DEPARTMENT OF THE AIR FORCE
377TH AIR BASE WING (AFGSC)

Colonel Richard W. Gibbs
377th Air Base Wing
2000 Wyoming Blvd SE
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Mr. John Kieling, Bureau Chief
Hazardous Waste Bureau (HWB)
New Mexico Environment Department (NMED)
2905 Rodeo Park Drive East, Building 1
Santa Fe NM 87505-6303

Dear Mr. Kieling

Attached please find the *Work Plan for Bioventing and Air-Lift Enhanced Bioremediation Pilot Tests, Bulk Fuels Facility, Solid Waste Management Unit (SWMU) ST-106/SS-111, Kirtland Air Force Base, New Mexico, dated November 2017.* This work plan has been prepared to summarize proposed pilot tests that will be implemented to aid in the Corrective Measures Evaluation to address the leak at the Kirtland Air Force (AFB) Base Bulk Fuels Facility, SWMU ST-106/SS-11.

If you have any questions or concerns, please contact Mr. Scott Clark at (505) 846-9017 or at scott.clark@us.af.mil or Mrs. Holly O'Grady at (505) 853-3484 or at holly.ogrady@us.af.mil.

Sincerely

RICHARD W. GIBBS, Colonel, USAF
Commander

Attachment:
Work Plan for Bioventing and Air-Lift Enhanced Bioremediation Pilot Tests, Bulk Fuels Facility, Solid Waste Management Unit ST-106/SS-111, Kirtland Air Force Base, New Mexico, dated November 2017; 2 Hard Copies/2 CDs

cc:
NMED (Borrego) letter
NMED GWQB (Agnew, Hunter), letter and CD
EPA Region 6 (King, Ellinger), letter and CD
SAF-IEE (Lynnes), electronic only
AFCEC/CZ (Renaghan, Clark, O'Grady), electronic only
USACE-ABQ District Office (Simpler, Phaneuf, Dreeland, Sanchez, Salazar), electronic only
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KIRTLAND AIR FORCE BASE
ALBUQUERQUE, NEW MEXICO

WORK PLAN FOR BIOVENTING AND AIR-LIFT ENHANCED BIOREMEDIATION PILOT TESTS
BULK FUELS FACILITY
SOLID WASTE MANAGEMENT UNIT ST-106/SS-111

November 2017

377 MSG/CEI
2050 Wyoming Boulevard Southeast
Kirtland Air Force Base, New Mexico 87117-5270

KIRTLAND AIR FORCE BASE
ALBUQUERQUE, NEW MEXICO

WORK PLAN FOR BIOVENTING AND AIR-LIFT ENHANCED BIOREMEDIATION PILOT TESTS
BULK FUELS FACILITY
SOLID WASTE MANAGEMENT UNIT ST-106/SS-111

November 2017

Prepared for
U.S. Army Corps of Engineers
Albuquerque District
4101 Jefferson Plaza NE
Albuquerque, New Mexico 87109-3435

Prepared by
EA Engineering, Science, and Technology, Inc., PBC
320 Gold Avenue SW, Suite 1300
Albuquerque, New Mexico 87102

Contract No. W9128F-13-D-0006/Delivery Order DM02

NOTICE

This Work Plan was prepared for the U.S. Army Corps of Engineers by EA Engineering, Science, and Technology, Inc., PBC for the purpose of performing bioventing and air-lift enhanced bioremediation pilot testing associated with the Kirtland Air Force Base (AFB) Bulk Fuels Facility, Solid Waste Management Unit ST-106/SS-111. This work is performed under the U.S. Air Force Environmental Restoration Program, under requirements set forth in the Resource Conservation and Recovery Act permit issued to Kirtland AFB, with the New Mexico Environment Department serving as the lead regulatory agency. Addressed are the tasks related to the methods for field data collection and evaluation for the bioventing pilot test and the air-lift enhanced bioremediation pilot tests.

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14. ABSTRACT
This Work Plan describes specific vadose zone treatability studies to be conducted under the Resource Conservation and Recovery Act for the Bulk Fuels Facility leak at Solid Waste Management Unit ST-106/SS-111 at Kirtland Air Force Base, New Mexico. The Work Plan includes the technical approach for pilot testing to investigate bioremediation options of petroleum hydrocarbons in the Bulk Fuels Facility source area. This Work Plan includes the methods for field data collection and evaluation for a bioventing pilot test and an air-lift enhanced bioremediation pilot test.

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Work Plan, Kirtland AFB, Bulk Fuels Facility, soil vapor monitoring well installation, bioventing, air-lift enhanced bioremediation, Solid Waste Management Unit ST-106/SS-111, light non-aqueous phase liquid

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Richard W. Gibbs

RICHARD W. GIBBS, Colonel, U.S. Air Force
Commander, 377th Air Base Wing

21 NOV 17
Date

This document has been approved for public release.

Athana Zuch

KIRTLAND AIR FORCE BASE
377th Air Base Wing Public Affairs

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Date

PREFACE

This Work Plan is prepared by EA Engineering, Science, and Technology, Inc., PBC (EA) for the U.S. Army Corps of Engineers (USACE), under Contract Number W9128F-13-D-0006, Delivery Order DM02. This Work Plan pertains to the conductance of bioventing and air-lift enhanced bioremediation pilot tests to address a leak at the Kirtland Air Force (AFB) Base Bulk Fuels Facility (BFF) (site), Solid Waste Management Unit ST-106/SS-111. The site is located in Albuquerque, New Mexico. This Work Plan was prepared in accordance with the permit issued to Kirtland AFB under the Resource Conservation and Recovery Act and applicable federal, state, and local laws and regulations.

The objective of the Work Plan is to describe specific vadose zone pilot testing activities to be performed in the source area of the BFF, including the field methods for data collection and evaluation of a bioventing pilot test and an air-lift enhanced bioremediation pilot test.

This Work Plan is prepared for work to be performed between October 1, 2017 and September 22, 2021. Mr. Trent Simpler, PE, is the USACE–Albuquerque District Project Manager. The Environmental Restoration Section Chief for this program is Mr. Scott Clark of Kirtland AFB. The Work Plan was prepared by Devon Jercinovic, PG, CPG, PMP; Jay Snyder, PE, PG, CHg; Dustin Graves, PG; Pamela Moss; Joshua Messenger; and Denise Wilt of EA and Dr. Robert Hinchee of Integrated Science & Technology, Inc. Devon Jercinovic is the EA Project Manager.

Devon Jercinovic, PG, CPG, PMP
Project Manager
EA Engineering, Science, and Technology, Inc., PBC

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ACRONYMS AND ABBREVIATIONS

%	percent
AFB	Air Force Base
AFCEC	Air Force Center for Engineering
APP	Accident Prevention Plan
ASTM	ASTM International
BFF	Bulk Fuels Facility
BTEX	benzene, toluene, ethylbenzene, xylenes
DoD	Department of Defense
DRO	diesel-range organics
EA	EA Engineering, Science, and Technology, Inc., PBC
EAT	Eurofins Air Toxics, Inc.
EDD	electronic data deliverable
ELAP	Environmental Laboratory Accreditation Program
ELLE	Eurofins Lancaster Laboratories Environmental, LLC
ERPIMS	Environmental Resources Program Information Management System
GRO	gasoline range organics
GWTS	groundwater treatment system
NMED	New Mexico Environment Department
No.	Number
PDF	portable document format
QA	quality assurance
QAPjP	Quality Assurance Project Plan
QC	quality control
RCRA	Resource Conservation and Recovery Act
ROI	radius of influence
SIM	selective-ion monitoring
SSHP	Site Safety and Health Plan
SVM	soil vapor monitoring
SWMU	Solid Waste Management Unit
TPH	total petroleum hydrocarbons
USACE	U.S. Army Corps of Engineers
USAF	U.S. Air Force
VOC	volatile organic compound

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EXECUTIVE SUMMARY

The objective of the Work Plan is to detail the activities to be implemented for performing vadose zone treatability studies to support a future corrective measures evaluation of the BFF source area and solute plume. This Work Plan outlines the activities involved to complete bioventing and air-lift enhanced bioremediation pilot tests. Bioventing includes the delivery of oxygen to the contaminated vadose zone (unsaturated soils) via air injection to stimulate biodegradation. Bioventing can be augmented by the introduction of "moisture" (i.e. water injection) prior to the injection of air. The goal of the bioventing test is to measure oxygen utilization rate by microbes in the subsurface. The rate of oxygen utilization is directly proportional to the aerobic biodegradation rate of fuel hydrocarbons in the subsurface, and is therefore an indication of effectiveness of bioventing to achieve site cleanup in a timely manner. Contaminant mass destruction rate, cleanup time, and cost of corrective measure implementation can be estimated to support corrective measures evaluation.

Air-lift enhanced bioremediation includes stimulating microbes within the aquifer matrix by creating a circulation cell through the injection of air below the water table. The injected air forces entrained water out of the lower portion of well screen and "lifts" it above the static water level where it flows outward into the capillary fringe and upper water table. While lifting, contaminants are stripped and the groundwater is oxygenated. This "aerated" water flows out into the upper water table, a zone of the solute plume typically with high solute and residual contamination, where it adds oxygen to enhance aerobic biodegradation. The intake of water through the lower screen is a "sink," and the outflow above the water table a "source," and a circulation cell is established whereby water locally flows downward through the impacted aquifer thickness to the lower screen intake. This process sequentially aerates and oxygenates the aquifer until sufficient mass of oxygen is delivered to degrade fuel hydrocarbons present. The outflow of air in the upper screen facilitates bioventing which will be evaluated in the air-lift enhanced well as described above.

Pilot tests for both the bioventing and air-lift enhanced bioremediation include relatively short-term applications of these technologies, coupled with data collection to determine the feasibility of applying the technology site-wide as potential corrective measures. The work to be completed is presented under each of the tasks listed below:

- Perform short-term respiration tests, both "dry" and with "moisture added," in nine bioventing test wells.

- Perform two long-term bioventing pilot tests simultaneously, with one test "dry" and one test "moisture added."

- Perform long-term air-lift enhanced bioremediation pilot test.

This Work Plan has been prepared by EA Engineering, Science, and Technology, Inc., PBC (EA) with support from Integrated Science & Technology, Inc. to address activities to be performed at Solid Waste Management Unit (SWMU) ST-106/SS-111, the Bulk Fuels Facility (BFF) at Kirtland Air Force Base (AFB), New Mexico. The Work Plan demonstrates the U.S. Air Force's (USAF's) commitment to continue addressing fuel contamination resulting from the BFF fuel leaks. This Work Plan outlines activities to be performed in support of bioventing and air-lift enhanced bioremediation pilot tests to support corrective measures evaluation. Work will be performed in accordance with the approved Quality Assurance Project Plan (QAPjP) (U.S. Army Corps of Engineers [USACE], 2017a), which is included in the *Work Plan for Vadose Zone Coring, Vapor Monitoring, and Water Supply Sampling*. In conjunction with the QAPjP, this Work Plan will become the procedural guidance document for conducting these activities. These documents meet the most recent requirements of the Department of Defense (DoD) regarding planning documents for DoD facilities. The Work Plan was written in accordance with Kirtland AFB's Resource Conservation and Recovery Act (RCRA) Permit Number (No.) NM9570024423.

1. INTRODUCTION

Under Contract No. W9128F-13-D-0006, Delivery Order DM02, EA was contracted to perform tasks associated with vadose zone treatability studies at SWMU ST-106/SS-111, at Kirtland AFB, New Mexico. SWMU ST-106/SS-111 is known as the BFF site. Environmental restoration efforts at the BFF site are being conducted under requirements set forth in RCRA Permit No. NM9570024423 (RCRA Permit) with the New Mexico Environment Department (NMED) serving as the lead regulatory agency (NMED, 2010).

This Work Plan addresses the methods for field data collection and evaluation for a bioventing pilot test and an air-lift enhanced bioremediation pilot test, and is the procedural guidance document for activities to be executed as part of the RCRA Corrective Action Process. This Work Plan meets the most recent requirements of the DoD regarding planning documents for DoD facilities.

The requirements for the protection of health and attaining safety on the job sites are addressed in the companion *Accident Prevention Plan (APP) for the Kirtland AFB BFF Expansion of the Groundwater Treatment System (GWTS) and Vadose Zone Treatability Studies (Revision 5)* (EA, 2017). The APP also incorporates the Site Safety and Health Plan (SSHP). The APP is a dynamic document that will be revised to cover all activity-specific concerns and will be updated as necessary.

1.1 Scope of Activities

The BFF site is located in Albuquerque, New Mexico (Figure 1-1). This Work Plan covers activities required to meet the performance objectives associated with performing a bioventing pilot test and an air-lift enhanced bioremediation pilot test. The work associated with the bioventing test includes performance of "dry" and "moisture added" respiration tests utilizing 9 existing vadose zone wells for injection and two new well clusters (6 wells each) for observation. The initial short-term respiration test will be followed by performance of two long-term bioventing pilot tests simultaneously, one test "dry" and one test "moisture added." Additionally, an air-lift enhanced bioremediation pilot test will be performed utilizing a new air-lift recirculation well with existing nearby observation wells. Data will be evaluated and a report will be generated for each of the bioventing and air-lift enhanced bioremediation pilot tests.

This Work Plan was prepared in accordance with the RCRA Permit for Kirtland AFB (NMED, 2010) and applicable federal, state, and local laws and regulations. For completeness, this Work Plan includes the required elements of a Sampling and Analysis Plan/Field Sampling Plan for data collection, data analysis, and data management.

1.2 Work Plan Organization

The Work Plan is divided into the following sections:

- ***Section 1***—Presents an introduction to the plan and the scope of activities and organization of the Work Plan.
- ***Section 2***—Presents the site description and operational history.
- ***Section 3***—Summarizes the project tasks with sufficient detail on how the objectives will be accomplished.

- ***Section 4***—Summarizes the project schedule.
- ***Section 5***—Refers to the organizational structure.
- ***Section 6***—Refers to the data management requirements.
- ***Section 7***—Refers to the quality assurance (QA) and quality control (QC) requirements that are further detailed in the QAPjP provided in Appendix A.
- ***Section 8***—Presents information on the management and disposal of the waste generated during this project.
- ***Section 9***—Refers to the safe work practices to be employed while executing this project, which are further detailed in the APP (EA, 2017).
- ***Section 10***—Provides references cited in the Work Plan.

Figures and tables follow the main body of the Work Plan. Appendices provided at the end of this Work Plan include:

- ***Appendix A***—Test Well Completion Diagrams
- ***Appendix B***—Manufacturer's Specification Cut Sheets – Field Instruments and Equipment
- ***Appendix C***—Field Forms
- ***Appendix D***—Project Schedule.

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. The BFF site is located in the northwestern portion of Kirtland AFB.

2.2 Site History

The BFF and associated infrastructure operated from 1953 until 1999. During this time, the fueling area was separated into a tank holding area where bulk shipments of fuel were received and a fuel loading area where individual fuels trucks were filled. Kirtland AFB removed the underground piping at the facility from service in 1999 due to discovery of underground leakage. Even though the fuel leak was identified by Kirtland AFB, the exact history of the leaks or releases is unknown. Releases could have occurred when fuel was transferred from railcars to the pump house. Initially, it was thought that the leak only affected surface soil around the identified source area; however, Kirtland AFB learned through characterization activities that the leaked fuel had reached the groundwater and that the dissolved-phase fuel contamination migrated northeast and north of Kirtland AFB.

To comply with NMED Hazardous Waste Bureau requirements, Interim Measures were implemented for both groundwater and soil. The goals of the groundwater Interim Measure are to protect drinking water supply wells and collapse the distal ethylene dibromide plume. The soil vapor extraction system addressing light non-aqueous phase liquid in the source area was shut down in Quarter 2 of 2015 (USACE, 2017b).

2.3 Ongoing Soil Vapor Monitoring

Semiannual soil vapor monitoring (SVM) has been ongoing as part of the ST-106/SS-111 investigation to monitor the nature and extent of soil vapor contamination in the vadose zone. A total of 284 soil vapor monitoring points at 56 SVM locations are being sampled semiannually.

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3. SITE-SPECIFIC ACTIVITIES

The design of the bioventing pilot test, air-lift enhanced bioremediation, field data collection, analytical laboratory analysis, data analysis, and reporting are discussed in the following sub-sections. The area where the bioventing and airlift enhanced bioremediation tests will be performed is shown on Figure 3-1. The field area and test wells for the bioventing pilot test are shown on Figure 3-2, and for the air-lift enhanced bioremediation test on Figure 3-3.

3.1 Bioventing Pilot Test Design

The bioventing pilot test designed herein follows procedures outlined in Principles and Practices of Bioventing, Volume 2: Bioventing Design (Leeson and Hinchee, 1996). The bioventing pilot testing will allow for verification of the design parameters estimated in the respiration testing, and will determine the sustainability of biodegradation rates over a longer period. Test layout, test wells, bioventing equipment and instrumentation, measurement of field parameters, and analytical chemistry regimen are discussed herein and provided in the tables and appendices. Also provided are methods and schedules for evaluating oxygen utilization rate, hydrocarbon degradation rate, carbon dioxide production rate, and establishing air permeability and radius of influence (ROI). Details regarding bioventing pilot testing are provided in the sections below.

3.1.1 Scope of Bioventing Pilot Test

The bioventing pilot testing will include short-duration “dry” and “moist” respiration tests (approximately 3 weeks), followed by two longer-term (2 years in duration) pilot tests conducted simultaneously (schedule provided in Appendix D). Data collected from the short-duration tests will be used to refine the design and details of the long-term test. One of the long-term tests will be conducted “dry” without moisture addition, while one test may be conducted “moist,” with moisture added. The moisture will be added periodically over the course of the test, pending the results of the short-duration “moist” respiration test (i.e., if data indicate moisture addition was not beneficial, then the long-term test will only be performed “dry”). The basis for total volume, rate of injection, and frequency of addition of moisture during the long-term test will be obtained from the short-term respiration tests.

The bioventing test will begin with “dry” respiration tests to establish oxygen utilization rates and, accordingly, hydrocarbon degradation rates at each test well. Moisture will then be added to the test wells and the subsurface will be given 2 weeks to equilibrate before “moist” respiration tests are conducted. When respiration test data have been obtained, long-term pilot tests will be refined for both “dry” and “moist” applications. During the long-term bioventing tests, wells will be respiration-tested quarterly (for the first year) to evaluate time rate of change of biodegradation rates.

3.1.1.1 Bioventing Test Well Details

The bioventing pilot test design utilizes existing soil vapor extraction wells and existing SVM wells for air injection and two new SVM well clusters (completed under a separate work plan [USACE, 2017a]) for observation (Table 3-1). Well locations are shown on Figure 3-2. The new wells (KAFB-106V1 and KAFB-106V2) include multiple screen depths to facilitate discrete vertical monitoring of the vadose zone. The designs for KAFB-106V1 and KAFB-106V2 bioventing observation wells are provided in Figures 3-4 and 3-5.

The wells selected for air injection vary from a 0.5- to 4-inch diameter. Table 3-1 also provides radial distances to nearby wells suitable for use as observation wells. Completion diagrams for the existing test wells are provided in Appendix A.

The construction details, diameters, and open intervals for the designated air injection wells are provided in Table 3-2, along with the air injection rate and nominal pipe velocity. Test cell pore volume is defined by filter pack length (plus 5 feet above and below to allow for leakage) and a control radius of 15 feet. The air injection rate is limited by the pipe diameter, which in turn controls the injection time for the test volume.

3.1.1.2 Blower System, Instrumentation and Conveyances

The equipment selected for air injection is a 3-horsepower Geotech turn-key soil vapor extraction unit equipped with a positive displacement pump to provide adequate pressure for injection. The unit will be plumbed and configured to use in injection mode. An equipment, process, and instrumentation diagram of the test equipment is provided as Figure 3-6. The system will be delivered in an environmental enclosure to protect it from the elements. Other features of the bioventing system include:

- Direct reading rotameters to control flow rates on individual manifold legs and header
- Schedule 80 polyvinyl chloride header and manifold
- High density polyethylene conveyance lines that will run on the ground surface to the air injection wells
- Quick connecting fittings at wellheads to facilitate air injection or well sampling
- Single phase blower for use with single- or three-phase power.

3.1.1.3 Respiration Tests

"Dry" respiration tests will consist of ambient air injection into the wells sufficient to achieve the pore volume of air (porosity assumed to be 35 percent [%]). A 15-foot radius from the injection well is included for the defined control volume. The thickness is equal to the filter pack length, plus 5 feet above and below to account for vertical air flow. Delivery of the air is limited by well diameter; therefore, the injection rate and duration is designed to deliver the air within a reasonable pipe velocity as shown in Table 3-2. The proposed injection rate is based on four pore volumes of the test cell to hedge against unknowns such as heterogeneity in permeability or porosity, and vertical gas movement beyond the defined thickness to ensure the entire cell is flooded with ambient air.

After the air is injected, field measurements will be collected in accordance with Table 3-3, and samples will be collected for chemistry analysis in accordance with Table 3-4. These data will be used to analyze oxygen utilization rate, carbon dioxide production rate, and ultimately, hydrocarbon destruction rate as described below. Based on a review of rebound data from SVMW-10 and SVMW-11 (CB&I Federal Services LLC, 2016), oxygen utilization rate is low and in the range of 0.1%/day. The field data collection frequency provided in Table 3-3 is proposed based on this rate; however, the ultimate goal of the respiration tests is to collect sufficient data during the early portion of the linear oxygen decay curve to establish the oxygen utilization rate. Therefore, 5-10 measurements will be collected in this early response period, and the frequency of collection will be adjusted as necessary in response to the observed oxygen utilization rate. Figure 3-7 outlines the sequence of the respiration test and anticipated schedule of field parameter data collection. As shown in Table 3-2, injection periods are expected to last 2 days for the short-term tests.

Respiration testing will determine the rate of biodegradation that can be achieved by bioventing, as well as the oxygen uptake rate. This will be completed via “dry” and “wet” tests to evaluate the potential benefit of moisture addition. Since no respiration testing will be done at wells that are not injection wells, no direct measurement of ROI for either the moisture addition or air injection can be made. However, the respiration test data can be used to estimate ROI based on oxygen demand. ROI testing will provide an estimate of both the soil vapor permeability and the ROI to which pressure can be measured.

3.1.1.4 Moisture Addition

After the “dry” respiration tests have been completed, water will be injected into each test well under pressure (to the degree practicable) to radially force the water into the formation. The specified amount of water added is 1% of the treatment cell pore volume. For the 15-foot radius and 35% porosity, this equals 2.5 cubic feet (19 gallons) per foot of treatment cell height. This relatively minimal volume is not anticipated to alter the formation geochemistry or catalyze contaminant migration. The 2.5 cubic feet is added to a unit (per foot) test cell pore volume of 247 cubic feet. The site soils are relatively low initial moisture content and generally sandy. The field capacity of sand varies from around 5 to 8 percent, so the 1% addition of water is expected to be held in capillary tension and not drain-down to significant depth below the test cells. After the moisture is added, the test cells will be allowed to acclimate for a period of 2 weeks before the respiration tests are conducted in the manner described in Section 3.1.1.1 above.

3.1.2 Field Screening, Sampling and Analysis

The following subsections describe the data collection requirements for field measured data and analytical laboratory data.

3.1.2.1 Field Measurements

Field measurements will be made with hand-held portable meters as detailed in Table 3-3. The meters will be inserted into ports installed in a 2-foot-long by 4-inch diameter clear polyvinyl chloride cell. Measurements will be taken during purging. Purging will be performed with a high vacuum–low flow Gast Model vacuum pump or equivalent rated at 1.0-1.7 cubic feet per minute. Wells will be purged until oxygen stabilizes, but no more than three casing volumes will be removed before recording final field meter measurements. Data use and sampling frequency for field measured parameters are provided in Table 3-3. Manufacturer’s specifications for field equipment are provided in Appendix B.

3.1.2.2 Soil Vapor Sampling and Analysis

Samples for laboratory analyses will be collected in accordance with Table 3-4. Vapor wells will be purged at least three casing volumes before sample collection. Table 3-4 provides a summary of analytical parameters, test methods, number of samples, data use, and frequency of testing. Sample collection methodology and quality control will follow requirements in the *Work Plan for SVM and Drinking Water Monitoring, BFF, SWMU ST-106/SS-111* (USACE, 2016).

Analytical testing for vapor samples collected in support of the bioventing pilot test will be performed by Eurofins Air Toxics, Inc. (EAT), Folsom, CA. EAT maintains current DoD Environmental Laboratory Accreditation Program (ELAP) certification for EPA Method TO-15 selective-ion monitoring (SIM) for volatile organic compounds (VOCs); benzene, toluene, ethylbenzene and xylenes (BTEX) and total petroleum hydrocarbons (TPH) – gasoline range organics (GRO) will be analyzed in accordance with

EPA Method TO-3; and fixed gases (nitrogen, oxygen, hydrogen, carbon monoxide and dioxide) and C1 to C5 hydrocarbons in accordance with ASTM International (ASTM) Method D1945.

3.1.3 Air Permeability and Radius of Influence Measurements

Air permeability and ROI will be determined from pressure measurements, flow rate measurements, and soil gas measurements following Leeson and Hinchee (1996), Johnson et al. (1990), and USACE (2002). These parameters will be field measured in accordance with Table 3-3 and recorded on Field Forms (Appendix C). Formulas for the calculation of these metrics is provided in the sections below.

3.1.4 Air Emissions and Site Monitoring

No significant air emissions are anticipated as part of the bioventing pilot test. Air will be injected, not extracted. *De minimis* emissions from well sampling activities are the only anticipated air emissions.

3.1.5 Data Analysis

Data collected in accordance with Tables 3-3 and 3-4 will be evaluated to establish oxygen utilization rate and hydrocarbon degradation rate as described below.

