pump is used in three different, but related, processes.

a. To extract the water from the Spray Tank at a process flow rate of 70 gpm. (The Spray Tank re-circulates 90% of the extracted water back into the spray tank through multiple nozzles.)
b. To continuously route the remaining 10% of the extracted water through a filter, then through a jet pump on the suction side of the jet pump for condensate removal, and then return the fluid to the spray tank.
c. To discharge treated water from the system. Discharge pressure should be monitored to determine if downstream blockages are occurring. A periodic mild acid wash will keep this pump in good working order.

> **Note:** All process airflow from the Spray Aeration Tank to the engine must be turned off prior to commencing with the acid wash process.

Full Cone Spray Nozzles

These nozzles atomize the water into droplets for air-stripping purposes. A periodic mild acid wash will keep this component in good working order.

> **Note:** All process airflow from the Spray Aeration Tank to the engine must be turned off prior to commencing with the acid wash process.

Jet Pump

The jet pump is used to create a vacuum greater than the normal process flow vacuum to "drain" condensate traps throughout the entire system. A periodic mild acid wash will keep this pump in good working order. The operating pressure of the jet pump must be maintained at >12 psi for proper operation.

> **Note:** All process airflow from the Spray Aeration Tank to the engine must be turned off prior to commencing with the acid wash process.

Float Level Switches

The high and low float level switches control the process flow. These switches should be removed prior to any acid washing of the Spray Tank, and re-installed when acid wash is complete.

> **Note:** All process airflow from the Spray Aeration Tank to the engine must be turned off prior to commencing with the acid wash process.

Safety Shutdown Switch

The safety shutdown switch shuts down the entire process if it is switched for more than 5 continuous seconds, usually caused by a high water conditions. This switch should be tested routinely for correct operation and replaced when malfunctioning.

Liquid to Liquid Heat Exchanger

The liquid-to-liquid heat exchanger is a copper coil with copper fins designed to dissipate waste heat from the engine coolant to the extracted groundwater. The efficiency of this heat exchanger will diminish over time, as caused by "scaling". A periodic mild acid wash (on the outside) will keep this heat exchanger in good working order.

> **Note:** All process airflow from the Spray Aeration Tank to the engine must be turned off prior to commencing with the acid wash process.

Solenoid Valves

The solenoid valves are controlled (indirectly) by the float level switches and allow process flow in or out of the spray tank as necessary. These valves should be disassembled and cleaned periodically.

Bag Filters (100 micron)

One bag filter filters total suspended solids (TSS) from the influent water prior to the spray aeration vessel, and another filters TSS prior to discharge. They should be disassembled and the filter elements cleaned (or replaced) periodically.

Rotometers

Influent and effluent water process flow rates are measured. These flow meters should be disassembled and cleaned periodically.

Supplemental/Alternate Fuel Control System

The supplemental/alternate fuel control system is heated by the engine coolant system through feed and return hoses attached to the propane lockout unit mounted above the propane converter. This heated circuit has a thermostat mounted in-line to maintain a constant operating temperature to the lockout unit to keep the unit from freezing due to the ambient temperatures of the liquid propane used. If the lockout unit is showing indications of freezing, replace the thermostat and check the coolant flow through that unit.

Both the propane lockout and converter can be disassembled and cleaned. Repair kits are available from RSI which include gaskets, diaphragms and other minor components. It is advised that if the system is operating with propane as the supplemental fuel, the lockout and converter be cleaned and serviced semi-annually.

Transporter

Following is a basic checklist to be performed before moving the transporter/trailer unit:

1. Hitch – Check to make sure the hitch is secure and that the ball on the towing vehicle and the hitch on the Transporter are the same size. The single axle Transporter requires a 2" ball on the hauling vehicle. The dual axle Transporter requires a 2-5/16" ball on the hauling vehicle.
2. Safety Chain – Make sure the safety chain on the Transporter is properly hooked to the towing vehicle.
3. Bolts – Make sure the machine V3/V4 housing is securely bolted to the Transporter.
4. Electrical Plug – Make sure the towing vehicle is wired with towing package electrical connections and that the electrical polarity of the Transporter is the same as the towing vehicle.
5. Break Lights – Make sure Transporter break lights are illuminated when the brakes on the towing vehicle are engaged.

6. Turn Indicators – Make sure the Transporter turn indicators work properly when the turn indicators of the towing vehicle are engaged.
7. Tire Pressure – Make sure the Transporter tires are filled to the manufacturer's recommended tire pressure.
8. Spare Tire – Make sure the Transporter spare tire is on the trailer and is filled to the manufacturer's recommended tire pressure.
9. Wheel Lugs - Ten (10) wheel lugs are set at 85# torque.

Every 5,000 miles the Transporter must be inspected for the following:

1. Inspect axle bearings and lubricate or service as required.
2. Inspect tires for excessive and uneven tread wear. Verify tire inflation pressure.
3. Inspect mechanical hitch for damage or excessive wear.
4. Test brake lights and turn signals.

Well Gas Filter Housing And Water Trap

The well gas filter cartridge should be checked after every 720 hours of operation. RSI stocks the replacement cartridges for any style of well gas filter assembly. Seal gaskets and O-rings should be inspected every 720 hours and replaced annually or as needed. Hose clamps, latches and bolts should be checked for tightness every 720 hours or as needed if a vacuum leak in the well circuit is suspected.

Well Gas (Larger Capacity Options)

Post-well gas filter holding tanks and pre-knockout tanks are both used to hold excess liquids coming from the well. The outside of the vacuum vessel is powder coated to match the base system. The inside is coated with a 3M epoxy compound to protect the tank from rust and other contaminants. The tank is normally filled by vacuum as provided by the engine intake manifold. A periodic cleaning will keep this vessel in good working order. Inspection for loose fittings and rust should be performed monthly to keep the vessels in good operating condition.

MAINTENANCE SCHEDULE

Maintenance Schedule		✓	Qty.	Maintenance Schedule - Continued		✓	Qty.
Check All Fluid Levels: (add as necessary)	each visit			Oil Change/Replace Oil Filter – Shell Rotella T 15/40 w/Advanced Soot Control	Every 180 to 360 hrs*		Qt.
Coolant, (record coolant temp): (°F)	each visit		Qt.	Exhaust and Intake Manifold Bolts Torqued Note 1	Once at 360 hours*		
Oil, (record oil pressure): psi	each visit		Qt.	Power Take Off & PD Blower(s) Serviced	Every 360 hours*		
Record Cat Temps: Pre (°F) Post (°F)	each visit			Spark Plugs Replaced – Autolite # AUT 25	Every 720 hours*		
Check Battery Connections and voltage: (DC)	each visit			Fresh Air and Well Gas Filter Replaced	Every 720 hours*		
Check & Drain Moisture Knockout Tank	each visit			Rotor & Cap Replaced	Every 2160 hours*		
Check Emergency Contact Switches	each visit			PCV Valve Replaced	Every 2160 hours*		
Check Spray Aeration and DPE Filters. Clean or Replace Spray Aeration/DPE Filters as needed	each visit			Spark Plug Wires Replaced – 8 mm premium conductive silicon core & silicon jacket	Every 2160 hours*		
Check Belts and Hoses	each visit			Check Propane Filter – Replace If Necessary	Every 2160 hours*		
Check Spray Aeration Heat Exchanger	each visit			Flame Arrestor Serviced or Replaced	Every 2160 hours*		
Check and Clean Spray Aeration Solenoid Valves	as needed			Radiator Pressure Washed and Degreased	Every 2160 hours*		
Replace Ignition Module and Coil (as a set)	as needed			Catalytic Converters & O2 Sensor Replaced	Every 4320 hours*		
Clean Flow Measurement Devices	as needed			Coolant Changed & Radiator Flushed	Every 4320 hours*		Gal.
Spray Aeration Heat Exchanger- mild acid wash	as needed			Fire Extinguisher System Serviced	Annually		

SPECIFY BRAND, MODEL & QTY OF ALL PARTS AND MATERIALS USED:	COMMENTS:

Note 1. See torque specifications in Operators Manual. Perform only when engine is cold.