3.1.5.1 Oxygen Utilization Rate

Oxygen utilization in aerobic degradation is generally estimated stoichiometrically using a representative straight chain aliphatic. Leeson and Hinchee (1996) use hexane degradation to establish oxygen utilization as such:

$$C_6H_{14} + 9.5O_2 \rightarrow 6CO_2 + 7H_2O$$

This stoichiometric relationship renders the relation that one pound of fuel hydrocarbon is degraded with 3.5 pounds of oxygen, and this mass relationship is applicable for all hydrogen-saturated alkanes. If the oxygen utilization rate due to biodegradation is known, the vent rate to supply required oxygen mass can be calculated, and the vent design follows.

The oxygen utilization rate (k_o) is determined by the respiration test data by plotting oxygen content in soil gas versus time (Leeson and Hinchee 1996). The roughly-linear slope during early oxygen depletion (decreasing from approximately 20% to 5% oxygen by volume) yields k_o, the oxygen utilization rate.

3.1.5.2 Biodegradation Rate

Once the oxygen utilization rate is established from the respiration test data, the biodegradation rate (k_b) can be determined.

$$k_b = \frac{-\frac{k_O}{100}\theta_a \frac{1\,L}{1000\,cm^3}\rho_{O_2}C}{\rho_k\left(\frac{1\,kg}{1000\,g}\right)} = \frac{-k_O\theta_a\rho_{O_2}C(0.01)}{\rho_k}$$

Where:

k_b = Biodegradation rate (mg/kg-day).
k_o = Oxygen utilization rate (%/day).

θ_a = Gas-filled pore space (volumetric content at the vapor phase, m^3_{gas}/cm^3_{soil}).
ρ_{O2} = Density of oxygen (mg/L).
C = Mass ratio of hydrocarbons to oxygen required for mineralization (=1/3.5 for hexane-equivalent).
ρ_k = Soil bulk density (g/cm^3).

Oxygen utilization rate will be determined from the respiration test. The physical soil properties in the equation above will be estimated from Leeson and Hinchee (1996) and/or determined from laboratory data collected during implementation of *Work Plan for Vadose Zone Coring, Vapor Monitoring, and Water Supply Sampling* (USACE, 2017a).

3.1.6 Long-Term Bioventing Flow Rate

The required bioventing flow rate can be determined from the oxygen utilization rate established from the respiration test (Leeson and Hinchee, 1996).

$$Q = \frac{k_O V \theta_a}{(20.9\% - 5\%)\ \times 60\,\frac{min}{hr}}$$

Where:

Q = Flowrate (ft^3/min).
k_O = Oxygen utilization rate (%/hr).
V = Volume of contaminated soil (ft^3).
θ_a = Gas-filled pore space ($cm^3_{air}/cm^3_{soil,}$ ~ 0.2 or 0.3).

3.1.7 Intrinsic Permeability

Intrinsic permeability will be calculated following the analytic solution in Johnson et al. (1990).

$$k = \frac{ln\left(\frac{R_w}{R_I}\right) Q\mu}{\pi P_w H \left(1 - \left(\frac{P_{atm}}{P_w}\right)^2\right)}$$

Where:

k = Intrinsic permeability (cm^2).
R_w = Well radius (ft).
R_I = Radius of influence (ft).
Q = Flowrate (cm^3/s).
μ = Dynamic viscosity of air (g/cm-s).
H = Length of exposed screen (cm).
P_{atm} = Ambient atmospheric pressure (g/cm-s^2).
P_w = Well vacuum (g/cm- s^2).

3.1.8 Radius of Influence

Two methods will be used to determine ROI: the physical or pressure response ROI and the bioventing ROI. The former will be determined by plotting pressure response in observation wells versus log distance (USACE, 2002) in a manner similar to the distance drawdown technique used in well hydraulics (Driscoll, 1986).

The latter is estimated based on oxygen utilization only, and assumes that ROI is much greater than the well radius (Leeson and Hinchee, 1996).

$$R_I = \sqrt{\frac{Q(20.9\% - 5\%)}{\pi h k_O \theta_a}}$$

Where:

R_I	=	Radius of influence (ft).
Q	=	Flowrate (ft^3/day).
k_O	=	Oxygen utilization rate (%/day).
θ_a	=	Gas-filled pore space ($cm^3_{air}/cm^3_{soil,}$ ~ 0.2 or 0.3).
h	=	Aerated thickness (ft).

3.2 Air-lift Enhanced Bioremediation Pilot Test

An air-lift enhanced bioremediation pilot test will be performed whereby treatment of groundwater via in-well air stripping is conducted in concert with bioventing to evaluate cleanup of groundwater and soil concurrently. The process follows *In-Well Air Stripping/Bioventing Study at Tyndall AFB, Florida* (Alleman, 1996). Various configurations of these combined processes have been developed and implemented since the referenced study. Moreover, the greater depth to groundwater at Kirtland AFB relative to Tyndall AFB requires variations in the air-lift enhanced bioremediation design.

The air-lift pilot test will evaluate the feasibility of using air-lift pumping to aerate both groundwater and the vadose zone. Potential impacts at a distance can be monitored in soil vapor; however, given the spacing of available wells, the ROI may be less than the monitoring well spacing. Due to this spacing (i.e. nearest soil vapor monitoring well location approximately 88 feet from KAFB-106S1), soil vapor monitoring points consisting of nylon tubing extending from top-of-casing to a vapor sample port will be included in the annulus of KAFB-106S1 (Figure 3-8). These vapor sample ports will be monitored for field parameters in accordance with Table 3-7.

3.2.1 Air-lift Enhanced Bioremediation Well Design

The design of the air-lift enhanced bioremediation well is provided in Figures 3-8 and 3-9, and discussed below. The drilling and installation of the well will be completed under a separate work plan (USACE, 2017a).

- The air-lift enhanced bioremediation well will include a 4-inch diameter, continuous 60-foot screen, with approximately 20 feet of screen below the water table, and approximately 40 feet of screen above the water table (Table 3-5). Soil vapor observation points include three soil vapor monitoring points within the annulus at approximately five, 10, and 20 feet above the water table, respectively, and soil vapor monitoring wells KAFB-106114, KAFB-106116, and KAFB-106128

(Table 3-5). KAFB-106S1 is designed to allow intake of impacted groundwater by the air-lift process, and outflow of air-stripped, lifted water and injected air above the water table.

- Within the 4-inch casing, the air-lift wells is designed to have a 2-inch conductor casing to facilitate air injection to force air-lifted water and air out into the vadose zone.

- The outflow of air-lifted water above the water table, combined with intake below the water table, will set up the circulation cell and will aid in groundwater cleanup. Accordingly, the bioventing flow rate will be dictated by the up-hole velocity necessary to entrain and air lift groundwater to accomplish a circulation cell in nearby groundwater.

- The drilling and well installation will include two piezometers installed in the annulus between the borehole and air-lift well casing to facilitate installation of water level and water quality probes. Soil vapor monitoring points consisting of ¼ inch nylon tubing and vapor sample ports will also be installed in the annulus.

- It should be noted that biofouling of the air-lift components and the well screen is expected. The environment created by the air-lift design will promote bacterial growth and precipitation of metal oxides. Rehabilitation measures will be explored if fouling proves detrimental, including pulling and cleaning the air-delivery components or swabbing the well. The depth of the air-delivery conductor pipe can also be modified (i.e. decreased) to utilize a shallower portion of the screen once fouling occurs. The degree of maintenance required will be considered in long-term corrective measures cost in the Corrective Measures Evaluation.

3.2.2 Scope of Air-lift Enhanced Bioremediation Pilot Test

The scope of the air-lift enhanced bioremediation pilot testing will include an initial short-duration "dry" respiration test as described in Section 3.1.1.1, followed by the air-lift enhanced process described below in the recirculation test well KAFB-106S1. Table 3-6 provides the injected air requirements for the respiration test design. After the air is injected, field measurements will be collected in accordance with Table 3-7, and samples will be collected for laboratory analysis in accordance with Table 3-8. Prior to the initiation of the long-term air-lift enhanced bioremediation pilot test, well KAFB-106S1 will be sampled for baseline water quality (Table 3-8).

The air-lift and water recirculation is designed to create movement of groundwater in the circulation cell, expelling contaminants near the water table and enhancing biodegradation. Groundwater outside the well and within the circulation cell will be entrained and flow back to the well (hence, recirculation) and therefore will not catalyze contaminant migration away from the well. The process is expected to result in changes to the geochemistry, which is desired. Field parameters will be monitored to determine the impact on water quality within the zone of recirculation, and groundwater sampling will yield results of the technology on water quality.

The air-lift enhanced bioremediation test will be operated with sufficient air flow and up-hole velocity to entrain and "air lift" groundwater. Air is provided through the conductor casing, and the well has been designed to facilitate the inflow of groundwater in the air-lift well that will facilitate out-flow of both fluids into the formation above the water table (Figure 3-8). The goals of the process are to:

- Create a groundwater circulation around the air-lift well. The outflow of air-lifted groundwater through the screen, coupled with the intake of groundwater from 10 to 20 feet below the water table, will create this circulation.

- Evaluate if the "air lifting" component will transfer oxygen via the lifted groundwater, thereby increasing dissolved oxygen concentrations in groundwater.

- Evaluate if, in the presence of available dissolved oxygen, aerobic biodegradation of fuel hydrocarbons will proceed at a sufficient rate to measure solute contamination declines.

- Groundwater remediation will be evaluated with a continuously recording multi-parameter water quality probe.

- The addition of oxygen to the upper portion of the aquifer may increase the rate of natural source zone depletion of residual non-aqueous phase liquids, if present.

- The outflow of lifted air into the vadose zone will provide oxygen loading to facilitate aerobic degradation of soil contamination and residual non-aqueous phase liquid if present.

- The bioventing component performance will be measured with periodic respiration tests, the schedule and frequency of which may be modified following the results of the short-term respiration tests in the bioventing pilot test (Section 3.1).

3.2.3 Air-lift Enhanced Bioremediation Operation, Monitoring, and Analysis

During the course of the long-term air-lift enhanced bioremediation test, a respiration test will occur quarterly for the first year at KAFB-106S1 to evaluate biodegradation rate of change. Groundwater samples will be collected for the parameters listed in Table 3-8; the semiannual parameter list will be analyzed following the quarterly respiration tests (for the first year). Groundwater sampling will be performed via bailing from the deep piezometer (screened at the same depth as the bottom of the air-lift enhanced bioremediation well), and QC will be conducted in accordance with the *Work Plan for the Bulk Fuels Facility Expansion of the Dissolved-Phase Plume Groundwater Treatment System Design Revision 2* (USACE, 2017c). A multi-parameter water quality probe will be deployed in the piezometers to facilitate measurement of water quality parameters in advance of sample collection. Water quality parameters will include monitoring pH, temperature, dissolved oxygen, conductivity, turbidity and oxidation-reduction potential. Of particular concern will be measurement of dissolved oxygen and oxidation-reduction potential to evaluate aerobic degradation pathways. Frequency and schedule of field parameters and sample collection for analytical testing may be modified based on the results of the short-term respiration tests (Figure 3-7).

Analytical testing for vapor samples collected in support of the bioremediation test will be performed by EAT in accordance with EPA Method TO-15 SIM (VOCs); EPA Method TO-3 (TPH-GRO and BTEX); and ASTM D1945 for fixed gases and C1-C5 hydrocarbons.

Groundwater samples collected for the bioremediation test will be shipped to Eurofins Lancaster Laboratories Environmental, LLC, (ELLE), Lancaster, PA for analysis. ELLE maintains current DoD ELAP certification for EPA Method SW8260C for VOCs; EPA Method SW8015D for TPH-GRO and diesel-range organics (DRO); and EPA Method SW8011 for ethylene dibromide. Analysis and reporting will be performed in accordance with the QAPjP.

3.3 Reporting

Reports summarizing the data collected in support of the bioventing pilot test and the air-lift enhanced bioremediation pilot test will be prepared and submitted with the BFF Quarterly Monitoring Reports and submitted to NMED. The reports will include:

- Text describing quarterly activities and deviations from the approved work plan
- Summary tables of field and analytical laboratory data
- Calculations of parameters – oxygen utilization rate, biodegradation rate, bioventing flow rate, intrinsic permeability and ROI
- Assessment of pilot test progress
- Raw field data forms and laboratory data report.

The report will be a standalone document contained in an appendix, and summarized in *Section 2 Vadose Zone* of the BFF Quarterly Monitoring Report.

3.4 Permitting and Documentation

Prior to any mobilization, the appropriate permits will be obtained for the various field activities. The list of permits is presented below. The permit documentation will be on file with the field crew. Special attention will be taken for those permits that have an expiration date. The permitting process will be timed such that permit approvals will be received in time to maintain the schedule, but not too early in the process so that they expire before work is initiated. Permit renewals will be initiated such that the work will proceed with no interruption. Depending on the timing, permits may be combined. The list of permits/plans applicable to this project include:

- *Work Plan for Vadose Zone Coring, Vapor Monitoring, and Water Supply Sampling, Bulk Fuels Facility, Solid Waste Management Unit ST-106/SS-111.* (USACE, 2017a) pending approval)

- *Work Plan for Bioventing and Air-lift Enhanced Bioremediation Pilot Test* (pending approval)

- *Work Plan for the Bulk Fuels Facility Expansion of the Dissolved-Phase Plume Groundwater Treatment System Design Revision 2, Solid Waste Management Unit ST-106/SS-111* (USACE, 2017c).

- *Work Plan for Soil Vapor Monitoring and Drinking Water Monitoring, Solid Waste Management Unit ST-106/SS-111* (USACE, 2016).

- New Mexico Office of the State Engineer Well Drilling Permits for well locations with no consumptive use of water (i.e., KAFB-106S1, KAFB-106V1, and KAFB-106V2)

  Kirtland AFB-specific permits:

  - AF322
  - Erosion and Sediment Control Plan
  - Civil Engineer Digging Permit Request.

Drilling activities will be performed under the *Work Plan Vadose Zone Coring, SVM, and Water Supply Sampling* (USACE, 2017a), and all piping associated with the pilot tests will be temporary and installed above grade. As such, a fugitive dust permit is not anticipated.

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4. PROJECT SCHEDULE

The project schedule is provided in Appendix D.

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5. ORGANIZATIONAL PLAN

5.1 Organizational Structure

The organizational structure for this project is shown in Figure 5-1.

5.2 Responsibilities, Qualifications, and Authority of Key Personnel

Table 5-1 summarizes roles and responsibilities, qualifications, and authorities of project team members for the bioventing and air-lift enhanced bioremediation pilot tests.

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6. DATA MANAGEMENT AND DATA VALIDATION

This section provides the data management process and procedures to be implemented for the field data and analytical laboratory data generated from work activities in support of the BFF pilot tests. The data management will satisfy the requirements of the QAPjP, Appendix A of the *Work Plan for Vadose Zone Coring, Vapor Monitoring, and Water Supply Sampling, Bulk Fuels Facility, Solid Waste Management Unit ST-106/SS-111* (pending NMED approval)

6.1 Personnel Roles and Responsibilities Specific to Data Management

Specific data management roles and responsibilities for the Data Management Lead and Field Team Lead are discussed below:

- ***Data Management Lead***—Responsible for oversight of transfer of field data to electronic data deliverable (EDD) format for loading to the project database, loading of laboratory EDDs, updating the database as required with current data pulls from the Environmental Resources Program Information Management System (ERPIMS) data repository, and running reports to provide current and historical data from the database. Also responsible for uploading the database with data validation qualifiers following validation, edits resulting from data validation, and delivering the ERPIMS data deliverable to the USAF data management contractor.

- ***Field Team Lead (responsibility will be assigned for each task to qualified staff)***—Responsible for the accuracy of all field activity-related documentation and records collected in support of project plan implementation including all information related to field sample collection; field instrumentation and measurements; equipment decontamination; and sample management and shipping documentation, field variance, and corrective action.

6.2 Project Data Types and Records

Field and analytical data will be collected as appropriate in support of activities associated with the BFF bioventing and air-lift enhanced bioremediation pilot tests. The following section describes the types of records and documentation that will be included for current and historical datasets, databases that will be used, database input requirements, and how data will be maintained and archived.

6.2.1 Project Data and Records

Project data will be documented and recorded using various methods as applicable. The following is a list of the various field and laboratory documentation and records that may be generated during project data gathering activities as applicable:

- Air bills and sample shipping documentation
- Analytical laboratory reports
- Chain-of-custody records
- Communication logs/electronic mail
- Corrective action reports

- Documentation of corrective action results
- Documentation of deviations from methods (variances)
- Documentation of internal QA reviews
- Laboratory EDDs
- Field data collection forms, including boring logs, well construction logs, and field parameter logs
- Sampling notes in bound, waterproof field logbooks or on designated field forms
- Field instrumentation calibration logs
- Survey files for well location
- Identification of QC samples
- Photographs
- Sampling equipment decontamination records
- Sampling location figures (based on targeted and actual coordinates)
- Field variance request forms.

These records will be created in either written (e.g., sampling notes) or electronic formats (e.g., Global Positioning System files, measurement instrument/data-logger files, field databases, etc.). All records will undergo an independent review either at the laboratory or in the field by the technical leads, QA Officer, or the Project Manager. Additional information is provided in the QAPjP (USACE, 2017a).

6.2.2 Chemical Analytical Data

Samples to be collected in support of the bioventing and bioremediation pilot tests include soil vapor and groundwater. Soil vapor samples will be analyzed at EAT and groundwater at ELLE. Chemical analytical data will include level 4 type data reports as defined in the QAPjP, EQuIS® 6 EDD for validation and loading into the project database and ERIPMS version 6.0 EDDs for processing and submittal of validated analytical data to the AFCEC data management contractor.

The laboratories are responsible for ensuring that all analytical data reported in the electronic copy and level 4 type data report are consistent, accurate and complete in accordance with their scope. Verification of EDD formatting and completeness will be performed by the EA data management personnel during data review and upload of electronic data files. EDDs and data reports received from the laboratory that contain errors will be returned to the laboratory for correction and resubmittal. All chemical analytical data will be uploaded to the USAF data repository.

6.3 Handling and Management of Project Generated Data

Data handling and management procedures are established to effectively process analytical and measurement data generated during field activities such that the relevant data are readily accessible and accurately maintained. There are multiple activities involved in the recording, storage, processing, and maintenance of project datasets and systems to manage these. In order to ensure that data are accurately recorded and stored, data tracking systems will be implemented. Automated and manual QC checks will be conducted to verify that data have been accurately recorded and appropriately stored. Corrective actions will be taken and documented in the event data have not been properly handled. General data handling and management as well as information on naming conventions, loading, and reporting of laboratory analytical data are discussed in this section.

The following sub-sections describe the data handling and management of data collected during field activities in support of the pilot tests at Kirtland AFB, including onsite field and measurement data and offsite laboratory data. Field measurement and analytical data will be loaded into an EQuIS® database using Microsoft® Excel files and laboratory EDDs provided in the appropriate format per the templates provided by the data management team. These files will be saved and stored in Kirtland AFB project-specific folders located on the EA secure server.

6.3.1 Data Management Processes for Field-Related Data

Three general types of data will be collected and recorded in the field:

- Data to support sample collection and analysis
- Field measurements
- Field observations.

Project data collected during monitoring, investigation, and remediation sampling activities will be managed and stored using the EQuIS® Environmental Data Management System (Version 6.4). The types of field data to be managed in EQuIS® include field sampling parameters collected during well sampling and vapor monitoring, water level measurements, sampling observations and sample location information such as coordinates, etc. Field data will be recorded on the appropriate forms or electronically, and reviewed and transferred to the field data electronic format as appropriate. The EDDs will be reviewed for accuracy and completeness against field records prior to being loaded into the EQuIS® database. The Data Management Lead will be responsible for ensuring that all field data files uploaded into EQuIS and ERPIMS are maintained on the corporate project server along with the ERPIMS submittal files and the project-specific database.

Field data that cannot be integrated into the database (i.e., site photographs, field logbooks, or field forms) will be stored electronically in the project-specific network folders and/or in the project files, along with supporting metadata such as author/creator of data, date, location, and a brief description. The Field Team leads will be responsible for ensuring that all field data files are stored electronically in the project-specific network folders and all paper copies scanned and stored electronically in the project folders.

6.3.2 Analytical Data Management and Data Validation

Procedures for collecting field samples for laboratory analysis and the types of analyses to be conducted during the field activities are provided in the QAPjP (USACE, 2017a). This section provides an overview of the EDD to be used for analytical data, the EDD loading process, field data verification, and analytical data validation. Record-by-record review of hard copy to electronic data transmittals from laboratories will be verified including validation qualifiers provided by the validation subcontractor.

Data management staff will review data and records received from the field team, subcontractor laboratories, and other subcontractors using the following process to ensure accuracy:

- Review field notes, logbooks, and field forms.
- Verify field coordinates with the Geographic Information System group.
- Record-by-record review of hard copy or electronic data transmittals from laboratories to data validators against the records loaded in the database for all validated results.
- For data transmitted through subcontractors (not including the laboratories), 5-10% of loaded data records will be checked against data transmittals to verify import procedures.
- For calculated or reported total analyte results, calculations will be performed on 100% of data to verify concentrations.

Laboratories will be required to submit their results in ERPIMS and EQuIS® EDD formats to be obtained from the laboratory secure website. Designated data management personnel will check and load the EDDs into the EQuIS® and ERPIMS database systems. Any errors in the EDD for a given sample delivery group will prevent loading of data from that sample delivery group and the issue will be communicated to the Laboratory Project Manager for correction and resubmission. Analytical data will be managed in EQuIS® for validation and reporting purposes. The ERPIMS data deliverables will be submitted to the USAF data management subcontractor and processed for upload to the USAF data repository.

One hundred percent of the analytical data generated by the subcontractor laboratories in support of the pilot tests for analytical methods EPA TO-15 and EPA TO-3 for vapor samples and EPA SW8260C, EPA SW8011 and EPA SW8015D for groundwater samples will undergo EPA Stage 3 validation in accordance with the requirements in the project QAPJP. Validation qualifiers will be applied to the data results in the EQuIS® EDD and uploaded to the project database. Validation qualifiers will be included in the upload to the USAF data repository.

6.4 Data Security

The information systems that will house the BFF pilot test data, including field and analytical data as well as other electronic information, include systems maintained and managed within contractor offices. Servers located in contractor facilities are physically secured in locked buildings and rooms with access limited to authorized personnel.

Corporate servers are electronically secured behind firewalls with multiple layers of anti-malware software that protect the firewall, the local area network, and electronic mail networks. The servers are backed up nightly. Corporate servers and networking equipment are connected to battery-based uninterruptable power supplies with automated shutdown procedures in the event of a power outage.

7. QUALITY ASSURANCE/QUALITY CONTROL

QA/QC activities for the soil vapor and groundwater sampling will be conducted in accordance with the processes and procedures documented in the QAPjP (USACE, 2017a).

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8. WASTE MANAGEMENT

Limited investigation-derived waste is anticipated to be generated during the implementation of the bioventing or airlift pilot tests. The investigation-derived waste generated during the installation and development of wells KAFB-106S1, KAFB-106V1, and KAFB-106V2 is discussed in the *Work Plan for Vadose Zone Coring, Vapor Monitoring, and Water Supply Sampling* (USACE, 2017a). Purge water associated with groundwater sampling at KAFB-106S1 will be handled in accordance with the *Work Plan for the Bulk Fuels Facility Expansion of the Dissolved-Phase Plume Groundwater Treatment System Design Revision 2* (USACE, 2017c).

9. ACCIDENT PREVENTION PLAN/SITE SAFETY AND HEALTH PLAN

The safety requirements for the field implementation of this project are addressed in the companion document, *APP for the Kirtland AFB BFF Expansion of the GWTS and Vadose Zone Treatability Studies (Revision 5)* that also contains the SSHPs (EA, 2017). All field personnel associated with the project will be required to read and understand the elements of the APP, and the document will be available at the project location at all times.

10. REFERENCES

Alleman, B. 1996. *In-Well Air Stripping/Bioventing Study at Tyndall Air Force Base, Florida.* Prepared by Battelle Columbus Operations for the Environics Directorate. January.

C&BI Federal Services LLC. 2016. *Pilot Soil-Vapor Extraction System Shutdown Test, Bulk Fuels Facility Site, Solid Waste Management Unit ST-106/SS-111*. Kirtland Air Force Base, Albuquerque, New Mexico. July.

Driscoll, F.G. 1986. *Groundwater and Wells*. 2nd Edition, Johnson Division. St Paul, 1089.

EA Engineering, Science, and Technology, Inc., PBC (EA). 2017. *Accident Prevention Plan for the Base Bulk Fuels Facility Expansion of the Dissolved-Phase Plume Groundwater Treatment System Design and the Vadose Zone Treatability Studies, Revision 5*. Kirtland Air Force Base, New Mexico. February.

Johnson, P.C., C.C. Stanley, M.W. Kemblowski, D.L. Byers, and J.D. Colthart. 1990. *A Practical Approach to the Design, Operation. and Monitoring of in situ Soil-venting Systems. Groundwater Monitoring Review*. 10(2); 159-78.

Leeson, A. and R.E. Hinchee. 1996. *Soil Bioventing, Principles and Practice*. CRC, Lewis Publishers, Boca Raton.

New Mexico Environment Department (NMED). 2010. *Hazardous Waste Treatment Facility Operating Permit, EPA ID No. NM9570024423*, Issued to U.S. Air Force for the Open Detonation Unit Located at Kirtland Air Force Base, Bernalillo County, New Mexico, by the NMED Hazardous Waste Bureau. July.

U.S. Air Force (USAF). 2004. *Base-Wide Plans for the Environmental Restoration Program 2004 Update.* Kirtland Air Force Base, New Mexico. April.

U.S. Army Corps of Engineers (USACE). 2002. *Soil Vapor Extraction and Bioventing,* Engineering and Design. Manual No. 1110-1-4001. Washington, D.C. June 3.

———. 2016. *Work Plan for Soil Vapor Monitoring and Drinking Water Monitoring, Solid Waste Management Unit ST-106/SS-111.* Prepared by Sundance Consulting, Inc. for USACE–Albuquerque District. August 16.

———. 2017a. *Work Plan for Vadose Zone Coring, Vapor Monitoring, and Water Supply Sampling, Bulk Fuels Facility, Solid Waste Management Unit ST-106/SS-111.* Prepared by EA Engineering, Science, and Technology, Inc., PBC for USACE–Albuquerque District. June (pending approval).

———. 2017b. *RCRA Facility Investigation Report Bulk Fuels Facility Releases Solid Waste Management Unit ST-106/SS-111.* Prepared by Sundance Consulting, Inc., for the USACE Albuquerque District under USACE Contract No. W912PP-16-C-0002. January.

———. 2017c. *Work Plan for the Bulk Fuels Facility Expansion of the Dissolved-Phase Plume Groundwater Treatment System Design Revision 2, Solid Waste Management Unit ST-106/SS-111.* Prepared by EA Engineering, Science, and Technology, Inc., PBC for USACE–Albuquerque District. January 31.

FIGURES

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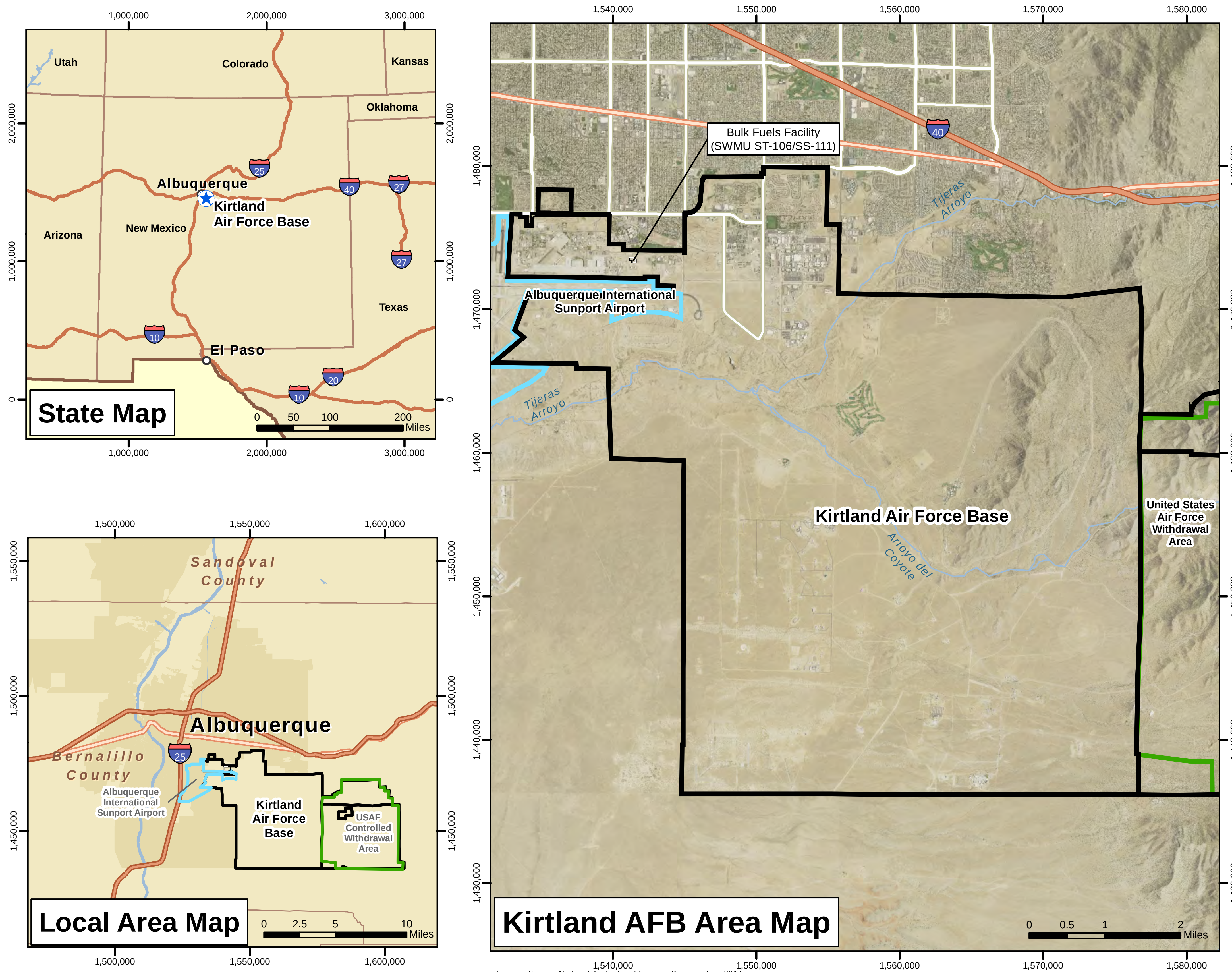

Legend

- Kirtland Air Force Base Installation Boundary
- Albuquerque International Sunport Airport
- United States Air Force Withdrawal Area
- Major Highways
- Highways
- Major Roads
- Rivers
- Bulk Fuels Facility

N

Projection: NAD83 State Plane New Mexico Central FIPS3002 Feet

WORK PLAN FOR BIOVENTING AND AIR-LIFT ENHANCED BIOREMEDIATION PILOT TESTS
BULK FUELS FACILITY
SOLID WASTE MANAGEMENT UNIT ST-106/SS-111
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 1-1

SITE LOCATION MAP

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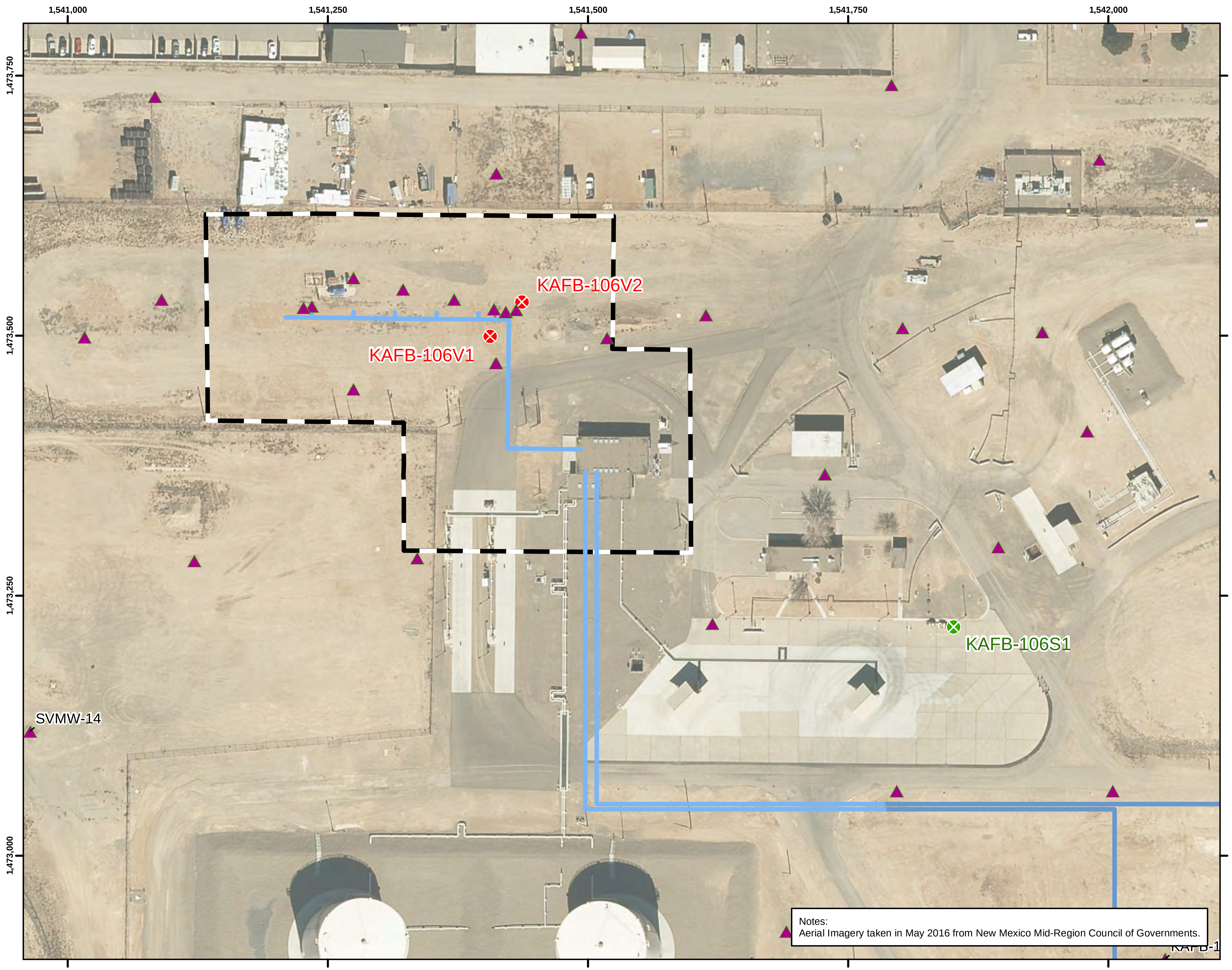
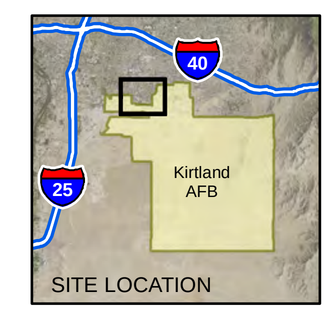


Legend

- Existing Soil Vapor Well
- Proposed Biovent Observation Well
- Proposed Air-lift Enhanced Bioremediation Well
- Former Buried Fuel Transfer Line
- Former Aboveground Fuel Transfer Line
- Bulk Fuels Facility (SWMU ST-106/SS-111)



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0 50 100 200

Feet

1 inch = 100 feet

Projection: NAD83 State Plane New Mexico Central FIPS3002 Feet

WORK PLAN FOR BIOVENTING AND AIR-LIFT ENHANCED BIOREMEDIATION PILOT TESTS
BULK FUELS FACILITY
SOLID WASTE MANAGEMENT UNIT ST-106/SS-111
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 3-1

PILOT TESTING AREAS

P:\gis\Projects\Kirtland\Figures\Vadose Zone Work Plan\VZ_WP_Bioventing\Figure 3-1 Pilot Testing Area.mxd 10/2/2017 EA rmullen

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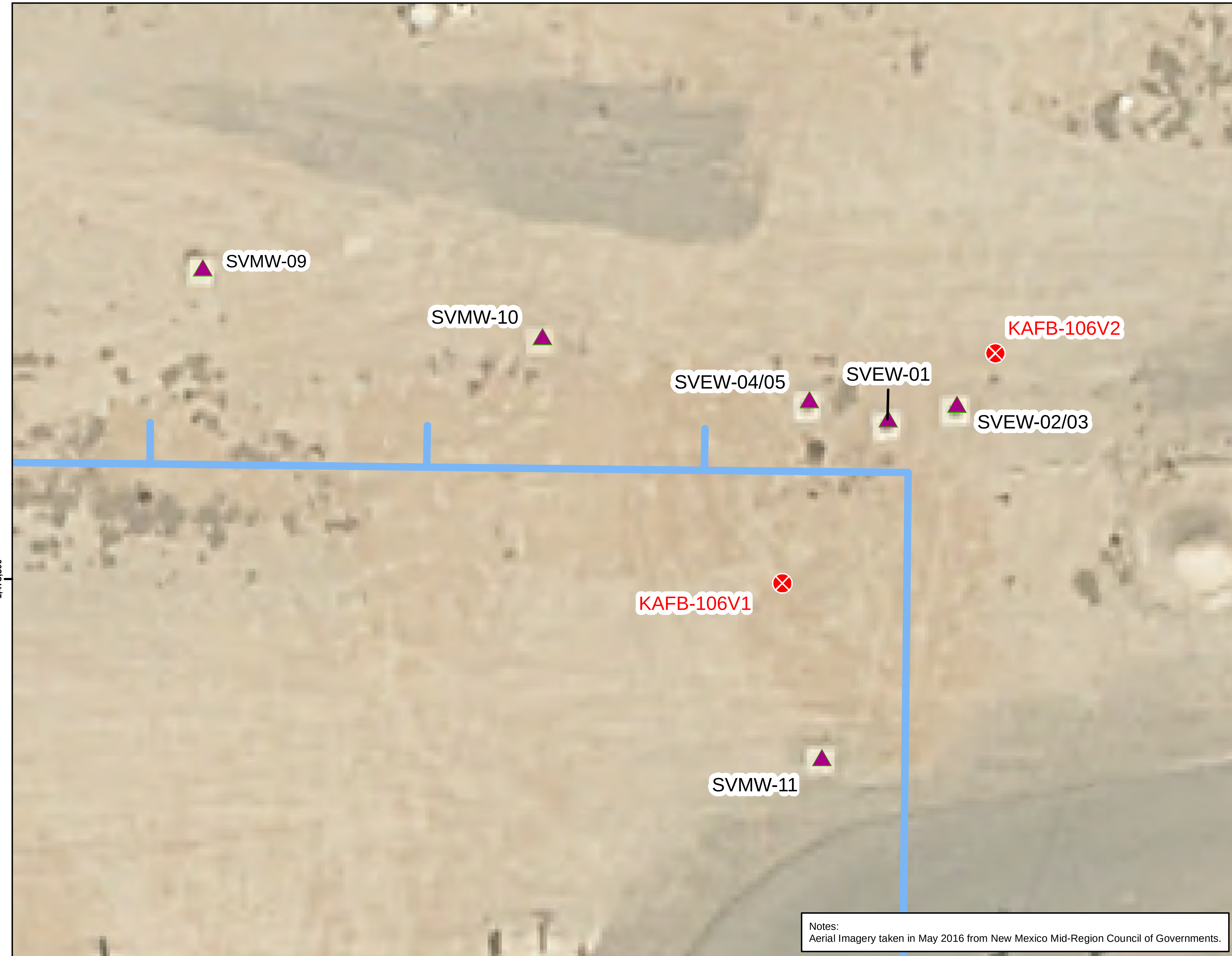
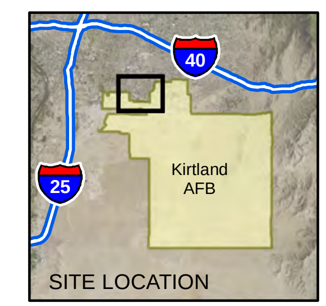


Legend

- Existing Soil Vapor Well
- Proposed Biovent Observation Well
- Former Buried Fuel Transfer Line
- Installation Boundary
- Source Area



N

0 7.5 15 30

Feet

1 inch = 15 feet

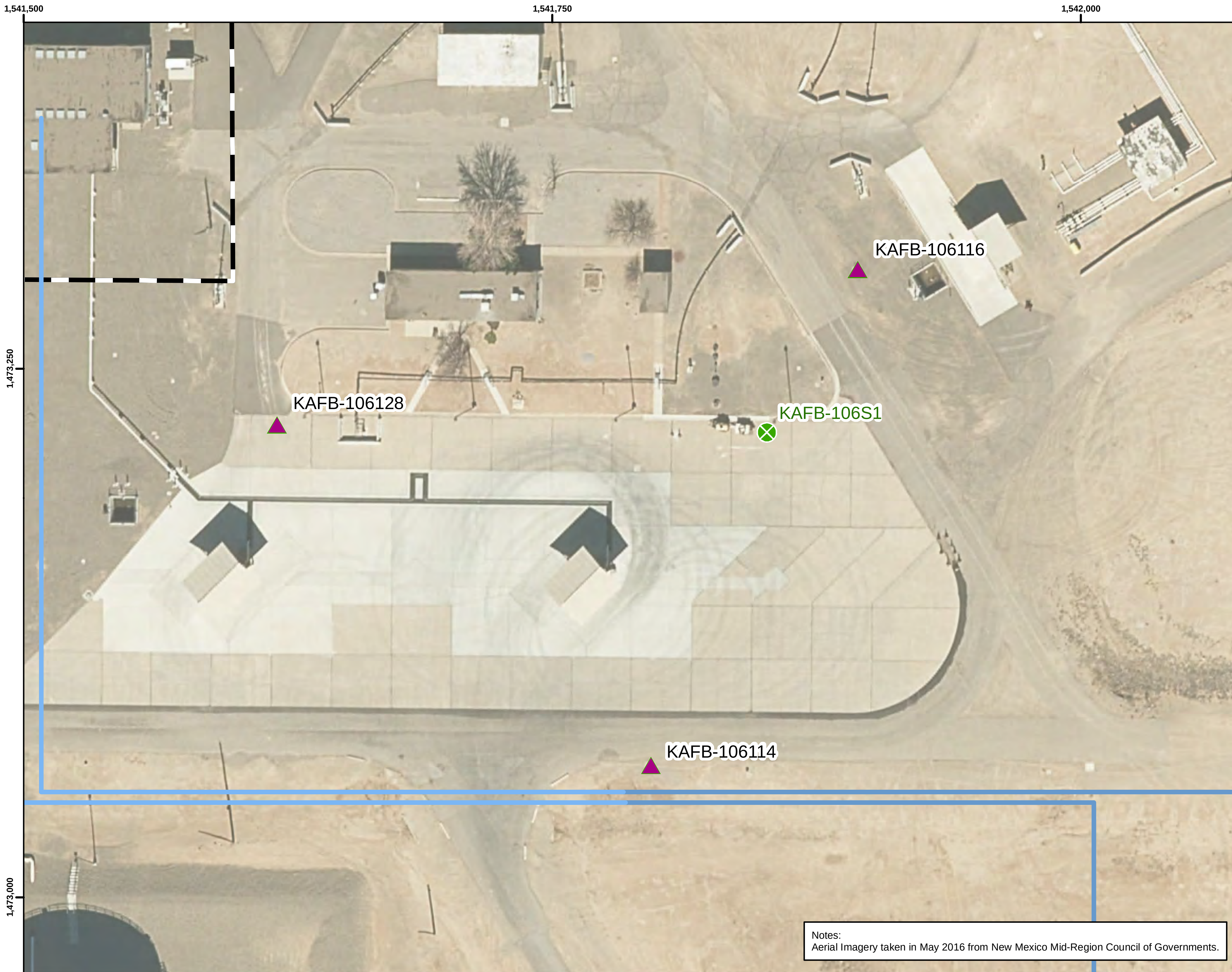
Projection: NAD83 State Plane New Mexico Central FIPS3002 Feet

WORK PLAN FOR BIOVENTING AND AIR-LIFT ENHANCED
BIOREMEDIATION PILOT TESTS
BULK FUELS FACILITY
SOLID WASTE MANAGEMENT UNIT ST-106/SS-111
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 3-2

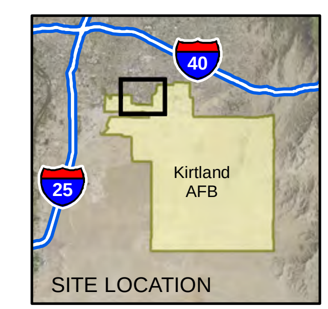
LOCATIONS OF BIOVENTING
PILOT TEST WELLS

P:\gis\Projects\Kirtland\Figures\Vadose Zone Work Plan\VZ_WP_Bioventing\Figure 3-2 Locations of Bioventing Pilot Test Wells.mxd 10/2/2017 EA rmullen



Legend

- Existing Soil Vapor Well
- Proposed Air-lift Enhanced Bioremediation Well
- Former Buried Fuel Transfer Line
- Former Aboveground Fuel Transfer Line
- Source Area



N

0 25 50 100

Feet

1 inch = 50 feet

Projection: NAD83 State Plane New Mexico Central FIPS3002 Feet

WORK PLAN FOR BIOVENTING AND AIR-LIFT ENHANCED BIOREMEDIATION PILOT TESTS
BULK FUELS FACILITY
SOLID WASTE MANAGEMENT UNIT ST-106/SS-111
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 3-3

AIR-LIFT ENHANCED BIOREMEDIATION PILOT TEST AREA

P:\gis\Projects\Kirtland\Figures\Vadose Zone Work Plan\VZ_WP_Bioventing\Figure 3-3 Airlift Enhanced Biovent Test Area.mxd 10/2/2017 EA rmullen

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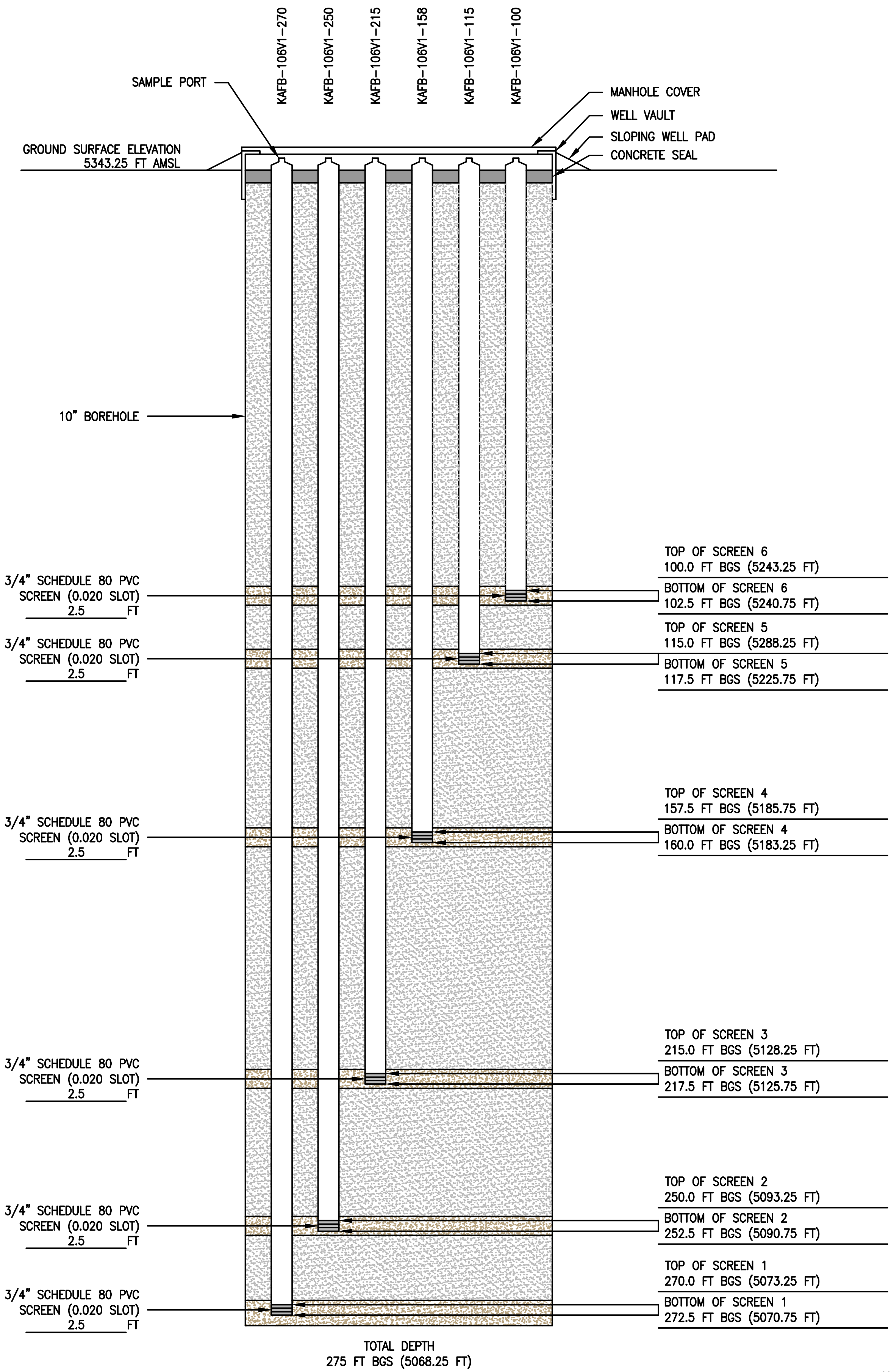
FIGURE 3-4: NESTED SOIL VAPOR WELL COMPLETION DIAGRAM FOR KAFB-106V1