*UPON INITIAL START-UP (AND AFTER A LENGTHY STORAGE) RSI ADVISES THAT THE USER VISUALLY CHECK THE UNIT MORE OFTEN THAN SCHEDULED MAINTENANCE EVENTS DICTATE. AIR QUALITY MONITORING AND/OR WATER DISCHARGE SAMPLING MAY BE REQUIRED IN MORE FREQUENT INTERVALS AS PERMIT CONDITIONS SPECIFY.

IMPORTANT: CERTAIN SITE CONDITIONS, SUCH AS LEADED FUELS, EXCESSIVE DUST AND TEMPERATURE EXTREMES MAY REQUIRE MORE FREQUENT SERVICING OF COMPONENTS THAN OUTLINED ABOVE. THIS MAINTENANCE SCHEDULE IS INTENDED TO PROVIDE GENERAL MAINTENANCE ADVICE AND MAY REQUIRE MODIFICATION TO FIT ACTUAL SITE CONDITIONS.

RSI SYSTEMS ARE DESIGNED TO OXIDIZE PETROLEUM HYDROCARBONS [NON-CHLORINATED HYDROCARBONS] IN THE NORMAL COMBUSTION PROCESS OF AN INTERNAL COMBUSTION ENGINE. ANY COMPOUNDS PRESENT IN THE EXTRACTED AIR STREAM OTHER THAN PETROLEUM HYDROCARBONS OR ATMOSPHERIC CONSTITUENTS MAY CAUSE DAMAGE TO THE ENGINE.

Chapter

8

DRAWINGS & BILLS OF MATERIALS

APPENDICES

APPENDIX A

Standard Controller Shutdown Alarms

Alarm Display	Full Name	Description	Cause	Controller Board	Source/ Pin#
H_2O_S	High Water Level Safety Switch grounded	Dedicated high water level switch	Ground pin for 5 sec	Cont I/O	24
AUX2	Ground signal from undefined component	Undedicated system shutdown for customer use	Ground pin for 5 sec	Cont I/O	25
FIRE	Fire, shutdown	Dedicated Fire suppression system activated	Fire sensor switch closed	Cont I/O	Software
ENG_T	Engine Coolant Temp Over Limit	Dedicated Coolant temperature monitor	Engine temperature > 210 F	DAQ Input	38
OIL_P	Low Oil Pressure	Dedicated Pressure Sender Engine oil pressure monitor	Engine oil pressure < 20	DAQ Input	39
E_CAT	Engine Post or Pre Cat Temp Over Limit	Dedicated Engine pre or post Cat temperature	Temperature > 1350 deg F	DAQ Therm	Software
V_LMT	Air or Fuel Valve Over Limit	Dedicated Valves remain above maximum level Set Point	Valve positions > switch setting	Cont I/O	Software
RPM	RPM Over Speed Over Limit	Dedicated Engine RPM exceeded Set Point	RPM > switch setting	Cont I/O	Software
REC_P	Low Recirculating Pump Pressure	Dedicated Pressure Sender Recirculating Pressure Monitor	Recirculating pressure < 3psi	DAQ Input	58
SPR_T	Spray Tank Temperature Over Limit	Dedicated Temp Sender Spray Tank Temperature Monitor	Spray Tank Water Temp > 160 F	DAQ Input	59
STALL	Engine Stalled	Engine stalled for no apparent reason	Unknown	Cont I/O	Software

Additional inputs for Enhanced Controller Only

Alarm Display	Full Name	Description	Cause	Controller Board	Source/ Pin#
BLO_T	CatOx Blower Temp	Dedicated Thermal Sender CatOx blower	Ground pin for 5 sec	CatOx I/O	54
LEL	LEL	Dedicated LEL sensor monitor	LEL > (Set Point + 10%)	CatOx I/O	53,12
C_CAT	CatOx Inlet or Outlet Temp	Dedicated CatOx inlet or outlet temperature	Temperature > 1250 deg F	CatOx Therm	Software
P1/P2	Pressure Switch	Dedicated Pressure Sender on Filters	Ground pin for 5 sec	CatOx I/O	57

APPENDIX B

Murphy System Shutdown Conditions Description & Troubleshooting

Display	Name	Description; Troubleshooting
AUX_V	AUX Volt	Auxiliary Voltage (generator)
AUX2	Aux2 Murphy	Undedicated system shutdown. This fault condition is caused by a ground-switch being activated. Check all external switches connected to pin # 25 on the breakout board to make sure none are activated/switched. Replace or repair as necessary. (pin # 25 is normally 8-9 volts DC when not grounded on the break out board).
BATT	Battery	System Battery Voltage. This fault condition is caused by a hard coded software limit being exceeded, usually caused by the alternator, voltage regulator & coil (change as a set), or other electrical problem.
BLO_T	CatOx Blower Temp	Thermal switch on CatOx blower. This fault condition is caused by a ground-switch being activated. Check all external switches connected to pin # 54 on the breakout board to make sure none are activated/switched. Replace or repair as necessary. (pin # 54 is normally 8-9 volts DC when not grounded on the break out board).
C_CAT	CatOx Outlet Temp	CatOx outlet temperature. This fault condition is caused by a hard coded software limit being exceeded. Assuming the fault is not due to CAT-OX overheat, check type K thermal wire(s) and connector(s) that is(are) connected to controller and to the type K temp probe(s) on the CAT-OX to make sure wire is securely fastened at both locations and no shorts exist. Replace probe(s) or repair wiring/wiring connections as necessary.
COMP_R	Compress Press	Compressor Pressure Low
E_CAT	Post Cat Temp	Engine post Cat temperature. This fault condition is caused by a hard coded software limit being exceeded. Assuming the fault is not due to automotive catalyst overheat (i.e. unburned hydrocarbons coming from the engine due to spark plug(s) fouled, spark plug wires malfunctioning, ignition timing, faulty carburetor, faulty controller, bad engine, etc.), check type K thermal wire(s) and connector(s) that is(are) connected to controller and to the type K temp probe(s) on the automotive catalyst to make sure wire is securely fastened at both locations and no shorts exist. Replace probe(s) or repair wiring/wiring connections as necessary. Also, make sure temp probes are not grounded out to exhaust system.
ENG_T	Engine Temp	Coolant temperature monitor. This fault condition is caused by a hard coded software limit being exceeded. Assuming the fault is not due to engine overheat (i.e. bad thermostat, bad water pump, clogged radiator, etc.), check wire connected to pin # 38 on the breakout board and the temp sender on the engine to make sure wire is securely fastened at both locations. Replace sensor or repair wiring as necessary.
FIRE	Fire Murphy	Fire suppression system activated. This fault condition is caused by the automatic fire extinguisher system being activated. Refer to manual for service information.

Display	Name	Description; Troubleshooting
H_2O_S	Aux1 Murphy	Undedicated system shutdown. A high-level float switch being activated causes this fault condition. Check all float switches to make sure none are activated/switched. Replace or repair as necessary. Float switches exist in the well gas filter housing, the spray aeration tank, and the DPE tank, and are wired in series to pin # 24 (normally 8-9 DC volts when not grounded) on the break out board.
LEL	CatOx LEL	LEL sensor monitor. This fault condition is caused by a hard coded software limit being exceeded. Assuming the fault is not due to high LEL, check wire connected to pin # 53&12 on the breakout board and the LEL sender in the engine compartment to make sure wire is securely fastened at both locations. Replace sensor or repair wiring as necessary. See GASTECH LEL service manual for further information.
OIL_P	Oil Pressure	Engine oil pressure monitor. This fault condition is caused by a hard coded software limit being exceeded. Assuming the fault is not due to engine low oil pressure (i.e. bad oil pump, kinked oil line, clogged oil cooler, bad engine, etc.), check wire connected to pin # 39 on the breakout board and the pressure sender on the engine to make sure wire is securely fastened at both locations. Replace sensor or repair wiring as necessary.
P1/P2	Delta P1/P2	Pressure switch on water filters. This fault condition is caused by a ground-switch being activated. Check all external switches connected to pin # 57 on the breakout board to make sure none are activated/switched. Replace or repair as necessary. (pin # 57 is normally 8-9 volts DC when not grounded on the break out board).
RECIR	Recirc Press	Recirculating Pressure Low
RPM	High RPM	Engine RPM monitor. This fault condition is caused by a hard coded software limit being exceeded, usually caused by major air fuel ratio changes due to site specific conditions.
STALL	Stalled condition	System unable to start. This fault condition is caused by a hard coded software limit being exceeded. If it happens during the initial starting sequence, it is probably due to the engine being cold. If the engine has been running for a period of time, it is normally due to an interrupted fuel supply, or faulty gas solenoid valve, propane lock off malfunction (vacuum hose came loose), or oil in the propane.
TIME	Time's up	Operational Time has expired
Vlim	Valve limit	Valve runaway. This fault condition is caused by a hard coded software limit being exceeded. Assuming the fault is not due to the engine not being able to breath (usually caused by automotive catalyst plugging causing back pressure in excess of 1.5 psi or the intake spark arrestor being plugged), ignition timing, faulty carburetor or faulty controller, then the problem probably is with the fuel supply. Check Propane for excessive oil, check vacuum hose connected to vacuum safety lock off to make sure it is securely connected, check 1" solenoid valve for correct operation.
WTEMP	Water Temp	Spray Tank Water Temp High

APPENDIX C

Phoenix-1000 Default Settings 8.xx releases

SET POINT MENU	8-Cyl	6-Cyl	4-Cyl	Description / Notes
				Requires Menu Access or Customer Override Code
Running RPM	1800	1800	2000	Changing this setting may affect system performance unless other settings are modified.
Max Engine Well Vacuum (in$H_2$0)	300	300	300	Well valve will not open past H_2O set point
Max CatOx Well Vacuum (in$H_2$0)	190	190	190	Well valve will not open if Well vac is above the set point
Data Save Interval (minute)	60	60	60	Data save at 60 will save 27 days of data. Clear History before changing this setting.
Total for Menu				
CONTROL MENU	**8-Cyl**	**6-Cyl**	**4-Cyl**	**Description / Notes**
				Requires Menu Access or Customer Override Code
Selected Data Set	0	0	0	0=none, all custom; 1=Data Set 1, 2=Data Set 2, etc.
Idle RPM	1800	1800	1800	Changing this setting may also affect initial air and fuel valve positions described below
Air Initial Position	90	50	40	Adjust to site specific conditions, i.e. climate, elevation, load and fuel type.
Fuel Initial Position	85	55	35	Adjust to site specific conditions, i.e. climate, elevation, load and fuel type.
Min Tank Vacuum (inches Hg)	23	23	23	Set at 14 if water treatment system is present
Target O_2	1800	1800	1800	Should always remain at factory settings if present in programming
KFRRun O_2	35	35	35	Should always remain at factory settings if present in programming
Number of Restart Attempts	1	1	1	Automatic restart or remote start feature is subject to local governing agencies.
Remote Start Enable / Disable	0	0	0	Change as required
Fuel Ratio (0=Demod, 1=O_2 @ Temp)	1	1	1	Should always remain at factory settings if present in programming
Fuel Type (0=Propane, 1=Natural Gas)	0	0	0	Set to appropriate setting
Modem Speed (0=2400, 1=4800, 2=9600)	2	2	2	May need to reduce modem speed for cellular. Must be at 9600 for DSD 1000 transfer
Number of Cylinders (4,6,8)	8	6	4	Set to appropriate setting
Emergency Phone #1 Area Code	0	0	0	Change as required, 0 for area code means local call
Emergency Phone #1 Prefix	0	0	0	Change as required, 0 for prefix means don't dial
Emergency Phone #1 4 Digits	0	0	0	Change as required
Emergency Phone #2 Area Code	0	0	0	Change as required
Emergency Phone #2 Prefix	0	0	0	Change as required
Emergency Phone #2 4 Digits	0	0	0	Change as required
System Access Code	1234	1234	1234	Change as required to protect entry into system operation
Control Menu Access Code	xxxx	xxxx	xxxx	Change as required to protect entry into customer access control menu

Phoenix-1000 Default Settings 7.xx and earlier releases

START OF SET POINT MENU	Scale Factor	8-Cyl	6-Cyl	4-Cyl
Idle RPM	1 bit / RPM	1800	1800	1800
Idle Time (sec)	1 bit / sec	60	60	60
Running RPM	1 bit / RPM	1800	1800	2000
Warm-up Time (sec)	1 bit / sec	60	60	60
Max Well Opening (%)	1 bit / %	100	100	100
Tank Vacuum (inches Hg)	1 bit / in. Hg.	10	10	10
Manifold Vacuum (inches Hg)	1 bit / in. Hg.	12	12	12
Engine Cranking Time (sec)	1 bit / sec	7	7	7
Number of Cylinders (4,6,8)	1 bit / Cyl	8	6	4
Max RPM Shutdown/Restart	1 bit / RPM	3000	3000	3000
Printer Enable (0=Off, 1=On)	0 = off, 1 = on	0	0	0
Fuel Type (0=Propane, 1=Natural Gas)	0 = Pro, 1 = NG	0	0	0
START OF CONTROL MENU	**Scale Factor**	**8-Cyl**	**6-Cyl**	**4-Cyl**
Modem Speed (0=2400, 1=4800, 2=9600)	N/A	2	2	2
Data Save Interval (minute)	1 bit / min	60	60	60
Data Print Interval (minute)	1 bit / min	10	10	10
Number of Restart Attempts	1 bit / attempt	1	1	1
Air Initial Position	1 bit / step	90	50	40
Fuel Initial Position	1 bit / step	85	55	35
Fuel Max Start Position	1 bit / step	95	65	45
Startup Fuel Valve Step Rate	1 bit / step	20	20	20
Well Valve Increment (steps)	1 bit / step	20	20	20
Max AIR Opening	1 bit / step	150	150	150
Max FUEL Opening	1 bit / step	150	150	150
Delta RPM Limit for Well Dec	1 bit / RPM	100	100	100
Max DRPM for Well Valve Dec	1 bit / RPM / sec	600	300	150
Max VAC Opening	1 bit / step	300	300	300
KRPM	gain	125	125	125
START OF CONTROL MENU	**Scale Factor**	**8-Cyl**	**6-Cyl**	**4-Cyl**
KDRPM	gain	50	50	35
Kvacuum	gain	10	10	10
Target Air/Fuel Mix	1 bit / %	100	100	100
Demodulator Amplitude	1 bit / step	2	2	1
Emergency Phone #1 Area Code	N/A	0	0	0
Emergency Phone #1 Prefix	N/A	0	0	0
Emergency Phone #1 4 Digits	N/A	0	0	0
Emergency Phone #2 Area Code	N/A	0	0	0
Emergency Phone #2 Prefix	N/A	0	0	0
Emergency Phone #2 4 Digits	N/A	0	0	0
Emergency Phone #3 Area Code	N/A	0	0	0
Emergency Phone #3 Prefix	N/A	0	0	0
Emergency Phone #3 4 Digits	N/A	0	0	0
Access Code	N/A	1234	1234	1234
Access Code (Verify)	N/A	1234	1234	1234