(ELEVATION) IS IN ABOVE MEAN SEA LEVEL
ASML = ABOVE MEAN SEA LEVEL

NOT TO SCALE
BGS = BELOW GROUND SURFACE
FT = FEET

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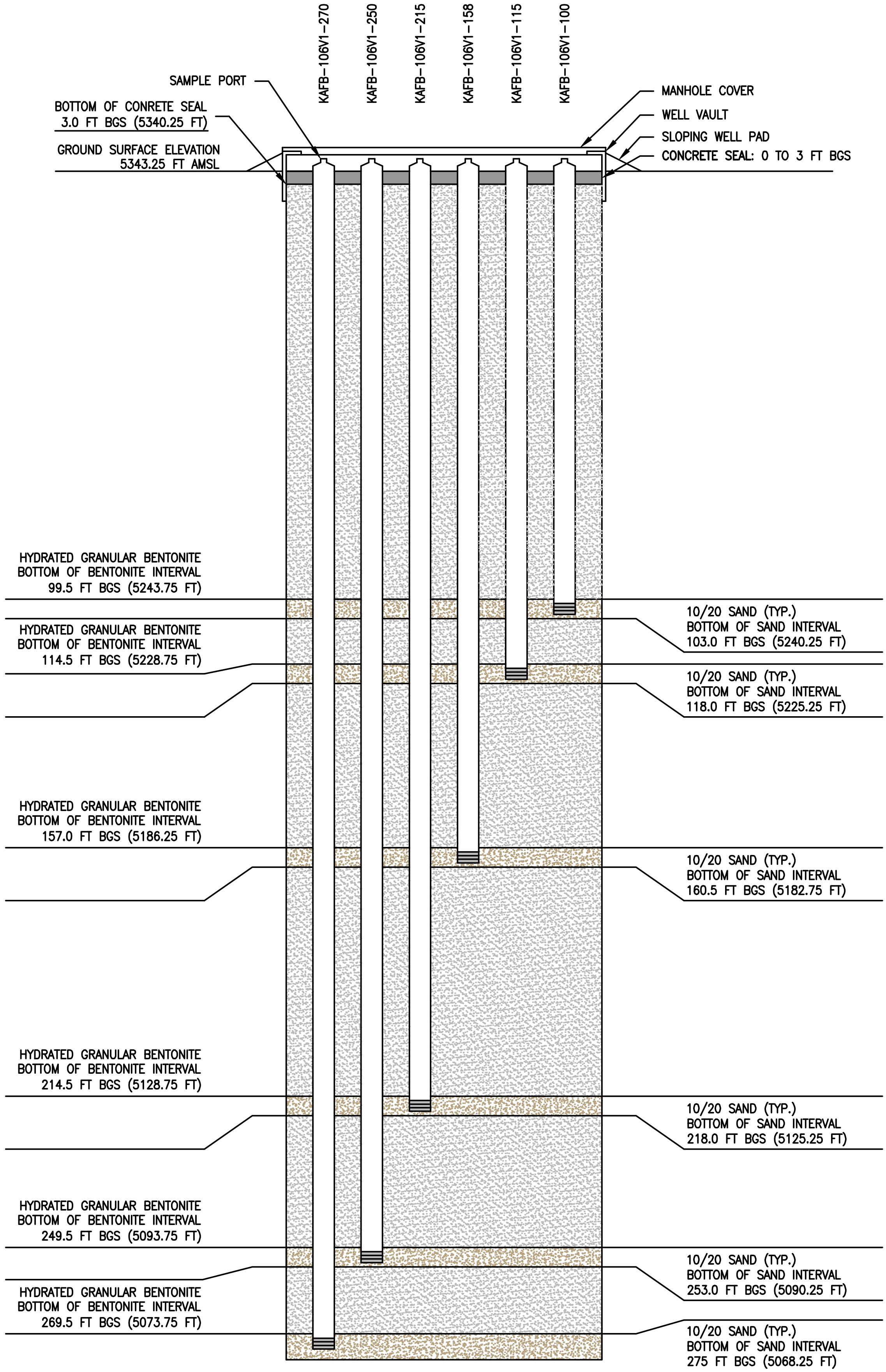
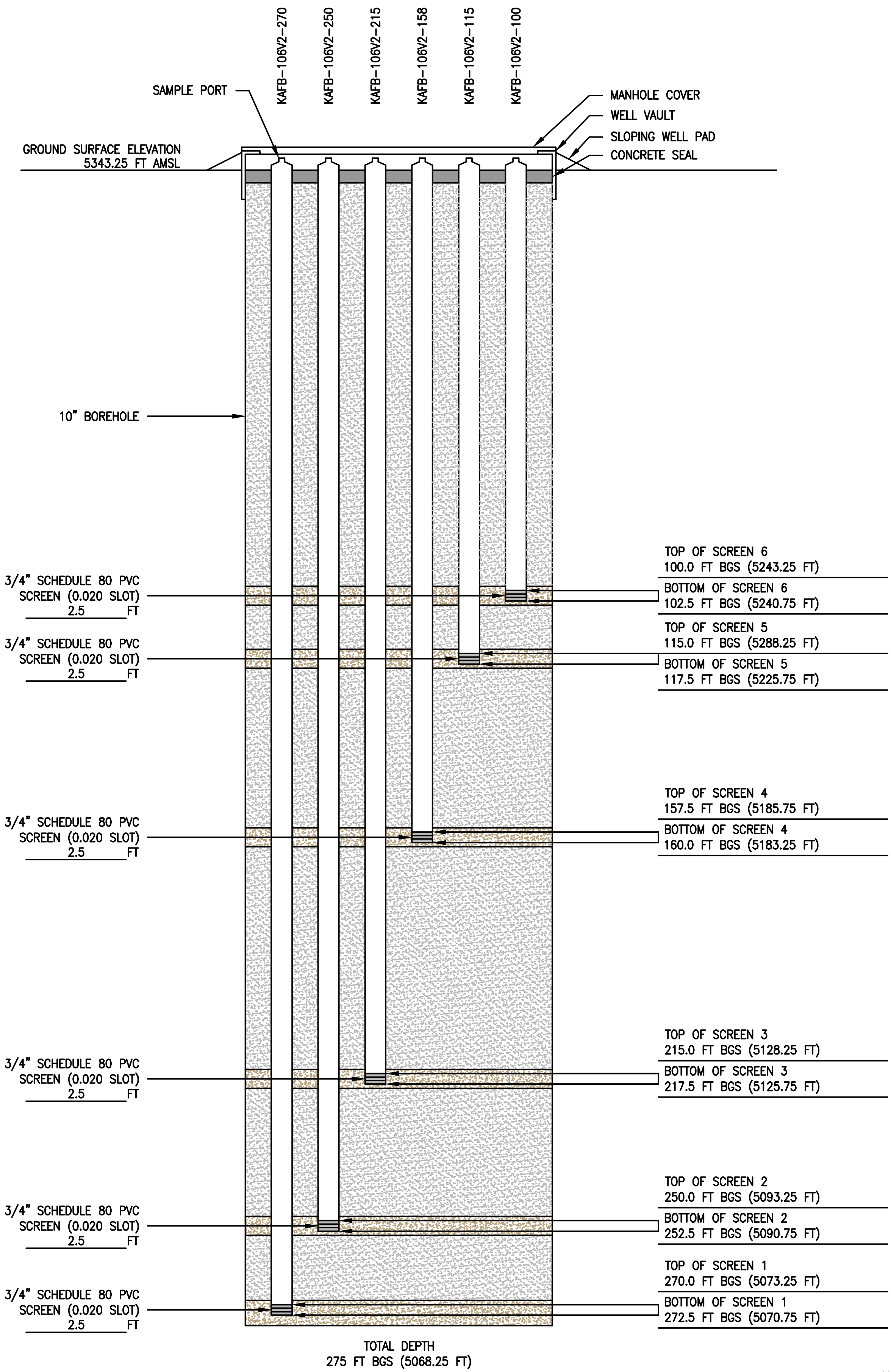
FIGURE 3-4: NESTED SOIL VAPOR WELL COMPLETION DIAGRAM FOR KAFB-106V1



(ELEVATION) IS IN ABOVE MEAN SEA LEVEL
ASML = ABOVE MEAN SEA LEVEL

NOT TO SCALE
BGS = BELOW GROUND SURFACE
FT = FEET

FIGURE 3-5: NESTED SOIL VAPOR WELL COMPLETION DIAGRAM FOR KAFB-106V2



(ELEVATION) IS IN ABOVE MEAN SEA LEVEL
ASML = ABOVE MEAN SEA LEVEL

NOT TO SCALE
BGS = BELOW GROUND SURFACE
FT = FEET

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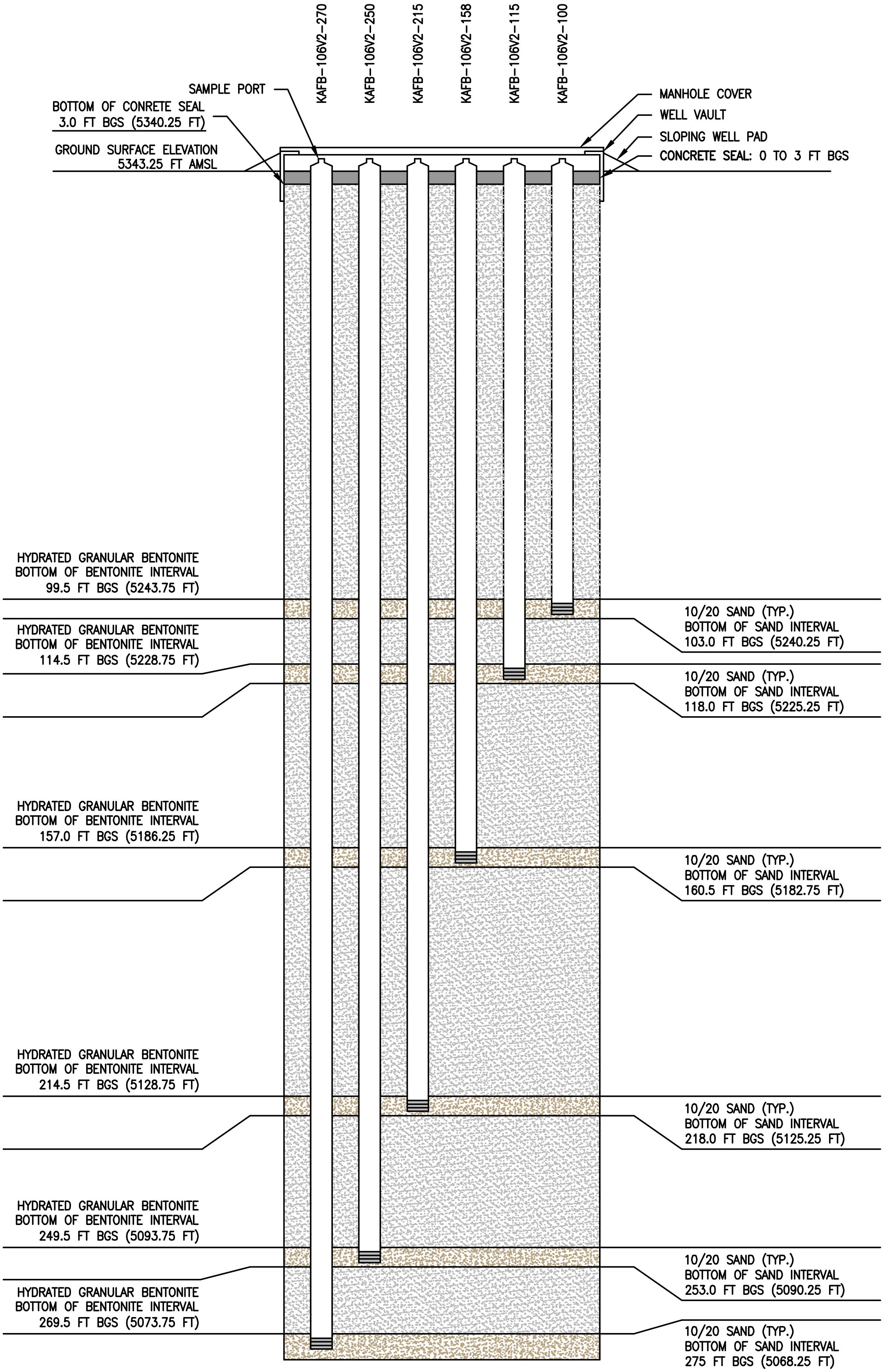
FIGURE 3-5: NESTED SOIL VAPOR WELL COMPLETION DIAGRAM FOR KAFB-106V2



(ELEVATION) IS IN ABOVE MEAN SEA LEVEL
ASML = ABOVE MEAN SEA LEVEL

NOT TO SCALE
BGS = BELOW GROUND SURFACE
FT = FEET

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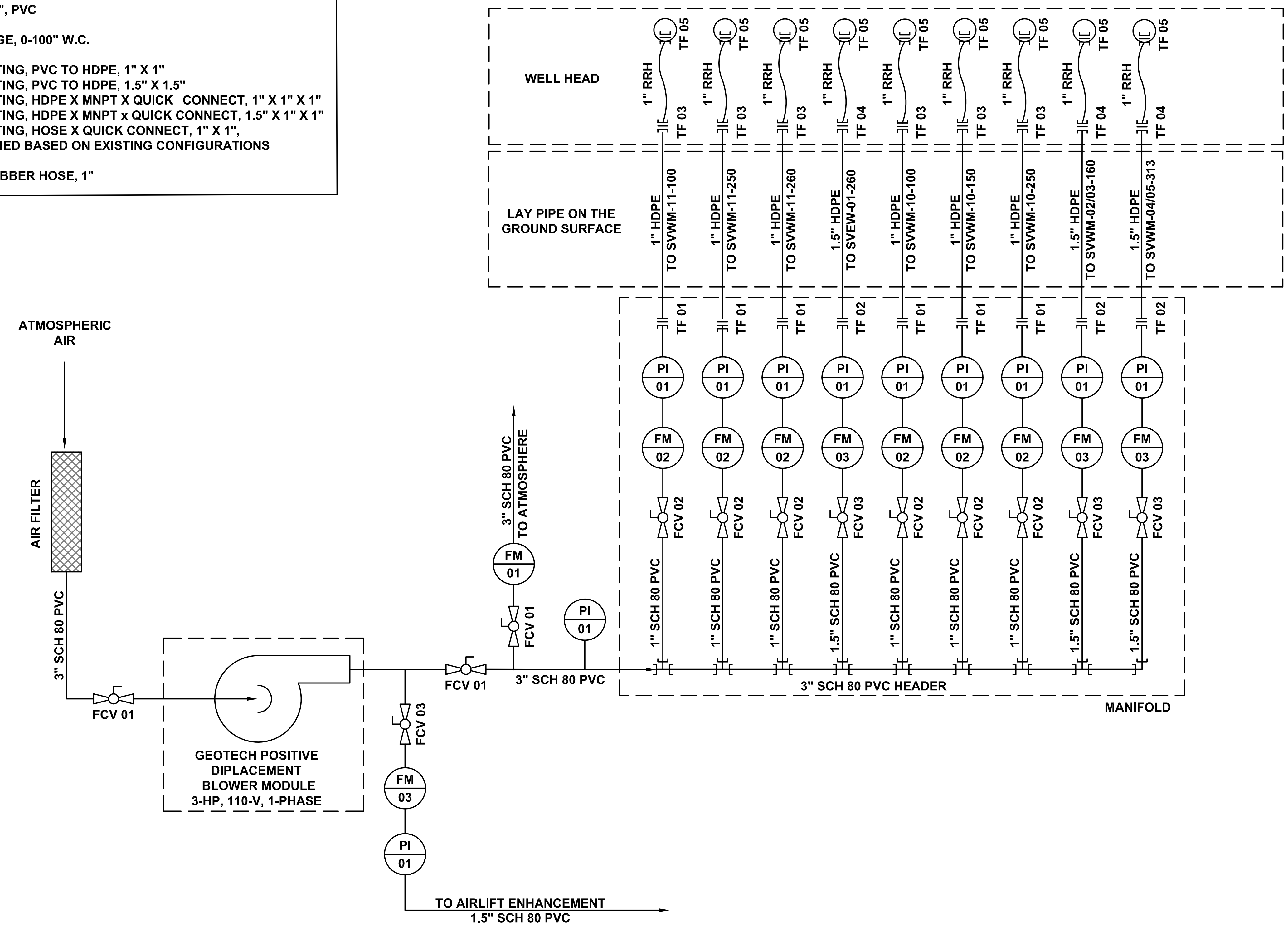
FM 01	OMEGA FL 293
FM 02	OMEGA FL 2061
FM 03	OMEGA FL 2092
FCV 01	BALL VALVE, 3", PVC
FCV 02	BALL VALVE, 1", PVC
FCV 03	BALL VALVE, 1.5", PVC
PI 01	PRESSURE GAUGE, 0-100" W.C.
TF 01	TRANSITION FITTING, PVC TO HDPE, 1" X 1"
TF 02	TRANSITION FITTING, PVC TO HDPE, 1.5" X 1.5"
TF 03	TRANSITION FITTING, HDPE X MNPT X QUICK CONNECT, 1" X 1" X 1"
TF 04	TRANSITION FITTING, HDPE X MNPT x QUICK CONNECT, 1.5" X 1" X 1"
TF 05	TRANSITION FITTING, HOSE X QUICK CONNECT, 1" X 1", TO BE DETERMINED BASED ON EXISTING CONFIGURATIONS
RRH	REINFORCED RUBBER HOSE, 1"



KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 3-6
BIOVENTING PIPING AND INSTRUMENTATION DIAGRAM

DRAWN BY: VM
DESIGNED BY: JS
PROJECT MANAGER: DJ
PROJECT NO.: 62599DM01

320 Gold Avenue, SW Suite 1300
Albuquerque, NM 87102
Phone: (505) 224-9013
Fax: (505) 224-9016
EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC., PBC

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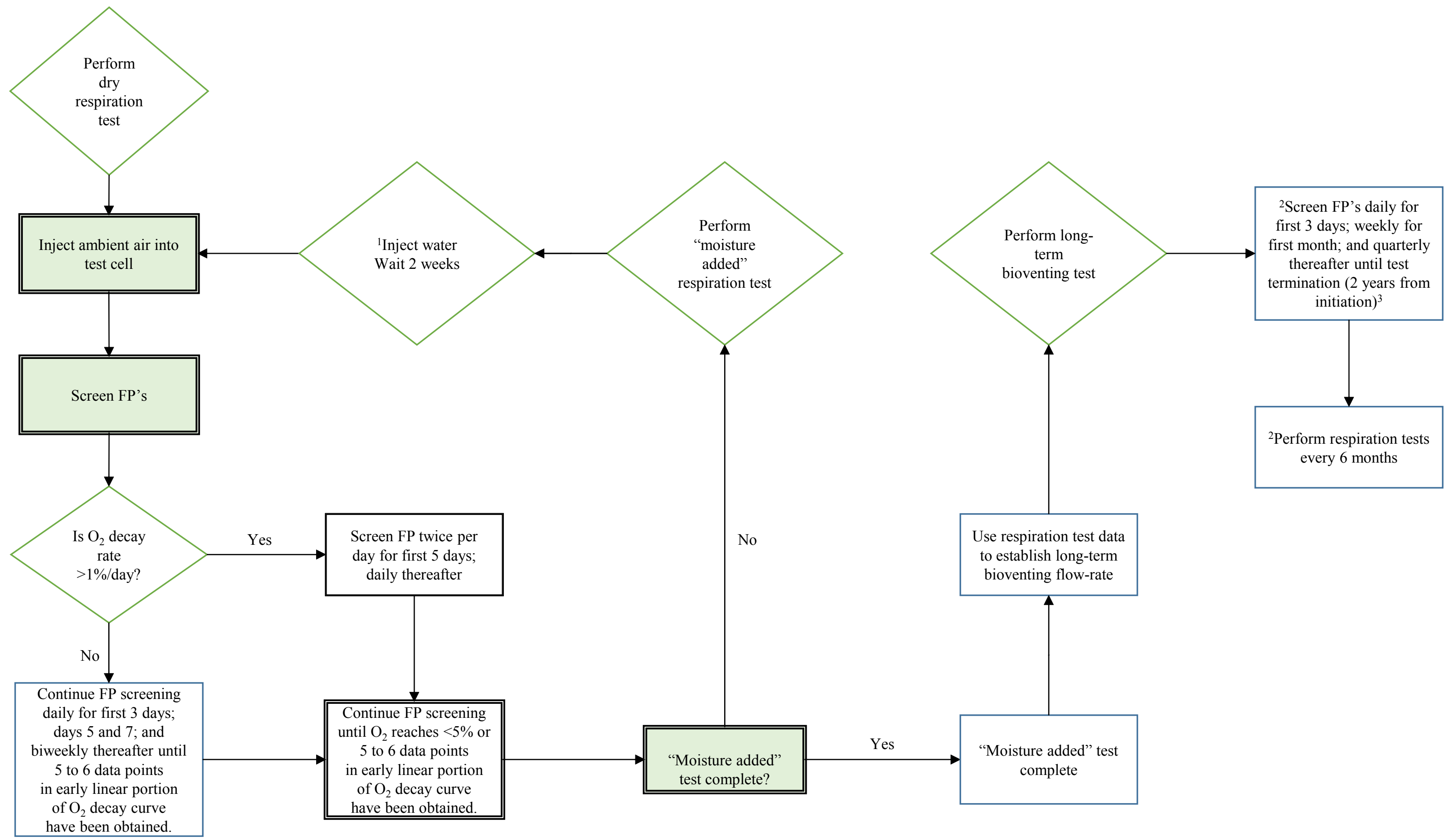


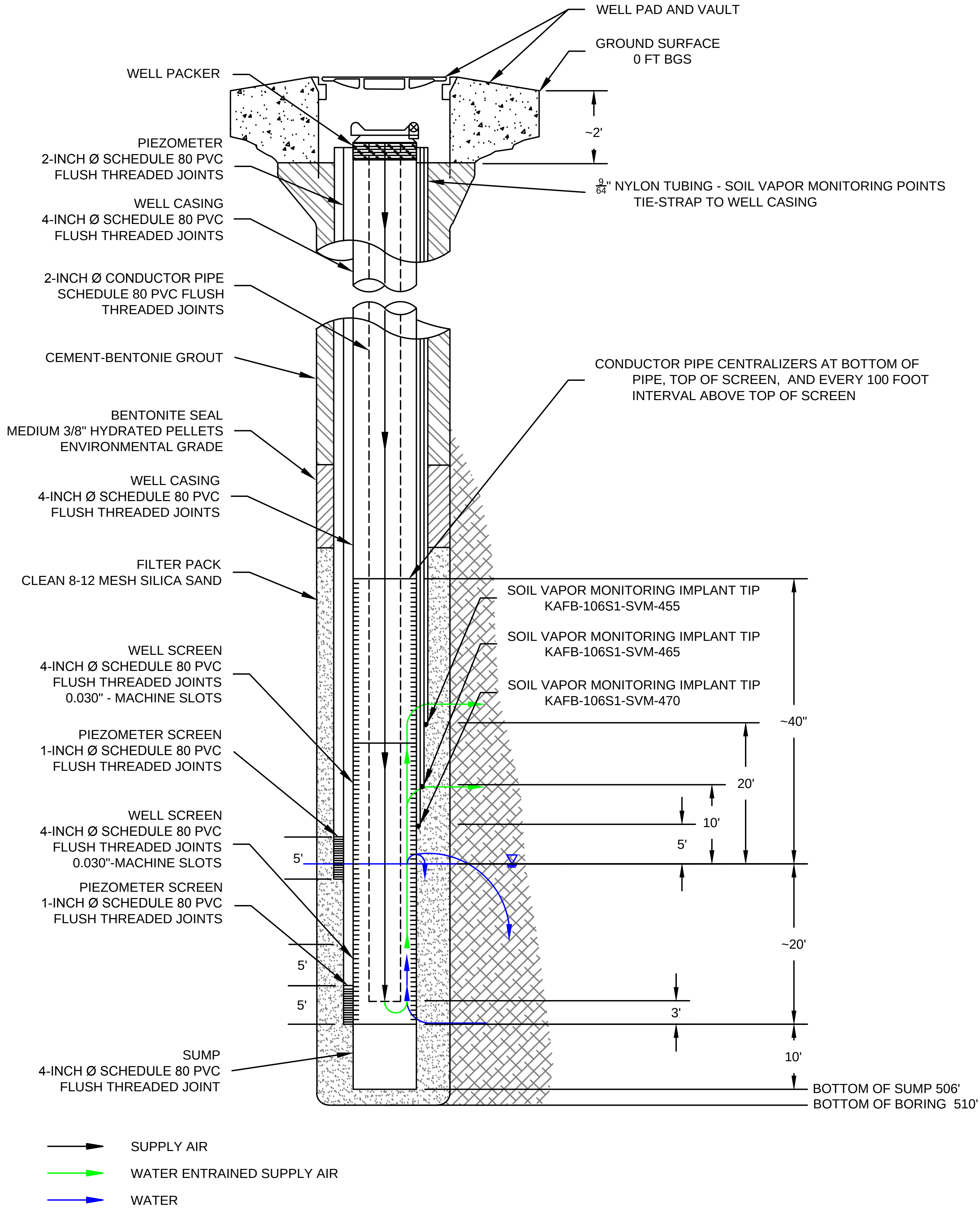
Notes:
Analytical sampling regimen is anticipated to conform to the plan included in Table 3-4, but maybe modified based on field data and professional judgement.
[1]Volume of water to be injected is provided in Table 3-2
[2]Schedule may be adjusted based on observed oxygen utilization rates in short-term respiration tests
[3]Test is anticipated to terminate after two years, but schedule may be modified based on collected data and professional judgement
FP = field parameters
RH = relative humidity

WORK PLAN FOR BIOVENTING AND AIR-LIFT ENHANCED BIOREMEDIATION PILOT TESTS
BULK FUELS FACILITY
SOLID WASTE MANAGEMENT UNIT ST-106/SS-111
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 3-7

DECISION LOGIC AND SEQUENCE SCHEMATIC FOR PILOT TESTS

FIGURE 3-8: AIR-LIFT ENHANCED BIOREMEDIATION PROCESS SCHEMATIC FOR KAFB-106S1



(ELEVATION) IS IN ABOVE MEAN SEA LEVEL
ASML = ABOVE MEAN SEA LEVEL

NOT TO SCALE
BGS = BELOW GROUND SURFACE
FT = FEET

\ABQ\Projects\Active Projects\62735DM02 Kirtland Vadose Zone\1.2 Bioventing_Air Lift Work Plan\Figures\Figures\Natives