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APPENDIX G

Standard Operating Procedures (SOPs) for Pre-Remedy Monitoring

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Title **Page**
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ACRONYMS AND ABBREVIATIONS

^{o}C	degrees Celsius
^{o}F	degrees Fahrenheit
AFB	Air Force Base
ASTM	ASTM International
BWHSP	Base-Wide Health and Safety Plan
BWP	Base-Wide Plan
C-O-C	chain-of-custody
cm	centimeter
DTB	depth to bottom
DTNAPL	depth to NAPL
DTW	depth to water
DWC	depth of the water column
ID	identification
IDW	investigation-derived waste
FID	flame ionization detector
FRA	flow restrictor assembly
ft	foot/feet
L	liter
LNAPL	light, non-aqueous, phase liquid
mg/L	milligrams per liter
mL/min	milliliter per minute
NAPL	non-aqueous phase liquid
NTU	nephelometric turbidity unit
O.D.	outside diameter
ORP	oxidation/reduction potential
PID	photoionization detector
PPE	personal protective equipment
ppmv	parts per million by volume
QAPP	Quality Assurance Project Plan
QAPjP	BFF Spill Quality Assurance Project Plan
SOP	Standard Operating Procedure
SSHP	Site Safety and Health Plan
WMP	Waste Management Plan

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KIRTLAND AFB BASE-WIDE SOP B1.11

EQUIPMENT DECONTAMINATION

Note: The Kirtland AFB Base-Wide Health and Safety Plan, Quality Assurance Project Plan, Field Sampling Plan, and Waste Management Plan referenced within these SOPs are superseded by the Bulk Fuels Facility Spill project-specific Accident Prevention Plan/Site Safety and Health Plan, BFF Spill Quality Assurance Project Plan (QAPjP), Field Sampling Plan (within the QAPjP), and Waste Management Plan.

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SOP B1.11 Equipment Decontamination

The objective of field decontamination is to remove contaminants of concerns from sampling, drilling and other field equipment to concentrations that will **not** impact study objectives. This SOP was developed for use by field personnel who are responsible for cleaning sampling or other equipment in the field.

Specification for Decontamination Materials

- Use a standard brand of phosphate-free laboratory detergent, either liquid or powder, preferably Liquinox® or Alconox®.
- Use tap water from any municipal water treatment system or use bottled drinking water. Soap and tap water will remove the gross contamination from the sampling equipment.

Handling and Containers for Cleaning Solutions

Improperly handled cleaning solutions may easily become contaminated, thereby jeopardizing the validity of the sample data. Containers should be constructed of the proper materials to ensure their integrity. The following containers should be used for storing the specified cleaning materials:

- Soap—Keep in clean containers until use. It should be poured directly from the container into the wash bucket or tub.
- Tap water—Keep in clean tanks, hand-pressure sprayers, or squeeze bottles, or apply directly from a hose.
- Deionized water—Store in clean containers that can be closed when not in use. It may be applied from squeeze bottles.

Decontamination of Large Equipment

The following procedure will be used to decontaminate large pieces of equipment, such as casings, auger flights, pipe and rods, and those portions of the drill rig that may stand directly over a boring or well location or that come into contact with casing, auger flights, pipe, or rods. This procedure shall also be employed for the decontamination of heavy machinery such as backhoes, excavators, etc.

- Wash the external surfaces of equipment with high-pressure hot water and Liquinoxor®
- Alconox or equivalent non-phosphate, laboratory-grade detergent. If necessary, scrub until all visible dirt, grime, grease, oil, loose paint, rust flakes, etc., have been removed. The inside surfaces of equipment which come in direct contact the media being sampled will also be washed as described above. Specific decontamination instructions will be included in the project-specific addenda.
- Rinse with potable water.
- This decontamination procedure will be performed before equipment is used and between each well or other sampling locations.

Decontamination of Sampling Equipment

The following procedure will be used to decontaminate devices such as split-spoons, bailers, sample trays, spatulas, spoons and augers that come in direct contact with the sample media:

- Wash and scrub equipment using tap water and laboratory detergent. Wire or plastic bristle brushes can be used.
- Rinse with tap water, removing all visible dirt and soap residue.
- Rinse with deionized water.
- Place onto clean plastic sheeting and allow to completely air dry.
- If not used immediately, wrap in aluminum foil.

Decontamination of sampling equipment will be kept to a minimum in the field and, whenever possible, dedicated sampling equipment will be used. Decontamination fluids will be disposed as required by the project specific addenda to the Waste Management Plan (WMP) (Appendix E of the Base-Wide Plan [BWP]). Personnel directly involved in equipment decontamination will wear appropriate personal protective equipment as specified in the Base-Wide Health and Safety Plan (BWHSP) (Appendix F of the BWP) and the Site Safety and Health Plan (SSHP).

Whenever possible, decontamination pads provided by Kirtland Air Force Base (AFB) should be used to clean large equipment. In other instances, a decontamination pad may need to be constructed at the investigation site.

Construction of a Decontamination Pad

Decontamination pads constructed in the field should meet the minimum specifications described below:

- The pad should be constructed in an area known or believed to be free of surface contamination. A temporary pad should be lined with a water impermeable material with no seams within the pad. The material should be either easily replaced (disposable) or repairable.
- The location of the pad should be out of the work zone and situated not to interfere with other work in progress.
- The pad should not leak excessively. Any sump or pit should be lined.
- Sawhorses or racks constructed to hold equipment while being cleaned should be high enough above the ground surface to prevent equipment for being splashed and re-contaminated.
- Water collected on the pad will be containerized and disposed of as per the Investigation-Derived Waste (IDW) Disposal Plan. Small amounts of water will be left to evaporate.

Personal Protective Equipment

Personnel directly involved in equipment decontamination shall wear appropriate personal protective equipment (PPE) as specified in the BWHSP (Appendix F of the BWP) and the SSHP. The appropriate PPE is selected based on the level of contamination present or suspected at the site. Care should be taken so the selected PPE protects decontamination workers from unnecessary contact with soils or decontamination fluids. The following is a list of the minimum PPE required to perform decontamination activities:

- Safety glasses with splash shields or goggles and latex gloves will be worn during all cleaning operations. For decontamination activities involving large amounts of water, rain suits or aprons and rubber over-boots should also be worn.

No eating, smoking, drinking, chewing, or any hand-to-mouth contact should be permitted during cleaning operations.

References for Other Applicable ASTM International (ASTM) Standards

ASTM D5088 – Decontamination of Field Equipment Used at Nonradioactive Waste Sites

ASTM D5608 – Decontamination of Field Equipment Used at Low Level Radioactive Waste Sites

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KIRTLAND AFB BASE-WIDE SOP B4.1

MONITORING WELL SAMPLING

Note: The Kirtland AFB Base-Wide Health and Safety Plan, Quality Assurance Project Plan, Field Sampling Plan, and Waste Management Plan referenced within these SOPs are superseded by the Bulk Fuels Facility Spill project-specific Accident Prevention Plan/Site Safety and Health Plan, QAPjP, Field Sampling Plan (within the QAPjP), and Waste Management Plan.

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SOP B4.1 Monitoring Well Sampling

The following guidelines and procedures will be used for sampling monitoring wells at Kirtland AFB. This SOP just provides general procedures for low-flow and non low-flow methods of monitoring well sampling. Please refer to project-specific work plans for any deviations from the procedures outlined in this SOP.

General Pre-Sampling Requirements

- Monitoring wells will be sampled in order of increasing contamination unless the wells are equipped with dedicated systems.
- Samples will not be collected within 2 weeks of well development.
- Samples to be analyzed for volatile and gaseous constituents will not be withdrawn with pumps that exert a vacuum on the sample (e.g., centrifugal).
- Wear appropriate PPE as outlined in the BWHSP (Appendix F of the BWP) and the SSHP. In addition, samplers will don new sampling gloves at each individual well prior to sampling.
- Visually examine the exterior of the monitoring well for signs of damage or tampering and record in the field logbook.
- All purging and sampling equipment will be decontaminated as specified in SOP B1.11 and will be protected from contamination until ready for use. If a centrifugal or submersible pump is used, discard pump suction line after each well. If the sampling equipment is dedicated to a specified well, the previous step may be eliminated. Portions of the pumps that contact the sample must be made of stainless steel and/or Teflon®.
- Unlock well cap or outer steel casing lid.
- Take photoionization detector (PID), lower explosive limit, and oxygen readings, with the appropriate meter(s), at the well head immediately upon opening the cap and record in field log book. If high concentrations are detected, take the appropriate measures as outlined in the BWHSP (Appendix F of the BWP) and the SSHP.
- Measure the static water level in the well with an electronic water level indicator as described in SOP B5.6 and record in the field logbook. Measure the total depth of the well to verify original construction details and determine if any appreciable fines have entered the well which may cause problems during sampling and/or potential problems with the analytical data. The water level indicator will be rinsed with deionized water in between individual wells to prevent cross-contamination.
- Calculate the volume of water in the well in gallons according to the Well Purge and Water
- Quality Field Data Sheet (Figure B4.1-1). This sheet is a typical well purge data sheet that will be used in the field to perform well volume calculations. The information required for the calculation includes well depth (measured from top of casing to bottom of well), well casing diameter, static water level (measured from top of casing) and the borehole diameter. Table B4.1-1 lists quick conversions for water volumes.

Monitoring Well Purge Procedures

Non Low-Flow Well Purging Procedure

- Purge three to five well volumes of water from the well using one of the methods described below:
  - Pump with a submersible pump equipped with a check valve to avoid backflush and polyethylene tubing. For a non-dedicated system, set intake at the surface level of the groundwater and start

pump; continue to lower the intake line through the well to just above screen depth ensuring that all standing water in the well has been purged. If the system is dedicated, it is not necessary to move the intake from it's set position.

— Pump with a centrifugal pump and polyethylene tubing. For a non-dedicated system, set intake at the surface level of the groundwater and start pump; continue to lower the intake line through the well to just above screen depth ensuring that all standing water in the well has been purged. If the system is dedicated, it is not necessary to move the intake from its set position. Discard the suction line after each well unless the tubing is dedicated.

– Bail well with a stainless steel or Teflonbailer and Teflon-coated stainless steel wire. Hand bailing the monitoring well is not a highly recommended purge method and should only be utilized as a last resort..

- Measure and record temperature, pH, specific conductance, turbidity, dissolved oxygen and oxidation/reduction potential (ORP) as each volume of groundwater is purged.
- After purging, allow the static water level to recover to approximately 80% of its static level or for 16 hours after purge completion, whichever comes first.
- When a well is pumped dry before three to five well volumes have been purged, the sample will be collected as soon as a sufficient amount of water has re-entered the well.
- Obtain the sample from the well after the required volume of groundwater has been purged and the temperature, pH, specific conductance, dissolved oxygen, ORP and turbidity have stabilized according to the stabilization requirements on Table B4.1-1. If the parameters do not stabilize within 3 to 5 well volumes the client should be notified and the well should be considered for additional purging or redevelopment.

Low-Flow Purging with Dedicated Submersible Pumps

- The pump intake shall be set at the bottom of the screened interval of each well where the depth to water (DTW) is within the screened interval. Where the DTW is above the screened interval, pump intakes shall be set at the top of the screened interval.
- Begin purging at a rate of approximately one liter per minute or as slow as the conditions and dedicated system allow (if greater than one liter per minute).
- Continuously monitor the water level and potential subsequent drawdown with an electric water level indicator. If the static water level prior to purging is within the screened interval, the drawdown shall not exceed a distance of 25 percent of the length of the saturated screened interval. If the water level falls below the 25 percent drawdown level, the pumping rate should be decreased to stabilize the water level to prevent cascading and potential loss of volatiles, excessive turbidity and entrapment of air in the filter pack. If the static water level is above the screened interval, acceptable drawdown is defined as the lowering of the water level to the top of the screened interval. If continued drawdown occurs below the top of the screened interval, the pump rate will be decreased to stabilize the water level to prevent atmospheric contact with the filter pack and formation, which could alter redox chemistry of the well.

  Note: In wells with slow recharge rates, it may be necessary to stop the pump and allow the well to recharge in order to remain at or above the drawdown limit. If this is necessary, be certain not to allow any water in the tubing to backflush into the well and when purging recommences

- Purging will be considered complete when a minimum of one saturated screen volume, calculated according to the formula presented in Table B4.1-1, has been removed and the groundwater quality parameters have stabilized according to the stabilization requirements (Table B4.1-1).
- In the event the pump seizes and locks up during purging or sampling activities and it is necessary to

jiggle or move the pump within the well, the purging will be re-initiated beginning with the first step of this procedure.

Low-Flow Purging with Non-Dedicated Submersible Piston Pumps

- Prior to deploying the pump, it shall be decontaminated in accordance with procedures specified in SOP B1.11, Equipment Decontamination. If sample collection tubing is non-dedicated, it shall also be decontaminated prior to deployment.
- Collect an equipment blank as described in the Field Sampling Plan (Appendix A)
- Measure the static water level in the well.
- If the DTW is within the screened interval set the pump intake at the bottom of the screened interval. If the DTW is above the screened interval the pump intake shall be set at the top of the screened interval.
- Begin purging at a rate of approximately one liter per minute or as slow as the conditions and dedicated system allow (if greater than one liter per minute).
- Continuously monitor the water level and potential subsequent drawdown with an electric water level indicator. If the static water level prior to purging is within the screened interval, the drawdown shall not exceed a distance of 25 percent of the length of the saturated screened interval. If the water level falls below the 25 percent drawdown level, the pumping rate should be decreased to stabilize the water level to prevent cascading and potential loss of volatiles, excessive turbidity and entrapment of air in the filter pack. If the static water level is above the screened interval, acceptable drawdown is defined as the lowering of the water level to the top of the screened interval. If continued drawdown occurs below the top of the screened interval, the pump rate will be decreased to stabilize the water level to prevent atmospheric contact with the filter pack and formation, which could alter redox chemistry of the well.

  Note: In wells with slow recharge rates, it may be necessary to stop the pump and allow the well to recharge in order to remain at or above the drawdown limit. If this is necessary, be certain not to allow any water in the tubing to backflush into the well and when purging recommences start at a slower rate to avoid increasing turbidity. See section on Low-Flow Purging of Wells with Low Recharge.

- Purging will be considered complete when a minimum of one saturated screen volume, calculated according to the formula presented in Table B4.1-1, has been removed and the groundwater quality parameters have stabilized according to the stabilization requirements (Table B4.1-1).
- In the event the pump seizes and locks up during purging or sampling activities and it is necessary to jiggle or move the pump within the well, the purging will be re-initiated beginning with the first step of this procedure.