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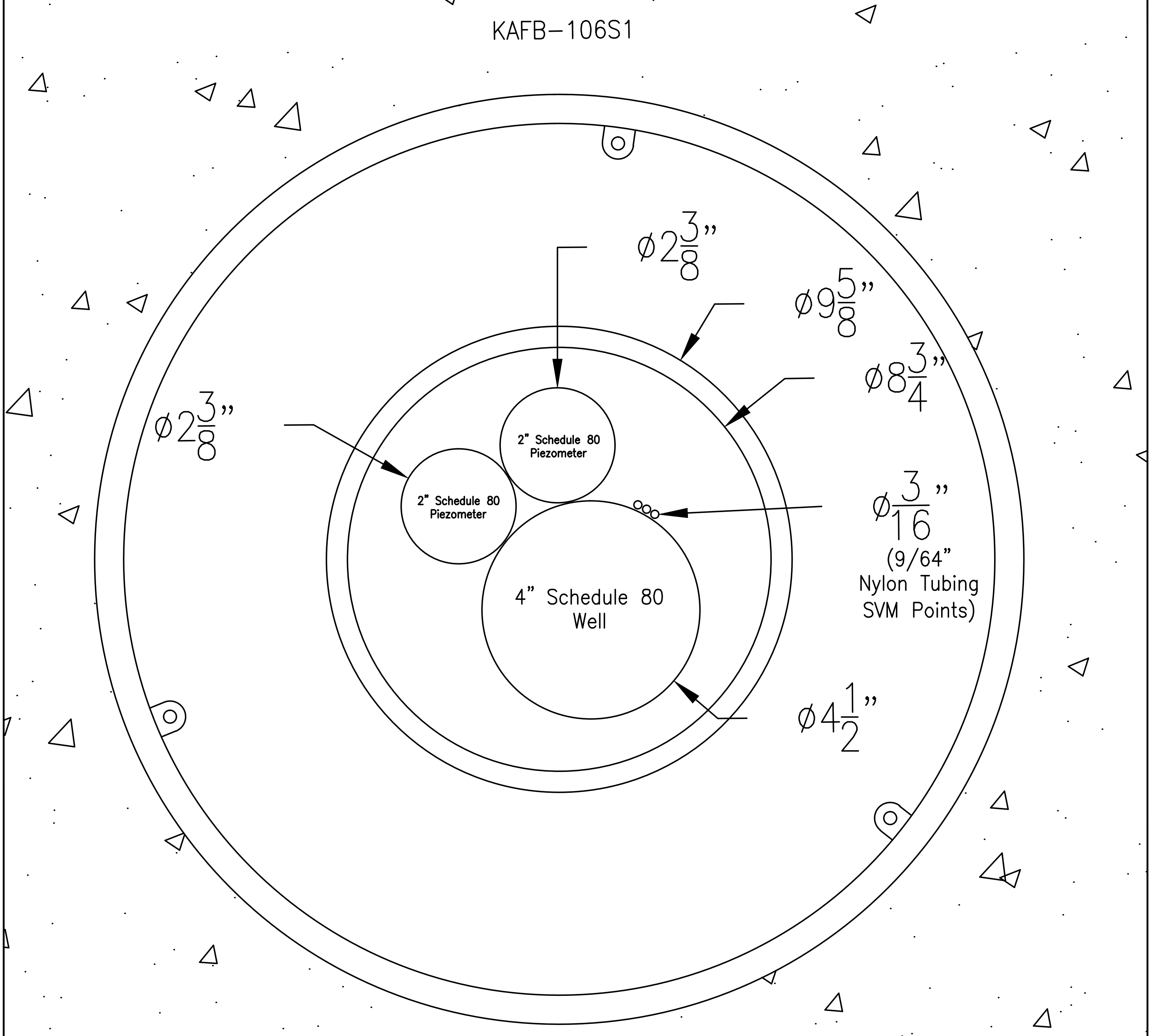
Figure 3-9 WELL HEAD CONFIGURATION
KAFB-106S1

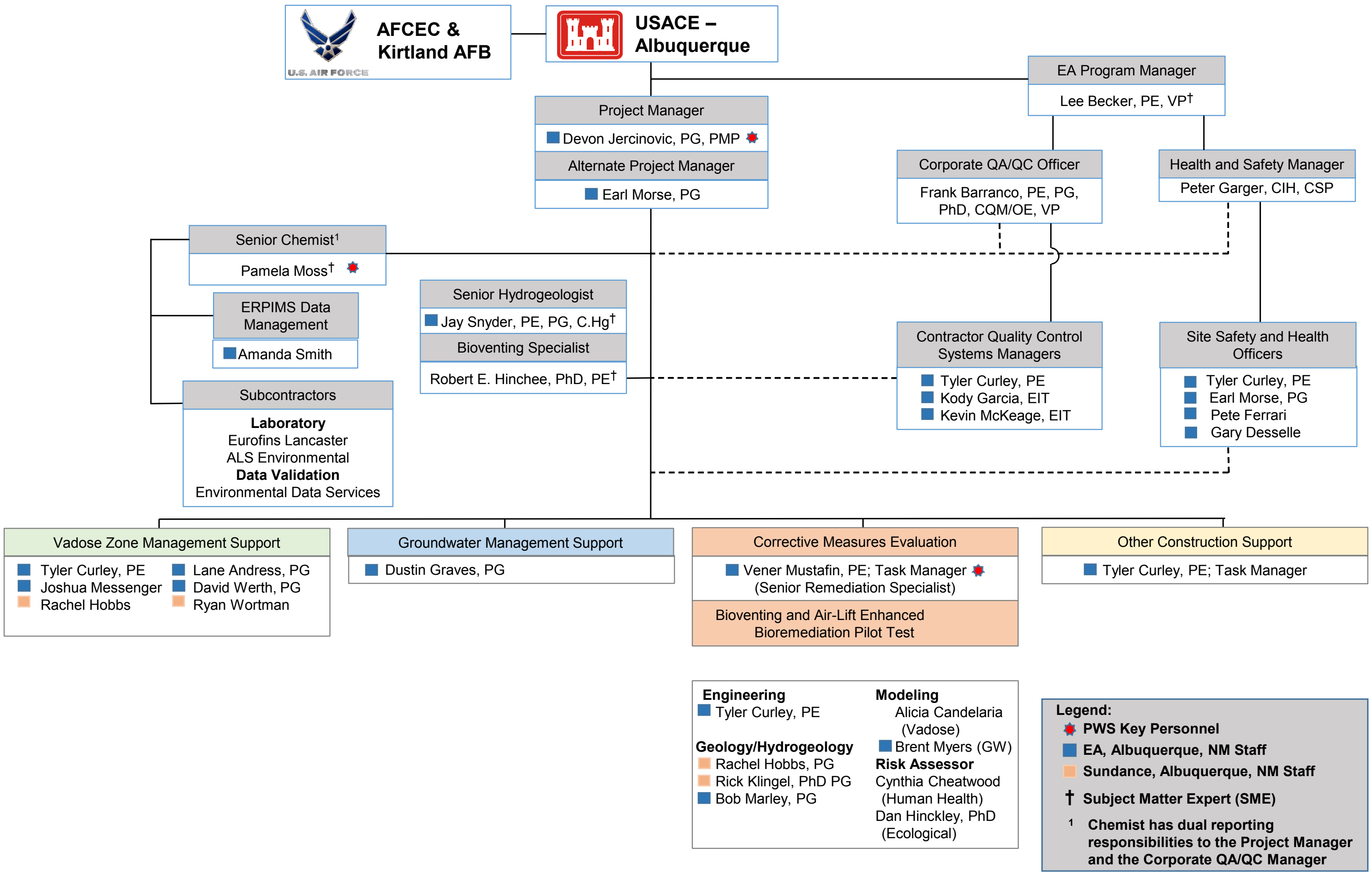
NOT TO SCALE



Distance Between Casing and Borehole is approximately 0.8"
SVM = soil vapor monitoring

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC., PBC 320 Gold Avenue, SW Suite 1300 Albuquerque, NM 87102 Phone: (505) 224-9013 Fax: (505) 224-9016	KIRTLAND AIR FORCE BASE	INSTALLATION START DATE/TIME: XX/XX/2018	INSTALLATION END DATE/TIME: XX/XX/2018
PROJECT NO.: 62599DM01	WELL ID: KAFB-106S1	GEOLOGIST: GEOLGIST	DRILLER: DRILLER

FILE PATH: Y:\ACTIVE PROJECTS\62735DM02 KIRTLAND VADOSE ZONE\1.2 BIOVENTING_AIR LIFT WORK PLAN\FIGURES\NATIVES\WELLHEAD COMPLETION-KAFB-106S1.DWG [KAFB 106S1 TOP VIEW] MCKEAGE, KEVIN 11/16/2017 10:12 AM



WORK PLAN FOR BIOVENTING AND AIR-LIFT ENHANCED BIOREMEDIATION PILOT TESTS
BULK FUELS FACILITY
SOLID WASTE MANAGEMENT UNIT ST-106/SS-111
KIRTLAND AIR FORCE BASE, NEW MEXICO

FIGURE 5-1

ORGANIZATIONAL STRUCTURE FOR BIOVENTING AND AIR-LIFT ENHANCED BIOREMEDIATION TESTS

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TABLES

Table 3-1
Bioventing Pilot Test Well Details and Function

Well ID	Screened Interval (ft bgs)	Diameter (in.)	Status	Well Use	Respiration Test	Long-Term Pilot Test	Attendant Observation Wells	Radial Distance to Observation Well (ft)
SVMW-11-100	100-102.5	0.5	Existing	Air Injection	Yes	Yes, Moist Injection	KAFB-106V1-100	27
							KAFB-106V2-100	65
							SVMW-10-100	72
SVMW-11-250	250-252.5	0.5	Existing	Air Injection	Yes	Yes, Moist Injection	KAFB-106V1-250	27
							KAFB-106V2-250	65
							SVMW-10-250	72
SVMW-11-260	260-262.5	0.5	Existing	Air Injection	Yes	Yes, Moist Injection	KAFB-106V1-250	27
							SVEW-01-260	50
							KAFB-106V2-250	65
							SVMW-10-250	72
SVEW-01-260	245-260	4	Existing	Air Injection	Yes	Yes, Dry Injection	KAFB-106V2-250	19
							KAFB-106V1-250	28
SVMW-10-100	100-102.5	0.5	Existing	Air Injection	Yes	Yes, Moist Injection	KAFB-106V1-100	49
							SVMW-09-100	50
							KAFB-106V2-100	64
SVMW-10-150	150-152.5	0.5	Existing	Air Injection	Yes	Yes, Moist Injection	KAFB-106V1-158	49
							KAFB-106V2-158	64
SVMW-10-250	250-252.5	0.5	Existing	Air Injection	Yes	Yes, Moist Injection	KAFB-106V1-250	49
							SVMW-09-250	50
							KAFB-106V2-250	64
SVMW-02/03-160	145-160	2	Existing	Air Injection	Yes	Yes, Dry Injection	KAFB-106V2-158	10
							KAFB-106V1-158	35
SVEW-04/05-313	298-313	2	Existing	Air Injection	Yes	Yes, Dry Injection	KAFB-106V1-270	25
							KAFB-106V2-270	28

Table 3-1
Bioventing Pilot Test Well Details and Function

Well ID	Screened Interval (ft bgs)	Diameter (in.)	Status	Well Use	Respiration Test	Long-Term Pilot Test	Attendant Observation Wells	Radial Distance to Observation Well (ft)
KAFB-106V1	100-102.5	0.75	Planned	Observation	Yes	Yes, Observation, Dry Test	N/A	N/A
	115-117.5	0.75			Observation			
	157.5-160	0.75						
	215-217.5	0.75						
	250-252.5	0.75						
	270-272.5	0.75						
KAFB-106V2	100-102.5	0.75	Planned	Observation	Yes	Yes, Observation, Moist Test	N/A	N/A
	115-117.5	0.75			Observation			
	157.5-160	0.75						
	215-217.5	0.75						
	250-252.5	0.75						
	270-272.5	0.75						

Table 3-2
Bioventing Pilot Test Injection Design

Injection Well	Screened Interval (ft bgs)	Screen Length (ft)	Screen Diameter (in.)	Casing Volume (ft^3)	Filter Pack Thickness (ft)	Assumed Venting Thickness (ft)[1]	Test Cell Pore Volume (ft^3)[2]	Added Moisture Volume (gallons)[3]	Air Injection Period (days)	Design Flow Rate (cfm)	Nominal Pipe Velocity (ft/min)
SVMW-11-100	100-102.5	2.5	0.5	0.140	8.2	18.2	4500	337	3	4.2	3058
SVMW-11-250	250-252.5	2.5	0.5	0.344	7.3	17.3	4278	320	3	4.0	2906
SVMW-11-260	260-262.5	2.5	0.5	0.358	22.5	32.5	8036	601	3	7.4	5460
SVEW-01-260	245-260	15	4	22.678	26	36	8902	666	3	8.2	95
SVMW-10-100	100-102.5	2.5	0.5	0.140	7.9	17.9	4426	331	3	4.1	3007
SVMW-10-150	150-152.5	2.5	0.5	0.208	9.5	19.5	4822	361	3	4.5	3276
SVMW-10-250	250-252.5	2.5	0.5	0.344	10.3	20.3	5020	375	3	4.6	3410
SVMW-02/03-160	145-160	15	2	3.489	29	39	9644	721	3	8.9	410
SVEW-04/05-313	298-313	15	2	6.825	25	35	8655	647	3	8.0	368

[1] Vertical leakance into formation assumed 5 feet above and 5 below filter pack interval
[2] Test cell design radius = 15 feet
[3] Moisture added at 1 % of pore volume
Assumed Porosity = 35 %
ft bgs = Feet below ground surface
ft = Feet
cfm = Cubic feet per minute
ft/min = Feet per minute

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Table 3-3
Bioventing Pilot Testing Field Measurement Equipment and Regimen

Parameter	Field Measurement	Media	Instrument[a]	Range/ Tolerance	Data Use	Repiration Test Frequency[b]	Long-Term Test Frequency[c]
Water Activity	Relative Humidity	Soil gas	Amprobe TH-3	0-100 % ± 3% R.H. at 23° C	Evaluate suitability of environment for biodegradation	Daily for first three days; days 5 and 7; biweekly thereafter.	Daily for first 3 days; weekly for first month; quarterly thereafter
Pressure/ Vacuum	Injection/ Extraction Pressure Distribution	Vadose zone	Dwyer 477-A7	0.05 inches water column	Establish radius of influence of test	Daily for first three days; days 5 and 7; biweekly thereafter.	Daily for first 3 days; weekly for first month; quarterly thereafter
Carbon Dioxide	Concentration in percent	Soil gas	CO_2Meter.com Model CM-0002	0 - 30 % ± 0.1 % by volume	Evaluate contaminant destruction rate	Daily for first three days; days 5 and 7; biweekly thereafter.	Daily for first 3 days; weekly for first month; quarterly thereafter
Oxygen	Concentration in percent	Soil gas	MSA Altair Pro O_2 Model #10074137	0-30 % ± 0.1 % by volume	Evaluate contaminant destruction rate	Daily for first three days; days 5 and 7; biweekly thereafter.	Daily for first 3 days; weekly for first month; quarterly thereafter
Total Petroleum Hydrocarbons	Concentration in parts per million	Soil gas	RKI Eagle Model	0-50,000 ppmv	Evaluate contaminant destruction rate	Daily for first three days; days 5 and 7; biweekly thereafter.	Daily for first 3 days; weekly for first month; quarterly thereafter
Flow Rate	Thermo-Anemometer	Soil gas	Dwyer AQTIA-AP2	0-6000 ft/min	Verify purge volume	Daily for first three days; days 5 and 7; biweekly thereafter.	Daily for first 3 days; weekly for first month; quarterly thereafter
Temperature	Temperature	Soil gas	Amprobe TH-3	-20 - 60° C ± 0.8° C	Evaluate suitability of environment for biodegration	Daily for first three days; days 5 and 7; biweekly thereafter.	Daily for first 3 days; weekly for first month; quarterly thereafter

Table 3-3
Bioventing Pilot Testing Field Measurement Equipment and Regimen

[a] Or engineer approved equivalent

[b] Schedule can be adjusted based on observed oxygen utilization rates; goal is 5-10 data points in early linear portion of oxygen decay curve

[c] Schedule may be adjusted based on observed oxygen utilization rates in short-term respiration tests

° C = degrees Celsius

ppmv = parts per million (by volume)

Table 3-4
Bioventing Pilot Test Analytical Requirements and Frequency

Parameter	Method	Media	No. of Samples Per Event[a]	Sample Container	Data Use	Repiration Test Frequency	Long-Term Test Frequency
BTEX/ TPH-GRO	EPA TO-3	Soil Vapor	12	1-liter Summa Canister	Track fuel hydrocarbon degradation	Baseline and end of test	Weekly for first month; quarterly to end of test
VOCs	EPA TO-15 SIM	Soil Vapor	12	1-liter Summa Canister	Evaluate degradation of EDB	Baseline and end of test	Weekly for first month; quarterly to end of test
Fixed Gases[b]	ASTM D1945	Soil Vapor	12	1-liter Summa Canister	Evaluate contaminant destruction rate	Baseline and end of test	Weekly for first month; quarterly to end of test
C1-C5 Hydrocarbon Compounds[c]	ASTM D1945	Soil Vapor	12	1-liter Summa Canister	Evaluate degradation of EDB	Baseline and end of test	Weekly for first month; quarterly to end of test

Notes:

[a] Soil vapor samples collected from each of the six nested wells in both KAFB-106V1 and KAFB-106V2 (does not include QC samples)

[b] Fixed gases - nitrogen, oxygen, hydrogen, carbon monoxide, carbon dioxide

[c] C1-C5 hydrocarbon compounds - methane, ethane, propane, butane, pentane

ASTM = ASTM International

BTEX = Benzene, toluene, ethylbenzene, and xylenes

EDB = ethylene dibromide (1,2-dibromoethane)

EPA = U.S. Environmental Protection Agency

GRO = Gasoline range organics

SIM = Selective ion monitoring

TPH = Total petroleum hydrocarbons

VOC = Volatile organic compounds

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Table 3-5
Bioventing Pilot Test Well Details and Function

Well ID	Screened Interval (ft bgs)	Diameter (in.)	Status	Well Use	Respiration Test	Long-Term Pilot Test	Attendant Observation Wells / SVMPs	Radial Distance to Observation Well (ft)
KAFB-106S1	436-496	4	Planned	Air-Lift	Yes	Yes, Air-Lift Enhanced	KAFB-106114	167
							KAFB-106116	88
							KAFB-106128	232
							KAFB-106S1-SVM-455	annulus
							KAFB-106S1-SVM-465	annulus
							KAFB-106S1-SVM-470	annulus
KAFB-106S1-SVM-455	454 -456	0.25	Planned	Observation	Yes	Yes	N/A	N/A
KAFB-106S1-SVM-465	464-466	0.25	Planned	Observation	Yes	Yes	N/A	N/A
KAFB-106S1-SVM-470	469-471	0.25	Planned	Observation	Yes	Yes	N/A	N/A
KAFB-106114	439.6-449.6	3	Existing	Observation	Yes	Yes	N/A	N/A
KAFB-106116	440-450	3	Existing	Observation	Yes	Yes	N/A	N/A
KAFB-106128	440-450	3	Existing	Observation	Yes	Yes	N/A	N/A

SVMP = soil vapor monitoring point

Table 3-6
Air-Lift Enhanced Bioremediation Pilot Test - Initial Respiration Test Design

Injection Well	Screened Interval (ft bgs)	Screen Length (ft)	Screen Diameter (in.)	Casing Volume (ft^3)	Filter Pack Thickness (ft)	Assumed Venting Thickness (ft)[a]	Test Cell Pore Volume (ft^3)[b]	Air Injection Period (days)	Design Flow Rate (cfm)	Nominal Pipe Velocity (ft/min)
KAFB-106S1	436-496	60	4	43.262	65	75	18546	3	17.2	197

[a] Vertical leakance into formation assumed 5 feet above and 5 below filter pack interval
[b] Test cell design radius = 15 feet
Assumed Porosity = 35 %
ft bgs = Feet below ground surface
ft = Feet
cfm = Cubic feet per minute
ft/min = Feet per minute

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Table 3-7
Air-Lift Enhanced Bioremediation Pilot Testing Field Measurement Equipment and Regimen

Parameter	Field Measurement	Media	Instrument[a]	Range/ Tolerance	Data Use	Repiration Test Frequency[b]	Long-Term Test Frequency[c]
Water Activity	Relative Humidity	Soil gas	Amprobe TH-3	0-100 % ± 3% R.H. at 23° C	Evaluate suitability of environment for biodegradation	Daily for first three days; days 5 and 7; biweekly thereafter.	Daily for first 3 days; weekly for first month; quarterly thereafter
Pressure/ Vacuum	Injection/ Extraction Pressure Distribution	Vadose zone	Dwyer 477-A7	0.05 inches water column	Establish radius of influence of test	Daily for first three days; days 5 and 7; biweekly thereafter.	Daily for first 3 days; weekly for first month; quarterly thereafter
Carbon Dioxide	Concentration in percent	Soil gas	CO_2Meter.com Model CM-0002	0 - 30 % ± 0.1 % by volume	Evaluate contaminant destruction rate	Daily for first three days; days 5 and 7; biweekly thereafter.	Daily for first 3 days; weekly for first month; quarterly thereafter
Oxygen	Concentration in percent	Soil gas	MSA Altair Pro O_2 Model #10074137	0-30 % ± 0.1 % by volume	Evaluate contaminant destruction rate	Daily for first three days; days 5 and 7; biweekly thereafter.	Daily for first 3 days; weekly for first month; quarterly thereafter
Total Petroleum Hydrocarbons	Concentration in parts per million	Soil gas	RKI Eagle Model	0-50,000 ppm	Evaluate contaminant destruction rate	Daily for first three days; days 5 and 7; biweekly thereafter.	Daily for first 3 days; weekly for first month; quarterly thereafter
Flow Rate	Thermo-Anemometer	Soil gas	Dwyer AQTIA-AP2	0-6000 ft/min	Verify purge volume	Daily for first three days; days 5 and 7; biweekly thereafter.	Daily for first 3 days; weekly for first month; quarterly thereafter
Temperature	Temperature	Soil gas	Amprobe TH-3	-20 - 60° C ± 0.8° C	Evaluate suitability of environment for biodegration	Daily for first three days; days 5 and 7; biweekly thereafter.	Daily for first 3 days; weekly for first month; quarterly thereafter
Water Quality	Field parameters[d]	Groundwater	In Situ Aqua Troll 600	Various	Monitor effects of air lift enhancement on water quality	Daily for first three days; days 5 and 7; biweekly thereafter.	Daily for first 3 days; weekly for first month; quarterly thereafter

Table 3-7
Air-Lift Enhanced Bioremediation Pilot Testing Field Measurement Equipment and Regimen

[a] Or engineer approved equivalent

[b] Schedule can be adjusted based on observed oxygen utilization rates; goal is 5-10 data points in early linear portion of oxygen decay curve

[c] Schedule may be adjusted based on observed oxygen utilization rates in short-term respiration tests

[d] Temperature, pH, oxidation reduction potential (ORP), specific conductance (SpC), dissolved oxygen (DO), turbidity

° C = degrees Celsius

ppm = parts per million (by volume)

Table 3-8
Air-Lift Enhanced Bioremediation Pilot Test Analytical Requirements and Frequency

Parameter	Method	Media	No. of Samples per Event[a]	Sample Container	Data Use	Repiration Test Frequency	Long-Term Test Frequency
BTEX/TPH-GRO	EPA TO-3	Soil Vapor	2	1-liter Summa Canister	Track fuel hydrocarbon degradation	Baseline then end of test	Weekly for first month; quarterly thereafter
VOCs	EPA TO-15 SIM	Soil Vapor	2	1-liter Summa Canister	Evaluate degradation of EDB	Baseline then end of test	Weekly for first month; quarterly thereafter
Fixed Gases[b]	ASTM D1945	Soil Vapor	2	1-liter Summa Canister	Evaluate contaminant destruction rate	Baseline then end of test	Weekly for first month; quarterly thereafter
C1-C5 Hydrocarbon Compounds[c]	ASTM D1945	Soil Vapor	2	1-liter Summa Canister	Evaluate degradation of EDB	Baseline then end of test	Weekly for first month; quarterly thereafter
VOCs	EPA SW8260C	Water	2	3 x 40-ml vials with HCL	Evaluate degradation of solute contaminaton	N/A	Baseline then semi-annual
TPH-GRO/ DRO	EPA SW8015D	Water	2	3 x 40-ml vials with HCL/ 2 x 250-ml amber glass with HCL	Evaluate degradation of solute contaminaton	N/A	Baseline then semi-annual
EDB	EPA SW8011	Water	2	2 x 40-ml vials with HCL	Evaluate degradation of solute contaminaton	N/A	Baseline then semi-annual

[a] Samples collected from two in-borehole piezometers (does not include QC samples)
[b] Fixed gases - nitrogen, oxygene, hydrogen, carbon monoxide, carbon dioxide
[c] C1-C5 hydrocarbon compounds - methane, ethane, propane, butane, pentane
ASTM = ASTM International
BTEX = Benzene, toluene, ethylbenzene, and xylenes
DRO = Diesel range organics
EDB = Ethylene dibromide (1,2-dibromoethane)
GRO = Gasoline range organics
HCL = Hydrochloric acid
ml = Milliliter
N/A = Not applicable
SIM = Selective-ion monitoring
TPH = Total petroleum hydrocarbons
VOC = Volatile organic compounds

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Table 5-1
Staff Roles, Responsibilities, and Authorities for Bioventing and Air-lift Enhanced Bioremediation Pilot Tests