Low-Flow Purging with Non-Dedicated Submersible Piston Pumps in Wells with Low Recharge Rates

- The pump intake shall be set approximately two feet above the bottom of the well.
- Measure the static water level in the well.
- Begin purging at a rate of approximately one liter per minute or as slow as the conditions and dedicated system allow (if greater than one liter per minute) until a minimum of one well casing volume is removed or the water level reaches the pump intake, whichever occurs first.
- Allow static water level to recover to approximately 80 percent of its static level or for 16 hours after purge completion, whichever occurs first.
- When sufficient time has passed, measure the water level to confirm 80 percent recharge.
- In the event that the pump is withdrawn from the well decontaminate the exterior of the pump and submerged portion of the tubing bundle with an Alconox wash and deionized water rinse. Collect an

equipment blank prior to redeployment of the pump system.

- Set the intake of the pump at the bottom of the screened interval, pump at a low flow rate and collect groundwater quality parameters for temperature, pH, specific conductance, turbidity, dissolved oxygen and ORP at 0.25 gallon intervals. Monitoring will continue until the groundwater quality parameters have stabilized according to the stabilization requirements presented in Table B4.1-1. **Note: The drawdown shall be monitored continuously during purging and shall not exceed a level less than one foot above the pump intake.**
- Prior to collecting samples, the volume of sample and the volume of the tubing bundle shall be calculates. If the volume of the tubing bundle exceeds the volume of the samples to be collected by more than one gallon the pump may be lowered to a minimum of two feet above the bottom of the well.
- Once readings have stabilized and the pump has been lowered (if the criteria for lowering is satisfied) commence sample collection. Continue to monitor drawdown during sample collection. In the event that the water level reaches a depth of 1 foot above the intake, pumping shall cease until the well has recharged to a level adequate to fill more sample bottles completely.

Sample Collection

- Sample collection will be with a low-flow submersible pump. Flow rates for sampling with low-flow pumps shall be maintained at 1 liter per minute or less.
- Sample containers shall be labeled prior to sample collection.
- Samples for volatile organic analysis shall be collected first. The samples shall be carefully filled to avoid overflow and potential loss of preservative and tapped so entrapment of air is minimized and no head space exists. If bubbles appear, the vial will be refilled.
- Samples for non-volatile organic analysis shall be collected following the volatile organic sample collection. Samples for dissolved metals analysis may be field filtered according to SOP B4.4. If field filtration is not performed the sample container must be clearly marked to state ―laboratory filtration required‖.
- Place analytical samples in a cooler and chill to 4 degrees Celsius. Samples will be shipped to the appropriate laboratory within 24 hours. The sample cooler shall be shaded from direct sunlight immediately after collection.\

Post-Sample Collection Requirements

- Re-lock well cap.
- Fill out field logbook, sample log sheet, custody seals and Chain-of-Custody forms. Example copies of these forms are included in the Quality Assurance Project Plan (QAPP) (Appendix C of the BWP)
- Decontaminate purging and sampling equipment according to the procedures specified in SOP B1.11.

References for Other Applicable ASTM Standards

ASTM D4750 – Determining Subsurface Liquid Levels in a Borehole or Monitoring Well

Figure B4.1-1. Well Purge and Water Quality Data Sheet

Well Purge and Water Quality Field Data Sheet

Page 1 of _____

Project: _____ Well No: _____
Project No.: _____
Date: _____ Samplers: _____
Time Start: _____
Time Finish: _____ Checked by: _____

Well Information

Depth to Water: _____ ft. Casing Diameter: _____ in. = _____ ft. Casing Stickup: _____ ft.
Bottom of Screen: _____ ft. Borehole Diameter: _____ in. = _____ ft. Screened Interval: _____ ft.
Sample Depth: _____ ft. Saturated Screen Well Volume: _____ gallons
Drawdown Limit: _____ ft. Calculations: Casing Volume (CV) = $\pi (cr^2)\, h\, (7.48)$

Note: All depths measured from top of casing.

Filter Pack Volume (FPV) = $\pi (br^2 - cr^2)[BS-(TS \text{ or } H)]\, P\, (7.48)$

Saturated Screen Well Volume = CV + FPV

Calculation Notes: cr = casing radius; br = borehole radius; H = depth to water; h = bottom of screen – depth of water in ft.; P = estimated porosity of filter pack (35%); TS = top of screen; BS = bottom of screen; If TS>H use TS, if TS<H use H

Field Equipment

pH Meter: _____ Serial No.: _____ Water Level Meter: _____ Serial No.: _____
Conductivity Meter: _____ Serial No.: _____ Turbidity Meter: _____ Serial No.: _____
Temperature Meter: _____ Serial No.: _____ Bailer: _____ Size: _____

Sample Equipment (check one)

☐ *Submersible Pump* *Pump Type (circle one):* *Piston* *Bladder* *Impeller*
☐ *Disposable Teflon Bailer* *Pump Model:* _____
Serial No.: _____

Field Chemistry

pH _____ = @ _____ °C pH _____ = @ _____ °C pH _____ = @ _____ °C Time _____
Conductivity Standard: _____ µmhos/cm @ 25°C Reading _____ µmhos/cm @ _____ °C Time _____
Turbidity Standard: _____ N.T.U. @ 25°C Reading _____ N.T.U. @ _____ °C Time _____

Note: Figure B4.1-1 included in this Kirtland AFB BWP SOP has been superseded by Forms 1 and 2 in Appendix D of this work plan.

Figure B4.1-1. Well Purge and Water Quality Data Sheet (Concluded)

Page 2 of _____

Water Quality Field Data Sheet

Project: _____ Well No: _____

Project No.: _____

Date: Samplers:

Time Start: _____

Time Finish: _____ Checked by: _____

Field Chemistry (cont'd)

Time	Volume gallons	Temp. °C	pH	Conductivity µmhos/cm	Turbidity N.T.U.	Comments

Table B4.1-1. Quick Conversions for Water Volumes

Conversions for low flow purge volumes

Monitoring well casing only

Size Conversion
2” 0.17 Multiply the height of the water column in the well (Bottom of screen -DTW)
4" 0.65 Multiply the height of the water column in the well (Bottom of screen -DTW)
5" 1.02 Multiply the height of the water column in the well (Bottom of screen -DTW)
6" 1.47 Multiply the height of the water column in the well (Bottom of screen -DTW)
Note: With a dedicated system, where the water is above the top of screen multiply the conversion by the screen
length. With a non-dedicated system the whole water column must be included in the calculation.

Monitoring well casing/Borehole size configuration

2”/6” 0.46 Multiply the occluded screened interval only to get additional volume in gallons 2”/8” 0.86 Multiply the occluded screened interval only to get additional volume in gallons 4"/8" 0.69 Multiply the occluded screened interval only to get additional volume in gallons 4”/10” 1.20 Multiply the occluded screened interval only to get additional volume in gallons 4”/12” 1.83 Multiply the occluded screened interval only to get additional volume in gallons 5"/8" 0.56 Multiply the occluded screened interval only to get additional volume in gallons 5"/10" 1.071 Multiply the occluded screened interval only to get additional volume in gallons 5"/12" 1.70 Multiply the occluded screened interval only to get additional volume in gallons 6"/12" 1.54 Multiply the occluded screened interval only to get additional volume in gallons

Add the two results together to obtain the saturated casing volume in gallons.

Water quality stabilization parameters:

Parameters are stabled after 4 consecutive readings are within the ranges listed below:

The pH range is 6.5 – 8.5. Check meter calibration if current readings are outside this range. Ensure the water quality meter pH is calibrated with either the 4.0/7.0 or 7.0/10.0 pH standard.

Stabilization Requirements

Temp.	pH	Cond.	Tubidity	Dissolved Oxygen	ORP
1 C/2 F	0.1 units	3 % µmhos/ cm	<10 NTUs or 10% when <10 NTUs cannot be achieved	0.3 mg/L	10 millivolts
	6.5 -8.5				

Miscellaneous Notes

3.785 Liters = 1 gallon

Table B4.1-1. Quick Conversions for Water Volumes (Concluded)

Conversions for low flow purge volumes					
Monitoring well casing only					
Size	Conversion				
2"	0.17	Multiply the height of the water column in the well (Bottom of screen - DTW)			
4"	0.65	Multiply the height of the water column in the well (Bottom of screen - DTW)			
5"	1.02	Multiply the height of the water column in the well (Bottom of screen - DTW)			
6"	1.47	Multiply the height of the water column in the well (Bottom of screen - DTW)			
Note: With a dedicated system, where the water is above the top of screen multiply the conversion by the screen length. With a non-dedicated system the whole water column must be included in the calculation.					
Monitoring well casing/Borehole size configuration					
2"/6"	0.46	Multiply the occluded screened interval only to get additional volume in gallons			
2"/8"	0.86	Multiply the occluded screened interval only to get additional volume in gallons			
4"/8"	0.69	Multiply the occluded screened interval only to get additional volume in gallons			
4"/10"	1.20	Multiply the occluded screened interval only to get additional volume in gallons			
4"/12"	1.83	Multiply the occluded screened interval only to get additional volume in gallons			
5"/8"	0.56	Multiply the occluded screened interval only to get additional volume in gallons			
5"/10"	1.071	Multiply the occluded screened interval only to get additional volume in gallons			
5"/12"	1.70	Multiply the occluded screened interval only to get additional volume in gallons			
6"/12"	1.54	Multiply the occluded screened interval only to get additional volume in gallons			
Add the two results together to obtain the saturated casing volume in gallons.					
Water quality stabilization parameters:					
Parameters are stabled after 4 consecutive readings are within the ranges listed below:					
The pH range is 6.5 – 8.5. Check meter calibration if current readings are outside this range.					
Ensure the water quality meter pH is calibrated with either the 4.0/7.0 or 7.0/10.0 pH standard.					
Stabilization Requirements					
Temp.	pH	Cond.	Tubidity	Dissolved Oxygen	ORP
± 1°C/2°F	± 0.1 units 6.5 - 8.5	± 3 % µmhos/cm	<10 NTUs or ± 10% when <10 NTUs cannot be achieved	± 0.3 mg/L	± 10 millivolts
Miscellaneous Notes					
3.785 Liters = 1 gallon					

KIRTLAND AFB BASE-WIDE SOP B4.4

FIELD FILTRATION

Note: The Kirtland AFB Base-Wide Health and Safety Plan, Quality Assurance Project Plan, Field Sampling Plan, and Waste Management Plan referenced within these SOPs are superseded by the Bulk Fuels Facility Spill project-specific Accident Prevention Plan/Site Safety and Health Plan, QAPjP, Field Sampling Plan (within the QAPjP), and Waste Management Plan.

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SOP B4.4 Field Filtration

The rationale for collecting the filtered samples will be clearly defined in the project-specific addenda. Filter apparatus must be made of polyethylene, polypropylene, or borosilicate glass. The filter used will be a cellulose-based membrane filter of 0.45-micron nominal pore size. The sample must be filtered immediately after collection to minimize changes in the concentration of the substance of interest. Samples are only passed through the filtration apparatus once. Samples are then preserved immediately as required. All paperwork accompanying the samples to the laboratory should clearly state that the samples have been field-filtered, in order to avoid second filtration at the laboratory. Field filtering of water samples should be conducted as follows:

- The filter apparatus will be decontaminated and clean.
- Pour the sample into the filter apparatus and filter sample through a cellulose-based membrane filter of 0.45-micron nominal size. Samples are only passed through the filter once.
- Preserve sample immediately as required.
- Place analytical samples in cooler and chill to 4°C. Samples will be shipped to the appropriate laboratory within 24 hours.
- Fill out field log book, sample log sheet, labels, custody seals, and chain-of-custody (C-O-C) forms. Example copies of these forms are included in the QAPP (Appendix C of the BWP).

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KIRTLAND AFB BASE-WIDE SOP B5.6

WATER LEVELS

Note: The Kirtland AFB Base-Wide Health and Safety Plan, Quality Assurance Project Plan, Field Sampling Plan, and Waste Management Plan referenced within these SOPs are superseded by the Bulk Fuels Facility Spill project-specific Accident Prevention Plan/Site Safety and Health Plan, QAPjP, Field Sampling Plan (within the QAPjP), and Waste Management Plan.

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SOP B5.6 Water Levels

Water levels will be measured using an electric water level indicator. The steps to be followed are as follows:

- Check operation of recording equipment above ground. Prior to opening the well, don personal protective equipment as required.
- Record all information specified below on a Groundwater Level Data form or in the field logbook if the form is not available.
- Record well number, top of casing elevation and surface elevation if available. Well diameter and total depth should be recorded. Water levels will be taken from the surveyed reference mark on the top edge of the inner well casing.
- Use a decontaminated water level indicator to record water level to the nearest 0.01 foot (ft) (0.3 centimeters [cm]).
- Record the time and day of the measurement.
- Many water level measuring devices have marked metal or plastic bands clamped at intervals along the measuring line used for reference points to obtain depth measurements. The spacing and accuracy of these bands will be checked frequently as they may loosen and slide up or down the line, resulting in inaccurate reference points.
- All groundwater level measurement devices must be cleaned before and after each use to prevent cross-contamination of wells.

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Figure B5.6-1. Groundwater Level Data Form

Page ____ of ____

Site: _____ Name: _____

Date: _____ Project: _____

Well ID	Time	Top of Casing	Well Depth (ft)	Depth to Water (ft)	Comments (pH, temperature, specific conductance)

Measurement Reference Point from: ___ Top of Ground or ___ Top of Casing

Weather Conditions:_____

_____

_____

Other Significant Observations:_____

_____

_____

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SHAW SOP EI-FS108

MEASUREMENT OF WATER AND LNAPL IN MONITORING WELLS

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Procedure No.	**EI-FS108**
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STANDARD OPERATING PROCEDURE

Subject: Measurement of Water Level and LNAPL in Monitoring Wells

1. PURPOSE

The purpose of this procedure is to provide the methods and procedures for measurement of groundwater well water levels and for conducting LNAPL measurements. Well water levels can either be determined as part of the well purging/sampling effort or be independently determined to provide information on site hydrology.

2. SCOPE

This procedure is applicable to all Shaw E & I projects where groundwater level and/or LNAPL measurements are taken.

3. REFERENCES

- American Society of Testing and Materials, D4750-87 (Reapproved 2001), *Standard Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well)*, West Conshohocken, PA.
- U.S. Department of the Interior, 1977 (updated 1984), *National Handbook of Recommended Methods for Water-Data Acquisition*, Chapter 2, Reston, VA.

4. DEFINITIONS

- **Measuring Tape**—Steel or plastic tape with graduations to 0.01 feet. The tape shall not stretch more than 0.05 feet under normal use.
- **Electronic Measuring Device**—Commercial probe and cable designed to register a signal when the probe contacts water. The cable must have graduations to 0.01 feet.
- **Oil/water Interface Probe**- a specialized electronic measuring device that detects organic liquids. It is used to determine the interface and physical extent of any oil within the well.

5. RESPONSIBILITIES

5.1 Procedure Responsibility

The Field Sampling Discipline Lead is responsible for maintenance, management, and revision of this procedure. Questions, comments, or suggestions regarding this technical SOP should be sent to the Field Sampling Discipline Lead.

5.2 Project Responsibility

Shaw E & I employees performing this task, or any portion thereof, are responsible for meeting the requirements of this procedure. Shaw E & I employees conducting technical review of task performance are also responsible for following appropriate portions of this SOP.