Position/Staff	Qualifications	Responsibilities	Authority Level
Program Manager Lee Becker, PE	• M.S. in Civil Engineering • 25 years of program management experience for USACE • Managed over $200 million of USACE/Army projects • Over 45 years of civil engineering experience	• As EA Officer, authorized to negotiate/sign contract and commit resources • Primary point-of-contact for USACE on contractual and programmatic items • Ensures consistency in deliverables and cost/performance reporting and progress reporting/invoicing • Coordinates issue resolution as needed with Contracting Officer's Representative and/or Contracting Officer	• Coordinates corrective action at programmatic level
Project Manager Devon Jercinovic, PG, PMP	• M.S. in Geology • 35 years of RCRA experience and 28 years of experience in management and technical support for site characterization • Project Manager for $80 million+ of RCRA/CERCLA investigations and remediation at Kirtland AFB since 1997 • Past NMED environmental regulator in the former Groundwater and Hazardous Waste Bureau	• Ensures that all work is accomplished with adequate internal controls • Main point-of-contact for USACE on project-specific matters • Reviews/confirms technical approach from kickoff meeting and throughout project execution to ensure project objectives are met • Assembles and schedules resources • Ensures on-schedule and high-quality services are delivered within budget • Coordinates EA's participation in the public meeting and community relations process • Ensures work is performed in accordance with USACE/U.S. Air Force Guidelines, state/federal regulations, and within the bounds of the RCRA, COA, and New Mexico Office of the State Engineer permits • Applies lessons learned from current and past projects • Responsible for front and back end transition activities to ensure continuity on the project • Ensures public relations sensitivities are met	• Full responsibility and authority to execute Task Orders • Approves subcontractor invoices, project charges, and deliverables • Implements corrective action • Stops work for any reason related to the project

Table 5-1
Staff Roles, Responsibilities, and Authorities for Bioventing and Air-Lift Pilot Test Tasks

Position/Staff	Qualifications	Responsibilities	Authority Level
Alternate Project Manager Earl Morse, PG	• M.S. in Geology • 31 years in environmental field programs (investigation and construction)	• Reports to the Project Manager • Serves as Deputy to Project Manager • Manages staffing and field resources for all field investigations • Manages subcontractors • Identifies and mitigates risks related to execution of the technical aspects of the work and ensures site safety •	• Stop work for any reasons related to any field activities
Corporate QA/QC Officer Frank Barranco, PE, PG	• Ph.D. in Environmental Science and Engineering • 27 years of engineering, environmental remediation, and construction experience • Serves as Program QA Manager on $400 million+ of federal projects	• Reports to Program Manager—independent of the Project Manager • Identifies approved senior technical reviewers and QC staff • Assists in developing and approves project quality certification programs • Monitors work, procedures, and documentation to ensure compliance with quality certification programs • Initiates/provides recommendations to improvements to the quality process • Develops and oversees corrective actions • Conducts independent QC audits	• Evaluates performance of review staff and review process and provides feedback, including recommendations, to Project Manager • Implements corrective action if the quality of the work is not acceptable
Health and Safety Manager Peter Garger, CIH, CSP	• ScM in Public Health • As Corporate Health and Safety Director, oversees health and safety activities for 450+ employees and 30 federal contracts • Prepared/reviewed over 3,000 APPs/SSHPs • Served as Chief of Industrial Hygiene for USACE–Baltimore Hazardous, Toxic, and Radioactive Waste Branch	• Oversees development of APP in accordance with Engineer Manual 385-1-1 and Occupational Safety and Health Administration regulations • Assists Project Manager and procurement staff in verification of safety performance of subcontractors • Investigates any incidents, accidents, or safety violations • Performs safety audits	• Approves APPs/SSHPs and all modifications before issuance to the USACE • Manages Health and Safety Program and directs training and required attendance • Investigates safety concerns raised by staff • Investigates any accidents • Stops work for noncompliance/safety violation

Table 5-1
Staff Roles, Responsibilities, and Authorities for Bioventing and Air-Lift Pilot Test Tasks

Position/Staff	Qualifications	Responsibilities	Authority Level
Senior Chemist Pamela Moss	• B.S. in Chemistry • 25 years of chemistry experience, including developing and implementing data quality objectives in accordance with RCRA/CERCLA to ensure performance standards are achieved • Expertise in developing QAPjP, Sampling and Analysis Plan, Field Sampling Plan for Department of Defense • Performed $35 million+ of project work at Kirtland, Cannon, and Holloman AFBs in New Mexico	• Reports to both the Project Manager and the Corporate QA/QC Manager • Ensures that project implementation is performed in compliance with QA Project Plans • Overall responsibility for chemical data quality and ensures that data meet data quality objectives • Supports development of project-specific work plans and QAPjP • Monitors implementation of QAPjP, including oversight of laboratory, analytical methods, reporting limits, and data deliverables • Coordinates third-party data validation and reviews data validation results and reports • Prepares data quality reports to document that data are usable and achieve data quality objectives • Direct interface with analytical laboratory Project Manager and QC Manager	• Coordinates all communication with the analytical laboratory • Coordinates data validation and evaluation • In coordination with the Project Manager, implements corrective actions related to laboratory performance
Project Geologist Jay Snyder, PE, PG, CHg	• M.S. in Geology/Geological Engineering • 26 years geological experience, working with within New Mexico and with New Mexico regulators	• Reports to the Project Manager • Senior technical support for bioventing and bioremediation pilot tests • Reviews all work plan, geological reporting, and data deliverables associated with pilot testing • Assists with establishing project-specific data quality objectives • Responsible for providing input for the design of the corrective actions and reviews corrective elements specific to geology or well installation	• Stop drilling work or pilot testing for any reasons related to drilling activities

Table 5-1
Staff Roles, Responsibilities, and Authorities for Bioventing and Air-Lift Pilot Test Tasks

Position/Staff	Qualifications	Responsibilities	Authority Level
Bioventing Specialist Robert Hinchee, PE	• Ph.D., Civil and Environmental Engineering • 35 years performing LNAPL/Petroleum Hydrocarbon Remediation on thousands of sites in North America, South America, Europe, Africa, the Middle East, and Asia. • SME for Bioventing - lead much of the early development of bioventing including serving as project manager, technical director, or technical reviewer of bioventing studies at 500 sites in the U.S. and Europe. Developed the first field treatability testing protocol that was applied at all sites, leading to scale up of the remediation systems at hundreds of sites. Co-authored the EPA's Bioventing Principals and Practice Manual	• Reports to the Project Manager • Senior subject matter expert for bioventing and bioremediation pilot tests • Participates in Vadose Zone Working Group • Reviews pilot test work plans, geological reporting, and data deliverables associated with pilot testing • Responsible for providing input for the design of the corrective actions and reviews corrective elements specific to vadose zone remediation	• Stop drilling work or pilot testing for any reasons related to drilling activities

Table 5-1
Staff Roles, Responsibilities, and Authorities for Bioventing and Air-Lift Pilot Test Tasks

Position/Staff	Qualifications	Responsibilities	Authority Level
Project Remediation Engineer Vener Mustafin, PE	• M.S. in Geology/Geological Engineering • 26 years geological experience, working with within New Mexico and with New Mexico regulators	• Reports to the Project Manager and serves as Task Manager for the Corrective Measures Evaluation and all vadose zone pilot tests. • Overall responsibility for design, implementation, and management of pilot tests • Reviews all work plans, geological reporting, and data deliverables for pilot tests • Assists with establishing project-specific data quality objectives • Coordinates with Field Geologists for oversight and quality control • Responsible for the design of the corrective actions and reviews all corrective elements	• Stop drilling work or pilot testing for any reasons related to drilling activities
Groundwater Support Dustin Graves, PG, CHMM	• M.S. in Geology • 12 years of geological experience with drilling and well installation oversight and groundwater and drinking water sampling • Past experience coordinating Kirtland BFF project tasks	• Reports to the Project Manager and serves as Task Manager for Groundwater Support activities • Oversees all drilling operations during well installations and abandonments • Conducts data analysis and reporting • Manages Subcontractors	• Stop drilling work for any reasons related to drilling activities

Table 5-1
Staff Roles, Responsibilities, and Authorities for Bioventing and Air-Lift Pilot Test Tasks

AFB	=	Air Force Base
APP	=	Accident Prevention Plan
CERCLA	=	Comprehensive Environmental Response, Compensation, and Liability Act
CHg	=	Certified Hydrologist
CIH	=	Certified Industrial Hygienist
CSP	=	Certified Safety Professional
EA	=	EA Engineering, Science, and Technology, Inc., PBC
EI	=	Engineer Intern
NMED	=	New Mexico Environment Department
O&M	=	operation and maintenance
PE	=	Professional Engineer
PG	=	Professional Geologist
PMP	=	Project Management Professional
QA	=	quality assurance
QAPjP	=	Quality Assurance Project Plan
QC	=	quality control
RCRA	=	Resource Conservation and Recovery Act
SSHP	=	Site Safety and Health Plan
USACE	=	U.S. Army Corps of Engineers

APPENDIX A

Test Well Completion Diagrams

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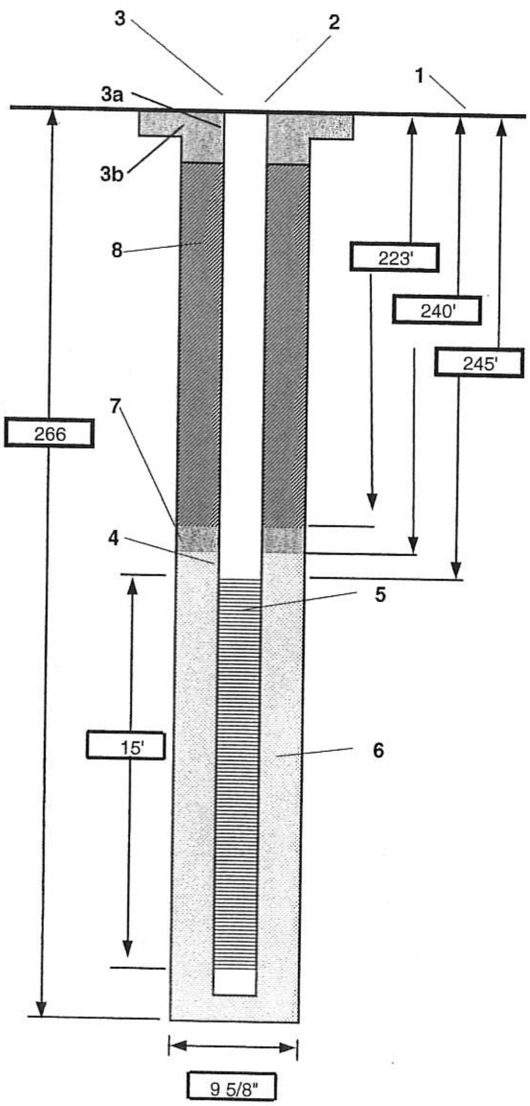
CH2MHILL

PROJECT NUMBER	WELL NUMBER	
168206.02.TT.WI	SVEW-01	SHEET 1 OF 1

WELL COMPLETION DIAGRAM

PROJECT : KAFB Bulk Fuels Facility (ST-106) LOCATION : Bulk Fuels Facility - KAFB
DRILLING CONTRACTOR : Water Development Corp/Mark Green
DRILLING METHOD AND EQUIPMENT USED : Star 30K - Air Rotary - Casing Hammer
WATER LEVEL : NA START : 02/26/2003 END: 02/26/2003 LOGGER : D.BossWalker/ABQ



1- Ground elevation at well: Approximately 5339'

2- Top of casing elevation:
a) vent hole? NA

3- Wellhead protection cover type: 12" Flush mount, locking caps
a) weep hole? NA
b) concrete pad dimensions: 4' square flush mount

4- Dia./type of well casing: 4" Stainless Steel

5- Type/slot size of screen: 4" Stainless Steel
0.050" slot

6- Type screen filter: 8x12 size sand, Colorado Silica Sand
28x50lb sacks

7- Type of seal: Enviroplug 3/8" Bentonite Chips
9x50lb sacks

8- Surface Seal
a) Grout mix used: Environplug Bentonite Slurry
b) Method of placement: Pump
c) Vol. of well casing grout:

Development method: NA

Development time: NA

Estimated purge volume: NA

Comments: 5' sump below screen.

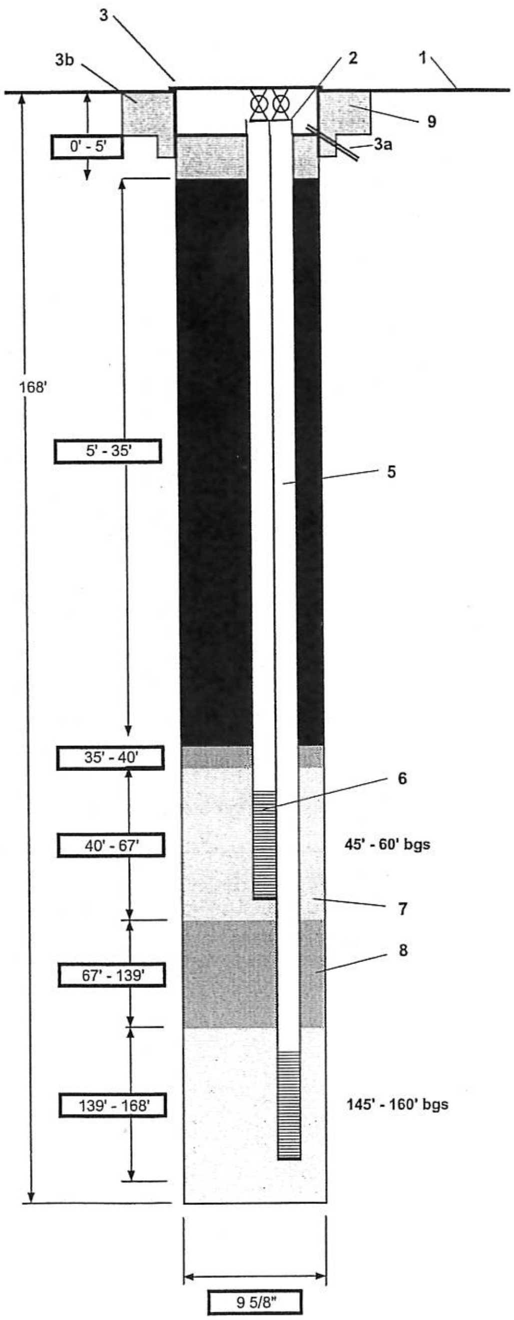
Illustration not to scale.

CH2MHILL

PROJECT NUMBER	WELL NUMBER	
179495.01.TT.WI	SVEW-02-03	SHEET 1 OF 1

SOIL VAPOR EXTRACTION WELL COMPLETION DIAGRAM

PROJECT : KAFB Bulk Fuels Facility (ST-106) LOCATION : Bulk Fuels Facility - KAFB
ELEVATION: NA DRILLING CONTRACTOR : Water Development Corporation- Mike Thomas
DRILLING METHOD AND EQUIPMENT USED: Star 30K - Air Rotary - Casing Hammer
WATER LEVELS : NA START : 9/10/2003 END : 9/16/2003 LOGGER : D.Boss-Walker



1- Ground elevation at well	approximately 5340'
2- Top of casing elevation	NA
3- Wellhead protection cover type	NA
a) drain tube?	None
b) concrete pad dimensions	NA
4- Dia./type surface casing	None
5- Dia./type of well casing	2" Nom. OD Stainless Steel - Nested pair
6- Type/slot/size of screen	2" Nom. OD Stainless Steel 0.050 slot, 15' long
7- Type screen filter	8 x 12 Oglebay Colorado Silica
quantity used	19 x 100 lb Sacks
8- Type of seal	Hydrated Enviroplug 3/8" (medium)
quantity used	Bentonite chips - 74 x 50 lb Sacks
9- Grout	
a) Grout mix used	Volclay Bentonite Grout - 43x50 lb Sacks
b) Method of placement	Grout Pump
c) Vol.of surface casing grout	NA
d) Vol. of well casing grout	NA
Development method	NA
Development time	NA
Estimated purge volume	NA

Comments

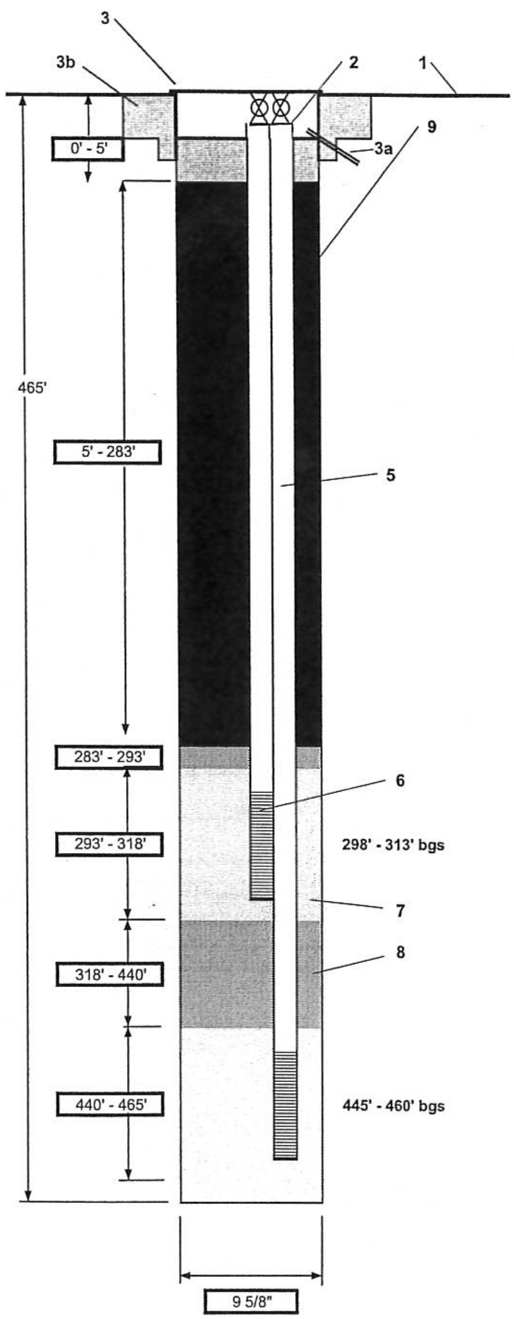
SVEW-03 is the deeper well with a screened interval of 145' - 160'
SVEW-02 is the shallower well with a screened interval of 45' - 60'

Illustration not to scale.

CH2MHILL	PROJECT NUMBER 179495.01.TT.WI	WELL NUMBER SVEW-04-05	SHEET 1 OF 1

SOIL VAPOR EXTRACTION WELL COMPLETION DIAGRAM

PROJECT : KAFB Bulk Fuels Facility (ST-106)
LOCATION : Bulk Fuels Facility - KAFB
ELEVATION: NA
DRILLING CONTRACTOR : Water Development Corporation- Mike Thomas
DRILLING METHOD AND EQUIPMENT USED: Star 30K - Air Rotary - Casing Hammer
WATER LEVELS : NA
START : 9/22/2003 END : 9/24/2003 LOGGER : D.Boss-Walker



1- Ground elevation at well	approximately 5340'
2- Top of casing elevation	NA
3- Wellhead protection cover type	NA
a) drain tube?	None
b) concrete pad dimensions	NA
4- Dia./type surface casing	NA
5- Dia./type of well casing	2" Nom. OD Stainless Steel - Nested pair
6- Type/slot/size of screen	2" Nom. OD Stainless Steel 0.050 slot, 15' long
7- Type screen filter	8 x 12 Oglebay Colorado Silica
quantity used	34 x 100 lb Sacks
8- Type of seal	Hydrated Enviroplug 3/8" (medium)
quantity used	Bentonite chips - 99 x 50 lb Sacks
9- Grout	
a) Grout mix used	Volclay Bentonite Grout - 50x50 lb Sacks
b) Method of placement	Grout Pump
c) Vol.of surface casing grout	NA
d) Vol. of well casing grout	NA
Development method	NA
Development time	NA
Estimated purge volume	NA
Comments	

SVEW-05 is the deeper well with a screened interval of 445' - 460'
SVEW-04 is the shallower well with a screened interval of 298' - 313'

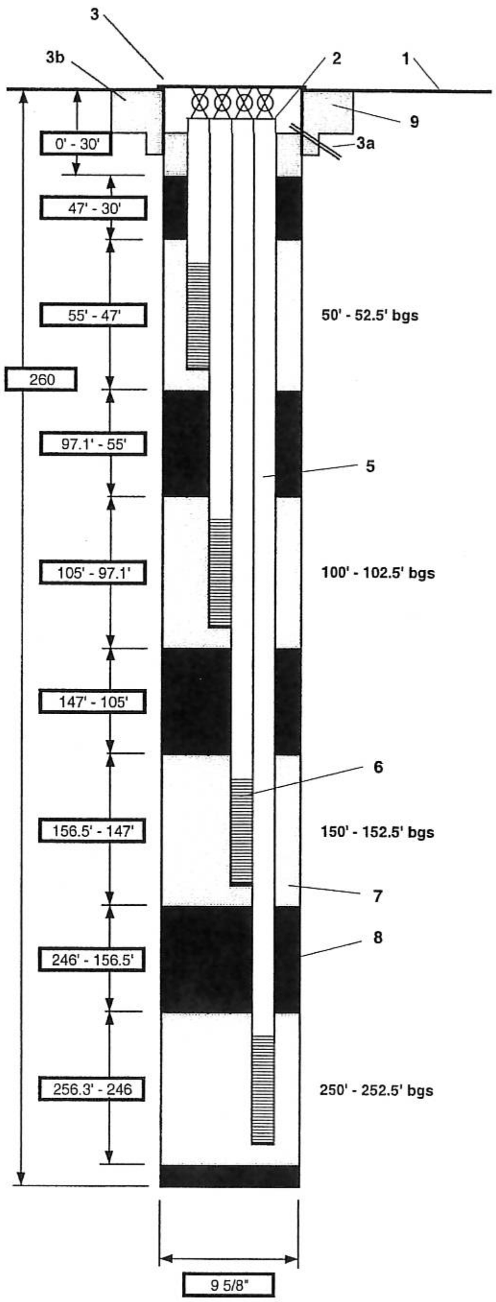
Illustration not to scale.

CH2MHILL

PROJECT NUMBER	WELL NUMBER	
168206.02.TT.WI	SVMW-10	SHEET 1 OF 1

SOIL VAPOR WELL COMPLETION DIAGRAM

PROJECT : KAFB Bulk Fuels Facility (ST-106) LOCATION : Bulk Fuels Facility - KAFB
ELEVATION: 5340.84' DRILLING CONTRACTOR : Water Development Corporation / Mark Green
DRILLING METHOD AND EQUIPMENT USED: SpeedStar 30K Stratex ARCH w/18" split spoon
WATER LEVELS : NA START : 02/20/2003 END : 02/21/2003 LOGGER : D.Boss-Walker



1- Ground elevation at well: approximately 5339'

2- Top of casing elevation: NA

3- Wellhead protection cover type: 12" flush mount, locking caps
a) drain tube?: None
b) concrete pad dimensions: 4' square flush mount

4- Dia./type surface casing: None

5- Dia./type of well casing: 1/2" Nom. OD Schedule 80 PVC w/ball valve

6- Type/slot/size of screen: 1/2" Nom. OD Schedule 80 PVC 0.050 slot, 2 1/2' long

7- Type screen filter: 8 - 12 Oglebay Colorado Silica
quantity used: 50 x 50 lb sacks

8- Type of seal: Hydrated Enviroplug 3/8" (medium)
quantity used: Bentonite chips - 119 x 50 lb sacks

9- Grout
a) Grout mix used: Potland Cement
b) Method of placement: Pump
c) Vol.of surface casing grout:
d) Vol. of well casing grout:

Development method: NA

Development time: NA

Estimated purge volume: NA

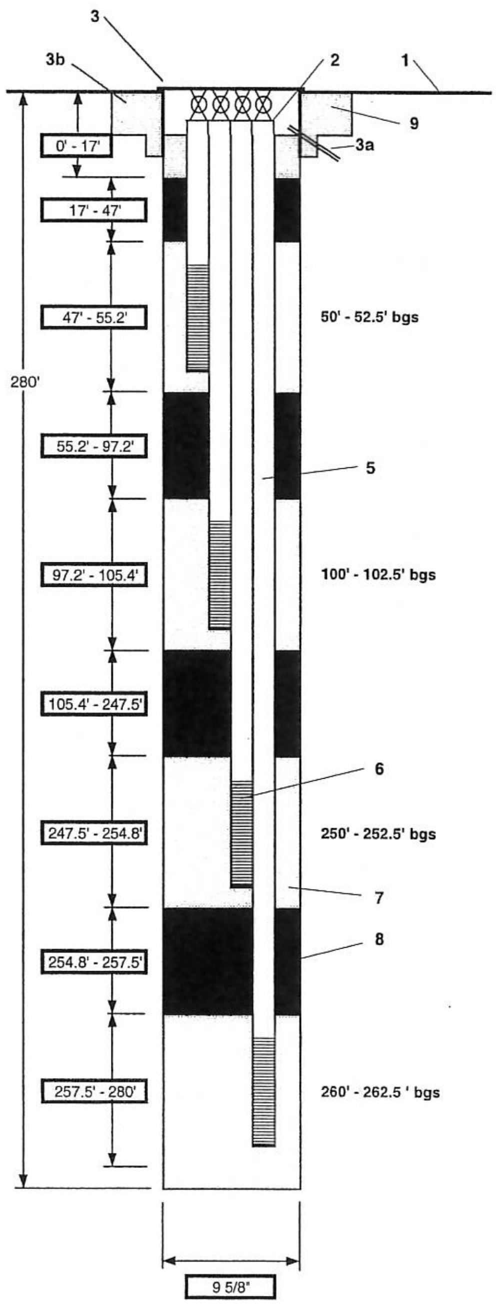
Comments
Each of the four 1/2" wells is labelled with a small metal plate attached with a hoseclamp by a small metal chain

Illustration not to scale.

PROJECT NUMBER	WELL NUMBER
168206.02.TT.WI	SVMW-11 SHEET 1 OF 1

SOIL VAPOR WELL COMPLETION DIAGRAM

PROJECT : KAFB Bulk Fuels Facility (ST-106) LOCATION : Bulk Fuels Facility - KAFB
ELEVATION: 5340.64' DRILLING CONTRACTOR : Water Development Corporation / Mark Green
DRILLING METHOD AND EQUIPMENT USED: SpeedStar 30K Stratex ARCH w/18" split spoon
WATER LEVELS : NA START : 02/23/2003 END : 02/24/2003 LOGGER : D.Boss-Walker



1- Ground elevation at well: approximately 5339'

2- Top of casing elevation: NA

3- Wellhead protection cover type: 12" flush mount, locking caps
a) drain tube?: None
b) concrete pad dimensions: 4' square flush mount

4- Dia./type surface casing: None

5- Dia./type of well casing: 1/2" Nom. OD Schedule 80 PVC w/ball valve

6- Type/slot/size of screen: 1/2" Nom. OD Schedule 80 PVC 0.050 slot, 2 1/2' long

7- Type screen filter: 8 - 12 Oglebay Colorado Silica
quantity used: 52 x 50 lb sacks

8- Type of seal: Hydrated Enviroplug 3/8" (medium)
quantity used: Bentonite chips - 163 x 50 lb sacks

9- Grout
a) Grout mix used: Potland Cement
b) Method of placement: Pump
c) Vol.of surface casing grout:
d) Vol. of well casing grout:

Development method: NA

Development time: NA

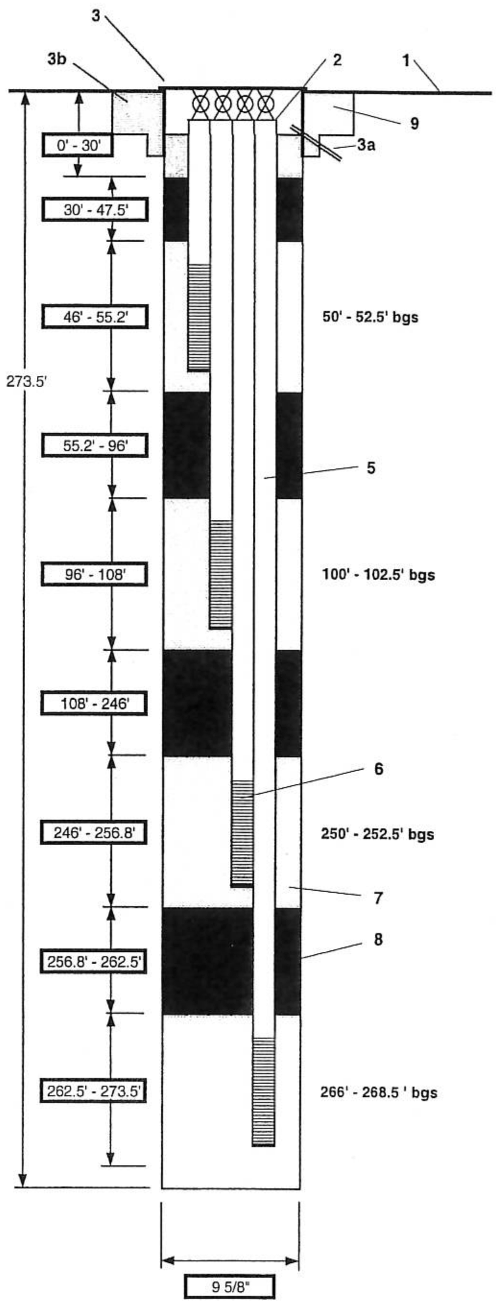
Estimated purge volume: NA

Comments
Each of the four 1/2" wells is labelled with a small metal plate attached with a hoseclamp by a small metal chain

Illustration not to scale.

CH2MHILL	PROJECT NUMBER 168206.02.TT.WI	WELL NUMBER SVMW-09 SHEET 1 OF 1
	SOIL VAPOR WELL COMPLETION DIAGRAM	

PROJECT : KAFB Bulk Fuels Facility (ST-106) LOCATION : Bulk Fuels Facility - KAFB
ELEVATION: 5340.75' DRILLING CONTRACTOR : Water Development Corporation / Mark Green
DRILLING METHOD AND EQUIPMENT USED: SpeedStar 30K Stratex ARCH w/18" split spoon
WATER LEVELS : NA START : 02/06/2003 END : 02/08/2003 LOGGER : D.Boss-Walker



1- Ground elevation at well: approximately 5339'

2- Top of casing elevation: NA

3- Wellhead protection cover type: 12" flush mount, locking caps
   a) drain tube?: None
   b) concrete pad dimensions: 4' square flush mount

4- Dia./type surface casing: None

5- Dia./type of well casing: 1/2" Nom. OD Schedule 80 PVC w/ball valve

6- Type/slot/size of screen: 1/2" Nom. OD Schedule 80 PVC 0.050 slot, 2 1/2' long

7- Type screen filter: 8 - 12 Oglebay Colorado Silica
   quantity used: 56 x 50 lb sacks

8- Type of seal: Hydrated Enviroplug 3/8" (medium)
   quantity used: Bentonite chips - 201 x 50 lb sacks

9- Grout
   a) Grout mix used: Potland Cement
   b) Method of placement: Pump
   c) Vol.of surface casing grout:
   d) Vol. of well casing grout:

Development method: NA

Development time: NA

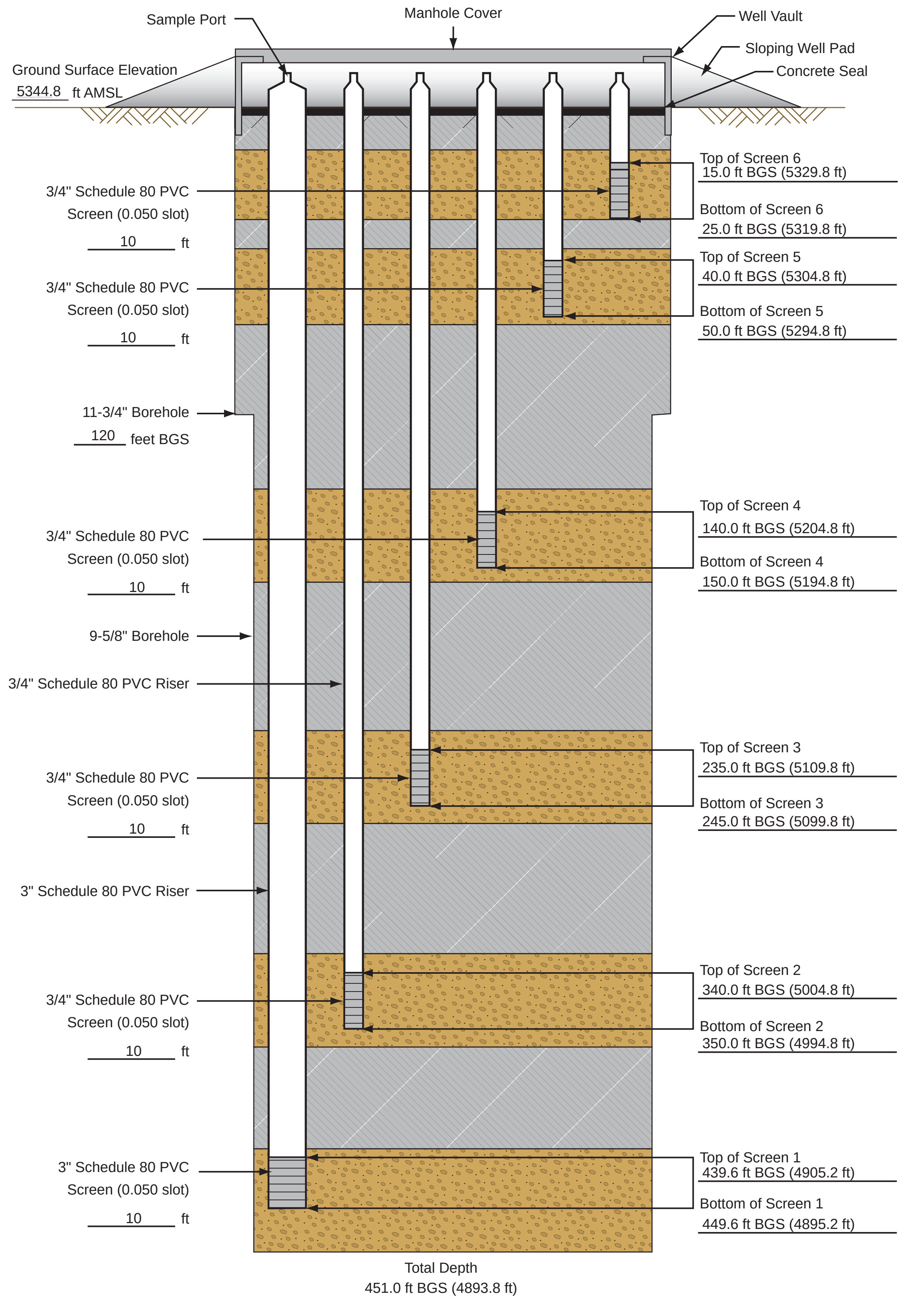
Estimated purge volume: NA

Comments
Each of the four 1/2" wells is labelled with a small metal plate attached with a hoseclamp by a small metal chain

Illustration not to scale.

Nested Soil Vapor Well Completion Diagram for KAFB-106114

Installation Start Date/Time: 2/23/2011 @ 16:10
Installation End Date/Time: 3/1/2011 @ 17:00

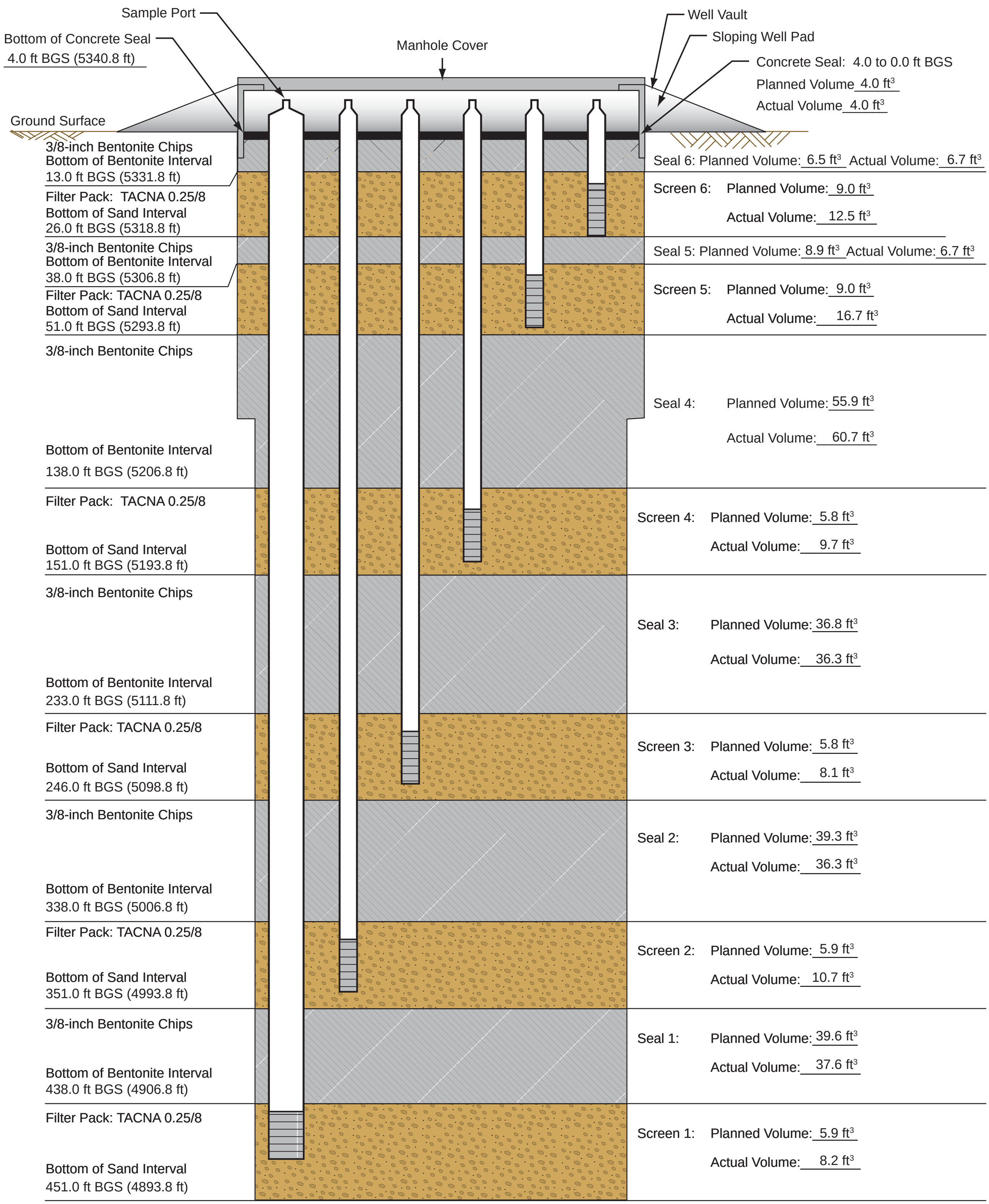


(elevation) is Above Mean Sea Level
AMSL = Above Mean Sea Level

Not to Scale
BGS = Below Ground Surface

140705_CA010020_SV_KAFB.106114 (a)

Nested Soil Vapor Well Completion Diagram for KAFB-106114



(elevation) is Above Mean Sea Level
All Materials Placed with Tremie Pipe

Not to Scale
BGS = Below Ground Surface

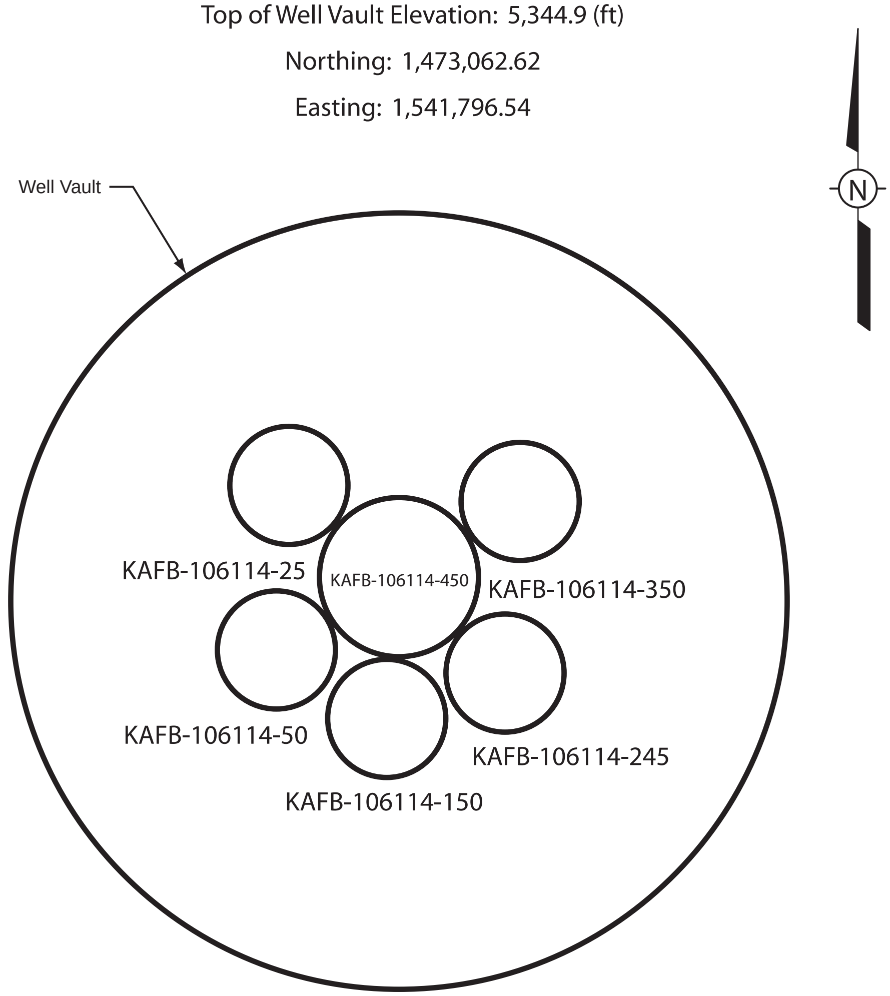
140705_CA010020_SV_KAFB.106114 (b)

Nested Soil Vapor Well Completion Diagram
Map View for KAFB-106114

Top of Well Vault Elevation: 5,344.9 (ft)

Northing: 1,473,062.62

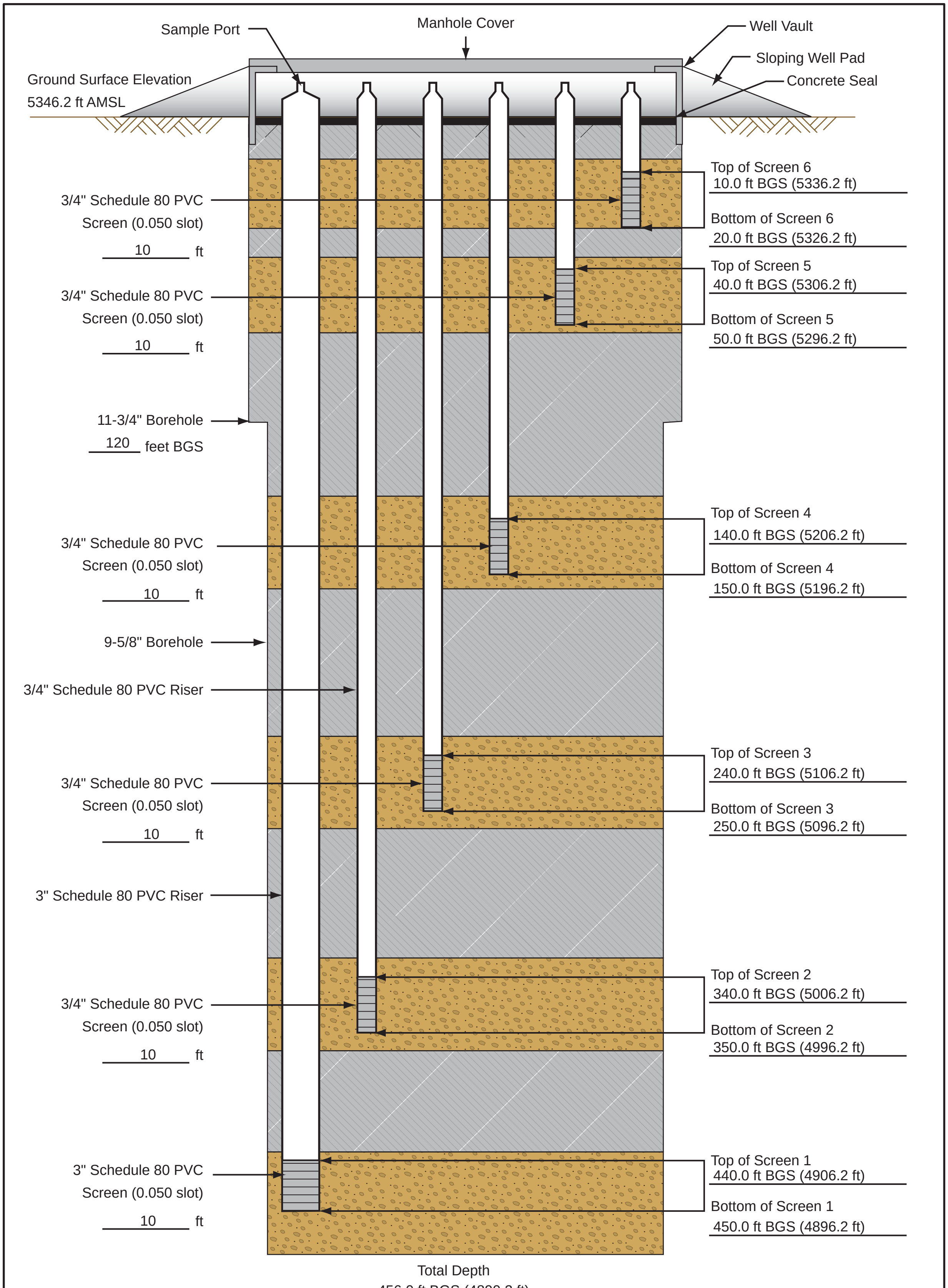
Easting: 1,541,796.54



Well Number	Well Diameter (in)	Well Depth (ft BGS)	Screened Interval (ft BGS)	Northing	Easting	Elevation (ft AMSL)
KAFB-106114-25	3/4	25.0	15.0 - 25.0	1,473,062.35	1,541,796.49	5344.6
KAFB-106114-50	3/4	50.0	40.0 - 50.0	1,473,062.13	1,541,796.24	5344.6
KAFB-106114-150	3/4	150.0	140.0 - 150.0	1,473,061.84	1,541,796.37	5344.6
KAFB-106114-245	3/4	245.0	235.0 - 245.0	1,473,061.86	1,541,796.68	5344.6
KAFB-106114-350	3/4	350.0	340.0 - 350.0	1,473,062.17	1,541,796.71	5344.6
KAFB-106114-450	3	449.6	439.6 - 449.6	1,473,062.21	1,541,796.50	5344.6

Nested Soil Vapor Well Completion Diagram for KAFB-106116

Installation Start Date/Time: 3/7/2011 @ 08:15
Installation End Date/Time: 3/10/2011 @ 12:32

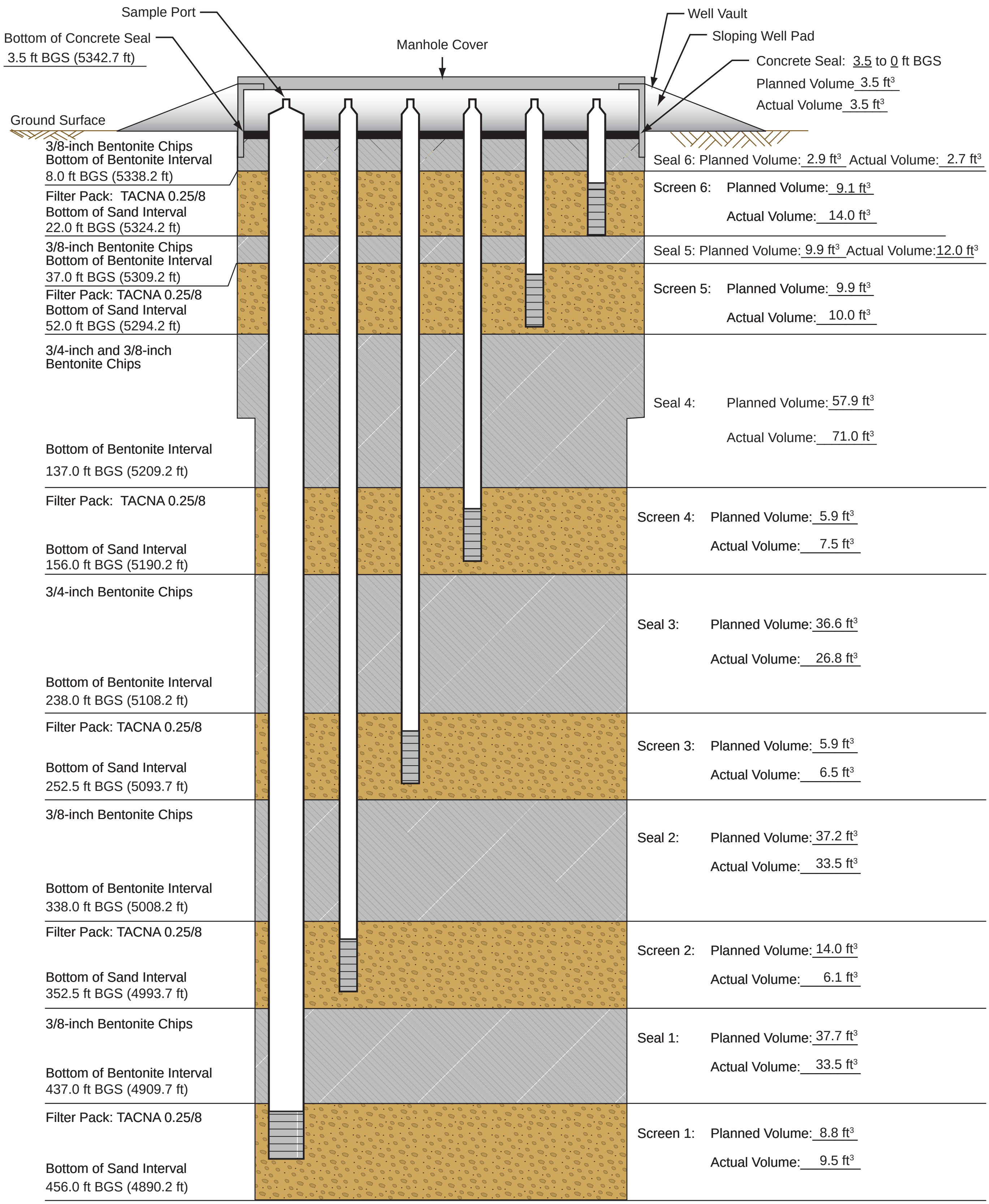


(elevation) is Above Mean Sea Level
AMSL = Above Mean Sea Level

Not to Scale
BGS = Below Ground Surface

140705_CA010020_SV_KAFB.106116 (a)