For those projects where the activities of this SOP are conducted, the Project Manager, or designee, is responsible for ensuring that those activities are conducted in accordance with this

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and other appropriate procedures. Project participants are responsible for documenting information in sufficient detail to provide objective documentation (checkprints, calculations, reports, etc.) that the requirements of this SOP have been met. Such documentation shall be retained as project records.

6. PROCEDURE

Two techniques are discussed below: the measuring-tape method and the electronic method.

6.1 Equipment

The following equipment should be used when measuring groundwater levels:

- Decontaminated, weighted tape with graduations to 0.01 feet. The weight should be sufficient to ensure plumbness of the tape, but slender enough so as not to raise the water level significantly when submerged in the water.
- Decontaminated, commercial electronic water-level measuring device.
- Engineer's rule, graduated to 0.01 feet.
- Oil/water interface probe and meter.

6.2 Weighted Steel Tape

The following procedure should be used when measuring groundwater levels with a measuring tape:

1. Unlock the well cover and remove the cap.
2. Locate the reference point on the riser pipe.
3. Don a pair of clean gloves.
4. Slowly lower the weighted tape down the well until the bottom is reached, indicated by a bump and sudden slack in the line.
5. Straighten the tape out, removing the slack, and measure the distance at the reference point.
6. Record the reading at the reference point as Depth to Bottom (DTB).
7. Withdraw the tape from the well and record the reading at the wet/dry interface as Depth to Water (DTW).
8. The difference between the two measurements is the depth of the water column (DWC).
9. Dry and decontaminate the wetted portion of the tape.

6.3 Electronic Measurement

The following procedure should be used when measuring groundwater levels with an electronic water-level measuring device:

1. Check for proper instrument response by inserting the probe in water. Fix or replace the instrument as needed.
2. Unlock the well cover and remove the cap.
3. Locate the reference point on the riser pipe.

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4. Don a pair of clean gloves.
5. Slowly lower the probe down the well until the signal indicates that the water has been contacted.
6. Record the reading at the reference point as DTW.
7. Withdraw the probe and repeat steps 5 & 6. Duplicate measurements should agree within 0.02 feet. If not, continue with measurements until 0.02 feet precision is achieved.
8. Lower the probe until the bottom of the well is reached, as indicated by slack in the line.
9. Pull slightly to remove the slack, measure at the reference point, and record as DTB.
10. Determine the water column length as (DTB-DTW) and record as DWC.
11. Remove the probe from the well and decontaminate it.

6.4 Light Non-Aqueous Phase Liquids

Oil or other light non-aqueous phase liquids (LNAPL) may be floating on the water in selected wells. If so, measure the LNAPL level and the water level using an oil/water interface probe as follows:

1. Check for proper instrument response by inserting the probe in water. Instruments typically indicate LNAPL with a steady indicator light and tone, while water is indicated by an intermittent light and tone.
2. Unlock the well cover and remove the cap.
3. Locate the reference point on the riser pipe.
4. Don a pair of clean gloves.
5. Slowly lower the oil/water interface probe down the well until the signal indicates that LNAPL has been contacted (typically a steady indicator light and tone).
6. Record the reading at the reference point as DTNAPL.
7. Continue lowering the probe until the signal indicates that water has been contacted (typically an intermittent light and tone).
8. Record the reading at the reference point as DTW.
9. Determine the depth of LNAPL as (DTW-DTNAPL) and record it.
10. Withdraw the probe and repeat steps 5 & 6. Duplicate measurements should agree within 0.02 feet. If not, continue with measurements until 0.02 feet precision is achieved.
11. Lower the probe until the bottom of the well is reached, as indicated by slack in the line.
12. Pull slightly to remove the slack, measure at the reference point, and record as DTB.
13. Determine the water column length as (DTB-DTW) and record as DWC.
14. Remove the probe from the well and decontaminate it.

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7. ATTACHMENTS

None.

8. FORMS

None.

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RTI LABORATORIES

LABORATORY-SPECIFIC SOP FOR AIR SAMPLE COLLECTION

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RTI LABORATORIES

1. SAMPLE TRAIN PURGING

1.1 Soil gas sample collection requires purging to flush stagnant gas from the soil gas probe prior to collection of a sample for laboratory analysis, much the same as purging stagnant water from a well prior to collection of a groundwater sample.

1.2 Purging can be performed in a variety of different ways. Vacuum pumps, personal monitoring pumps and a Tedlar™ bag/lung box apparatus are some of the procedures used. If field testing is to be performed, it is important that the sampling be performed before it goes through any kind of pump other than a personal monitoring pump, to avoid contamination of the sample. 1-3 L at a purge rate of 200-2000 mL/min should be sufficient for purging the sample train.

2. STATIC PRESSURE MEASUREMENT

2.1 Prior to sampling, the static vacuum or pressure in the soil gas probe should be measured and recorded. This is analogous to measuring a static water level in a groundwater monitoring well. These data can be used to assess whether and to what extent pressure gradients might influence soil gas flow. Connect a vacuum gauge to the valve at the top of the soil gas probe using tubing provided with the vacuum gauge. Level and zero the gauge. Open the valve and record the average reading. It may be necessary to shield the vacuum gauge from any wind, which can cause the readings to fluctuate. Record the static pressure or vacuum, along with the date, time, temperature and weather conditions.

3. LEAK CHECKING

3.1 Perform a “shut-in” test, where the pump is used to exert a pressure or vacuum on the sampling train, then all valves are closed and the pressure or vacuum is observed over time to ensure it does not dissipate. A target vacuum or pressure level of 100 in-H20 is appropriate, to maximize the resolution of the observations, and the stress on the sample train.

4. FIELD SCREENING

4.1 Field screening of total VOC vapor concentrations is conducted during purging to verify stable readings before collection of soil gas samples for laboratory analysis. Stable readings will typically be defined as reading that vary by less than 10% from previous readings and show no consistent trend in either increasing or decreasing concentrations.

RTI LABORATORIES

4.2 Samples of the extracted soil gas should be collected for field screening using a portable FID or PID after every purge volume removed (or 1 L if the purge volume is smaller). The FID or PID should be calibrated according to manufacturer's instructions to a span gas (i.e. isobutylene or hexane) of known concentration (typically 50 or 100 parts per million by volume [ppmv]) and to zero gas (in areas of poor outdoor air quality) or ambient outdoor air, immediately prior to use. The calibrations should be confirmed several times during the day to assess potential instrument drift. If the readings show more than 10% drift against the standard gas, or more than +/- 1 ppmv of zero gas or ambient air, the instrument should be recalibrated. The FID or PID reading will be made by connecting the Tedlar bag to the instrument and allowing the instrument to draw a sub-sample at ambient pressure (the bag must not be squeezed because this can cause a bias in the calibration). The time and the steady reading are recorded.

5. COLLECTION OF SAMPLES FOR LABORATORY ANALYSIS

5.1 Samples are collected in Bottle-Vac containers attached to a QT-connector and flow restrictor assembly (FRA). The tubing from the sampling site must be attached to the end of the FRA. To ensure the best seal, a 316-stainless steel union should be attached to the end of the FRA and seated with a ¼" Vespel/graphite or Teflon ferrule. This end of the union must be ¼" swagelok. If non-1/4" O.D. tubing is going to be attached, the other end of the union must be the size appropriate for the O.D. of the tubing that will be attached to it. The tubing should be attached with a Vespel/graphite or Teflon ferrule. See the figures at the end of this document for pictures of the sampling train.

5.2 Only after all of the connections are made, should the QT-connector be attached to the Bottle-Vac, as this is what initiates the sampling

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