Nested Soil Vapor Well Completion Diagram for KAFB-106116



(elevation) is Above Mean Sea Level
All Materials Placed with Tremie Pipe

Not to Scale
BGS = Below Ground Surface

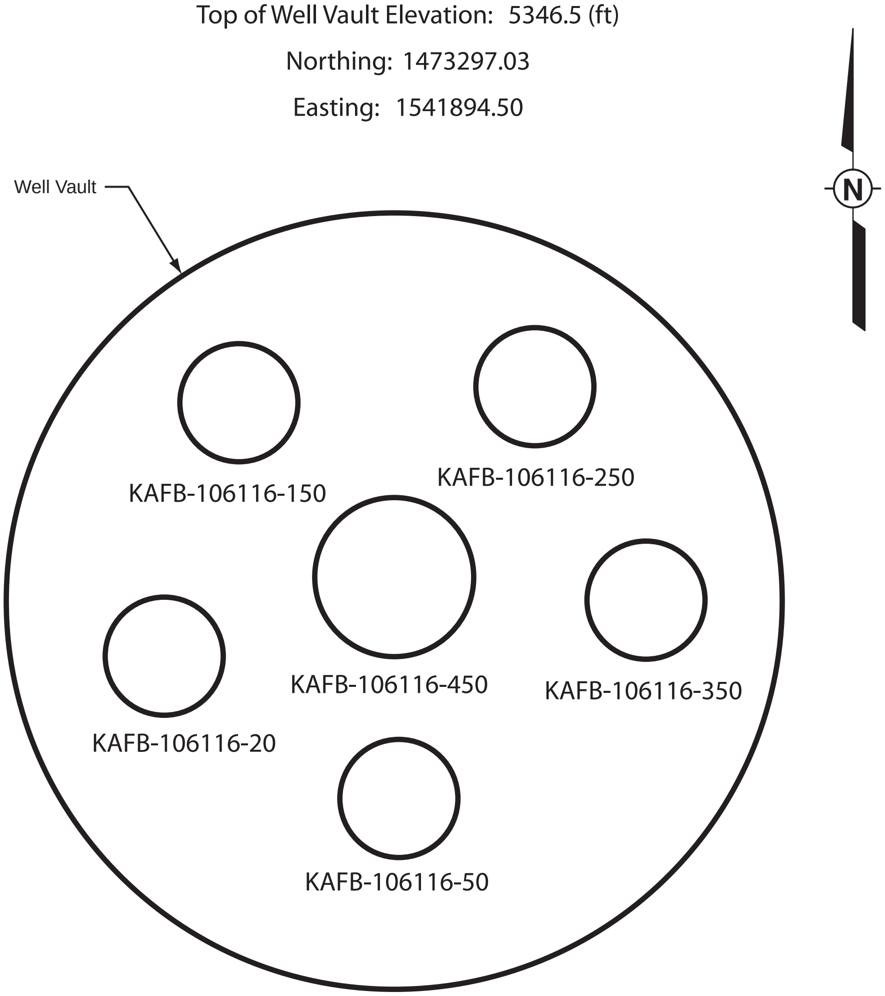
140705_CA010020_SV_KAFB.106116 (b)

Nested Soil Vapor Well Completion Diagram
Map View for KAFB-106116

Top of Well Vault Elevation: 5346.5 (ft)

Northing: 1473297.03

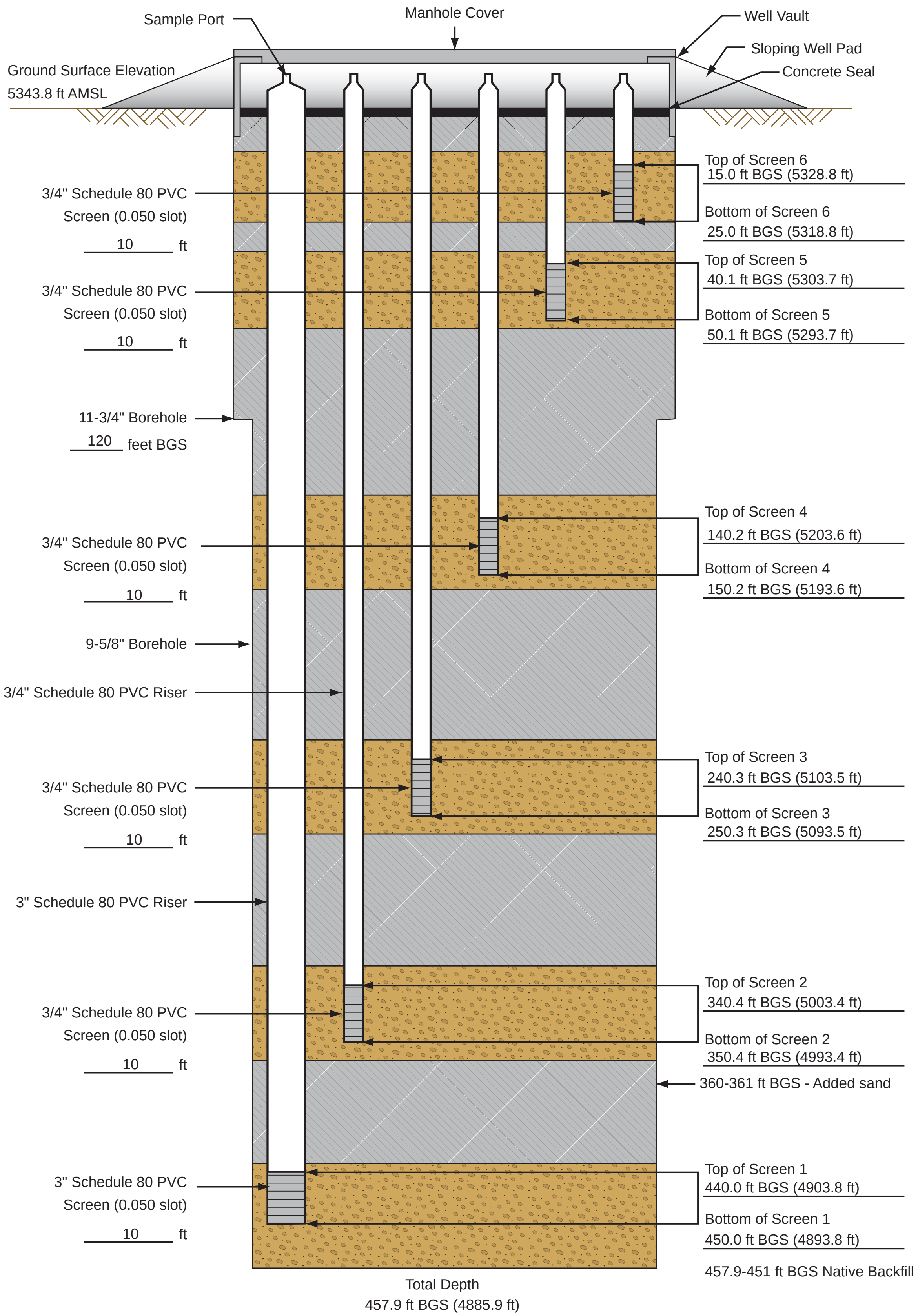
Easting: 1541894.50



Well Number	Well Diameter (in)	Well Depth (ft BGS)	Screened Interval (ft BGS)	Northing	Easting	Elevation (ft AMSL)
KAFB-106116-20	3/4	20.0	10.0 - 20.0	1473296.42	1541894.58	5346.0
KAFB-106116-50	3/4	50.0	40.0 - 50.0	1473296.44	1541894.90	5346.0
KAFB-106116-150	3/4	150.0	140.0 - 150.0	1473296.67	1541894.47	5346.0
KAFB-106116-250	3/4	250.0	240.0 - 250.0	1473296.88	1541894.69	5346.0
KAFB-106116-350	3/4	350.0	340.0 - 350.0	1473296.72	1541894.97	5346.0
KAFB-106116-450	3	450.0	440.0 - 450.0	1473296.72	1541894.69	5346.0

Nested Soil Vapor Well Completion Diagram for KAFB-106128

Installation Start Date/Time: 3/7/2011 @ 11:40
Installation End Date/Time: 3/8/2011 @ 17:45

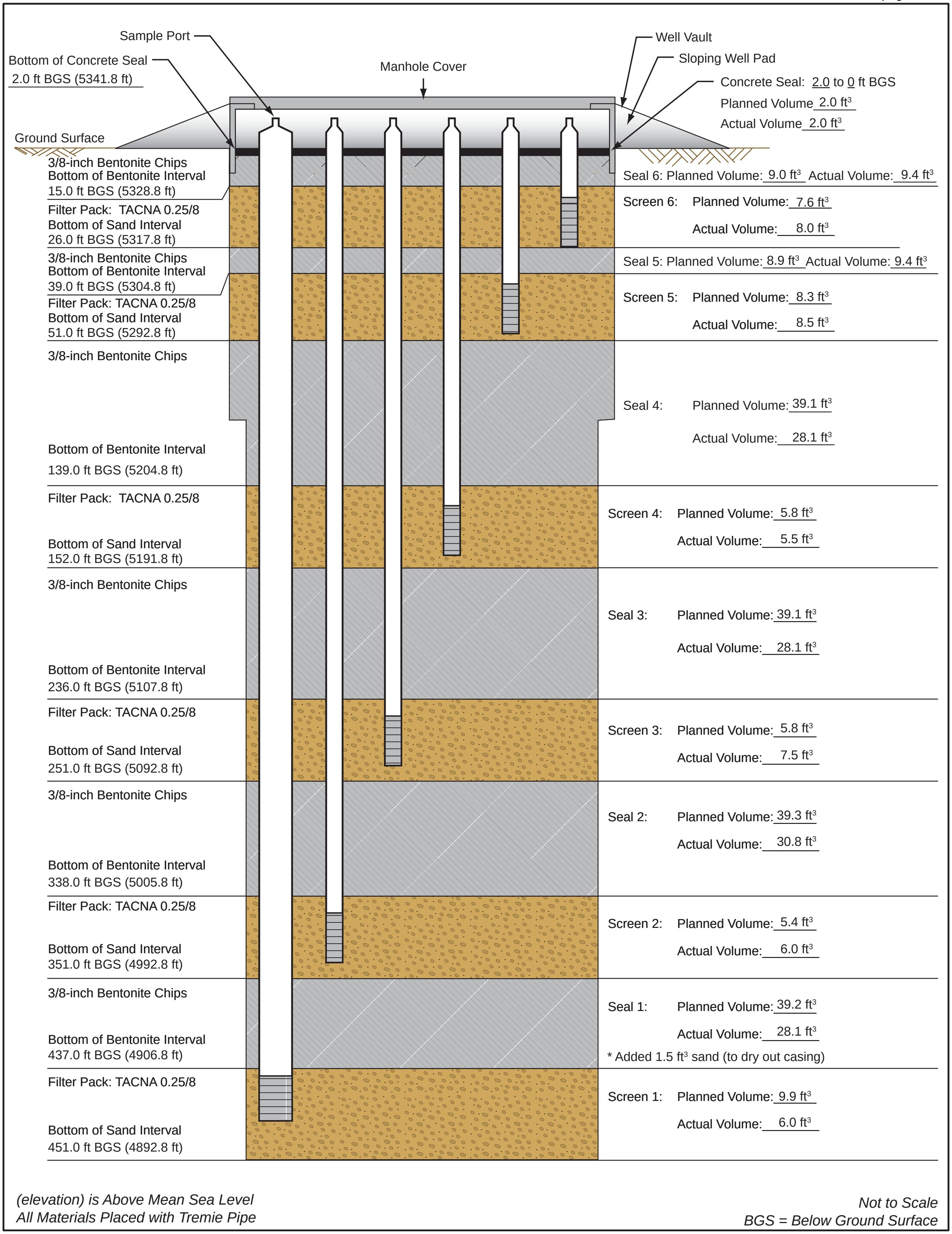


(elevation) is Above Mean Sea Level
AMSL = Above Mean Sea Level

Not to Scale
BGS = Below Ground Surface

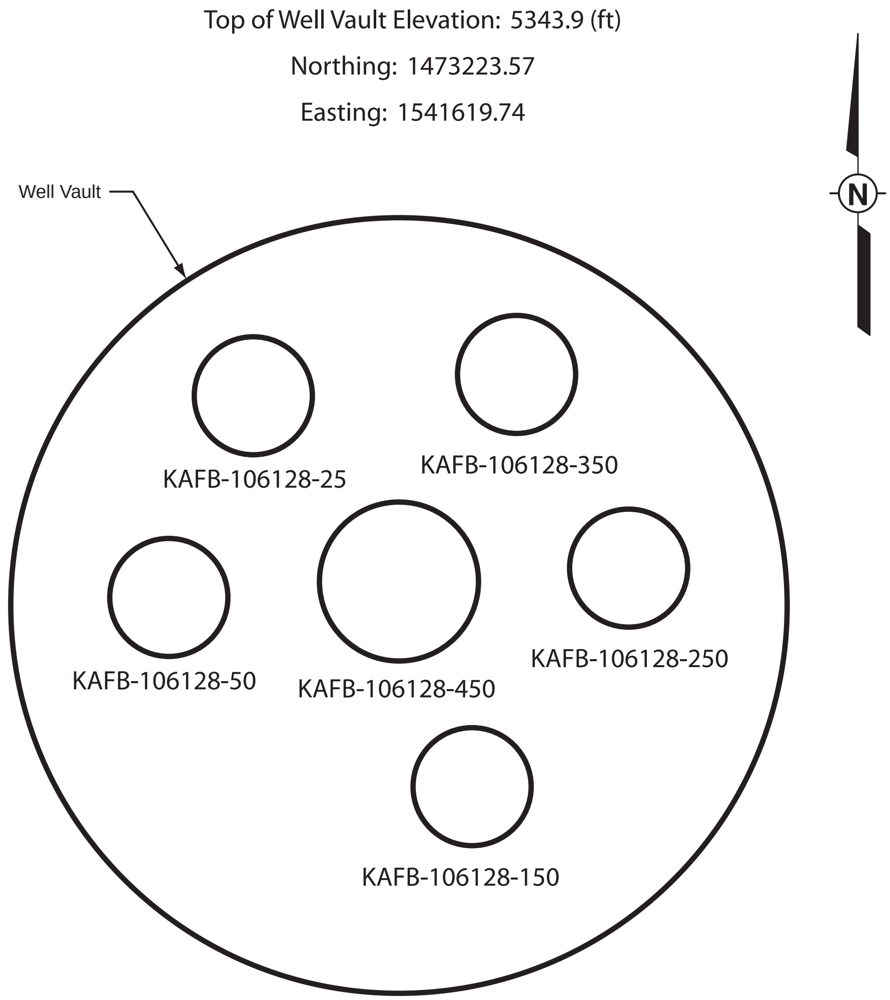
140705_CA010020_SV_KAFB.106128 (a)

Nested Soil Vapor Well Completion Diagram for KAFB-106128



140705_CA010020_SV_KAFB.106128 (b)

Nested Soil Vapor Well Completion Diagram
Map View for KAFB-106128



Well Number	Well Diameter (in)	Well Depth (ft BGS)	Screened Interval (ft BGS)	Northing	Easting	Elevation (ft AMSL)
KAFB-106128-25	3/4	25.0	15.0 - 25.0	1473223.25	1541619.61	5343.6
KAFB-106128-50	3/4	50.1	40.1 - 50.1	1473222.98	1541619.50	5343.6
KAFB-106128-150	3/4	150.2	140.2 - 150.2	1473222.78	1541619.72	5343.6
KAFB-106128-250	3/4	250.3	240.3 - 250.3	1473222.92	1541619.98	5343.6
KAFB-106128-350	3/4	350.4	340.4 - 350.4	1473223.25	1541619.92	5343.6
KAFB-106128-450	3	450.0	440.0 - 450.0	1473223.15	1541619.72	5343.6

APPENDIX B

Manufacturer's Specification Cut Sheets – Field Instruments and Equipment

Series 477A Handheld Digital Manometer

Specifications - Installation and Operation Instructions

Series 477A Digital Manometers are versatile, hand-held, battery operated manometers available in several basic ranges from 0-20 in. w.c. up to 100 psi. All models measure either positive, negative or differential pressures with ±0.10% of full scale accuracy. You can select from up to seven common English and metric pressure units so conversions are not necessary. A memory function allows storage of up to 40 readings for later recall and a backlight provides auxiliary lighting for hard-to-see locations. Also standard are a hold feature plus both visual and audible overpressure alarms.

SPECIFICATIONS

Service: Air and compatible gases.
Wetted Parts: Consult factory.
Accuracy: ±0.10% of full scale from 60 to 78°F (15.6 to 25.6°C); ±1% of full scale from 32 to 60 and 78 to 104°F (0 to 15 .6 and 25.6 to 40°C).
Pressure Hysteresis: ±0.1% of full scale.
Pressure Limits: See chart.
Temperature Limits: 32 to 104°F (0 to 40°C).
Storage Temperature Limits: -4 to 176°F (-20 to 80°C).
Display: 4-digit LCD (.425″ H x .234″ W digits).
Resolution: See chart.
Power Requirements: 9 volt alkaline battery. Battery included but not connected.
Weight: 10.2 oz. (289 g).
Connections: Two barbed connections for use with 1/8″ (3.18 mm) or 3/16″ (4.76 mm) I.D. tubing for 477A-1, 477A-2, 477A-3, 477A-4 and 477A-5 only. Two compression fittings for use with 1/8″ (3.18 mm) I.D. x 1/4″ (6.35 mm) O.D. tubing for 477A-6 and 477A-7 only.

Model Number	English Range	Metric Range
477A-1	0-20.00 in. w.c.	0-4.982 kPa
477A-2	0-40.00 in. w.c.	0-9.96 kPa
477A-3	0-200.0 in. w.c.	0-49.82 kPa
477A-4	0-10.00 psi	0-68.95 kPa
477A-5	0-30.00 psi	0-206.9 kPa
477A-6	0-50.00 psi	0-344.8 kPa
477A-7	0-100.0 psi	0-689.5 kPa

Maximum Pressure	
477A-1	3 psi (0.21 bar)
477A-2	3 psi (0.21 bar)
477A-3	15 psi (1.03 bar)
477A-4	30 psi (2.07 bar)
477A-5	60 psi (4.13 bar)
477A-6	100 psi (6.89 bar)
477A-7	200 psi (13.78 bar)

Available Pressure Units:

477A-1 & 477A-2: psi, in. w.c., mm w.c., in. Hg, mm Hg, Pa, kPa, bar, mbar

477A-3 & 477A-4: psi, in. w.c., mm w.c., in. Hg, mm Hg, kPa, bar, mbar

477A-5, 477A-6 & 477A-7: psi, in. w.c., in. Hg, mm Hg, kPa, bar, mbar

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Phone: 219/879-8000 **www.dwyer-inst.com**
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INSTRUCTIONS

Battery Installation

The unit is shipped with a separate 9 volt alkaline battery which must be installed before operation. Remove the two screws holding the bottom endcap in place and remove the endcap. Connect the battery to the enclosed battery clip observing correct polarity. Be careful not to trap wires between the battery, case or foam pads which retain the battery. This could make it difficult to install the battery or remove it later for replacement. Be sure the rubber gasket is properly seated in the gasket channel of the endcap and replace endcap. Note that the endcap will only fit one way because the holes are slightly off-center. Place the “Z” shaped wrist strap clip in one of the screw recesses and replace the screws. Do not overtighten the screws. Attach wrist strap to clip.

When battery replacement becomes necessary, use only a 9 volt alkaline type such as a Duracell® MN1604, Eveready® 522 or equivalent. Zinc-carbon types, often labeled Heavy-duty are not recommended because of the increased potential for leakage. Alkaline batteries are also a better value because they last up to three times longer in this device.

On-Off Operation

The on-off control is a toggle function. Press and release the ON/OFF key once to turn unit on; again to turn it off. If the manometer is left on with no activity for approximately 20 minutes, unit will turn itself off to conserve the battery.

Display Backlight

The Model 477A includes a display backlight to allow use in the dark or in poor lighting conditions. Manometer must be switched off before this feature can be activated. Next, press and hold the ON/OFF key down. After about 1 second the backlight will come on and remain lighted for approximately 2 minutes after which it will turn itself off to conserve battery life.

Zeroing Pressure Reading

Potential inaccuracy due to temperature effects can be minimized by re-zeroing immediately before use. To zero the display, vent both ports to atmosphere so no pressure is applied to either port. Press the ZERO/STORE key and - - - - will be momentarily displayed as zeroing occurs. Zeroing is not possible when the memory mode is in use. It must be done before selecting that function.

If the unit is accidently zeroed with pressure applied to one of the ports, the pressure reading might display incorrectly. To correct, vent the pressure ports to atmosphere and press the ZERO/STORE key to zero the unit.

Pressure Connections

To measure single positive pressure, connect tubing to port marked + and vent opposite port to atmosphere. To measure differential positive pressure, connect higher positive pressure to port marked + and lower positive pressure to port marked -. Manometer will indicate the difference between the two.

Selecting Pressure Units

Up to seven pressure units are available. The display will indicate the current selection. To change to different units, use the UNITS/LOC key. Each touch will cause an advance to the next choice. The selected units will remain in memory even when power is shut off. This way, your preference will always be displayed after the initial selection.

Display Hold

There may be situations where you want to temporarily retain a reading. The Model 477A includes a Display Hold feature which freezes the current reading and holds it in the display until cleared. To activate this operation, momentarily press the HOLD/MEMORY key when the pressure you want to save is displayed. A HOLD indicator will appear in the display to indicate that the reading shown is frozen. To return to normal operation, press the HOLD/MEMORY key again.The HOLD indicator will disappear and the current pressure will again be shown.

Memory Function

A memory function is included in the Model 477A that allows you to store up to 40 pressure readings for later review or recording. This feature is especially valuable for making a traverse of duct velocity pressures with a Pitot tube or for multipoint pressure measurements. The readings are stored in non-volatile memory so they will be retained even if the unit is shut off or the battery is removed.

Storing Pressure Readings

To store a reading, press and hold the HOLD/MEMORY until ST01 is displayed then release the key. Next, press ZERO/STORE key to save current reading to ST01 memory location. A beep will sound indicating that the reading has been saved. As each reading is saved, the memory location display will advance to the next number. To resume pressure measurement, press the HOLD/MEMORY key again. Note that in the memory mode, the display zero function is not available. To zero the display, you must first exit the memory mode and then press the ZERO/STORE key.

Viewing Stored Readings - Selecting a Location

To view the contents of memory, press and hold the HOLD/MEMORY until RD01 is displayed then release the key. Next, press UNITS/LOC to view other memory location. To resume pressure measurement, press the HOLD/MEMORY key again.

Clearing Memory

To clear the contents of memory, press and hold the HOLD/MEMORY until CLR is displayed then release the key. Next, press ZERO/STORE key to clear all previously stored readings. During this operation - - - - will be displayed. Once memory is cleared, the current pressure will be displayed.

Exiting Memory Mode

To exit the memory mode press the HOLD/MEMORY key again and the unit will return to normal operation.

Dampening Function

The dampening feature allows the user to enter a dampening number from 1 to 16 (default value = 2). Entering a larger number increases the amount of readings that are averaged for each display update.

In order to access the dampening feature, follow the instructions below:

1. Press and hold the HOLD/MEMORY button. The upper right portion of the LCD scrolls through a menu selection (HOLD, ST01, RD01, CLR, and DAMP). When “DAMP” is shown, release the HOLD/MEMORY button. This selects the dampening feature.

2. Once “DAMP” is selected, a number is shown in the upper right portion of the LCD, along with the current pressure reading. This number is the dampening number. Adjust the number up by pressing the ZERO/STORE button or down by pressing the UNITS/LOC button. The LCD update rate slows as the number increases from 1 to 16. Therefore, for best results, choose the smallest number that provides a stable pressure reading.

Once the pressure reading is stable, press and release the HOLD/MEMORY button to store the dampening value.

Overpressure Alarm

A visual indicator and audible alarm are provided to alert the operator that pressure has exceeded the operating range of the unit. Exceeding the range will not damage it or affect calibration as long as the maximum rated pressure is not exceeded. ***Do not exceed the maximum rated pressure of the manometer. Doing so will cause permanent damage to the sensor, may rupture the housing and/or cause injury.*** The maximum pressure is shown on the rear label and on page 1 of these instructions.

Low Battery Indicator

A weak battery can cause improper operation or inaccurate measurements. A low battery indicator is provided on the display to show when the battery needs replacement. Although the unit might appear to function and indicate properly, the accuracy of readings cannot be guaranteed when the LOW BAT indicator is illuminated. Replace the battery with a fresh one. Do not leave an exhausted battery in the unit due to potential leakage.

MAINTENANCE

The Series 477A handheld digital manometers are not field repairable and should be returned if repair is needed (field repair should not be attempted and may void warranty). Be sure to include a brief description of the problem plus any relevant application notes. Contact customer service to receive a return goods authorization number before shipping.

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In-Situ®

Aqua TROLL® 600 Multiparameter Sonde

Reduce operational expenses with this customizable, powerful, and easy-to-use multiparameter sonde. The Aqua TROLL 600 combines unique industry-leading water quality technology, built-in LCD display, and revolutionary smartphone mobility. Low power consumption and advanced antifouling for up to 9+ month deployment supports long-term installation in any application.

The Aqua TROLL 600 water quality platform is rugged in groundwater and corrosion-resistant in surface water, delivering accurate, reliable data in an easy-to-use, flexible instrument that performs for years. Base sensor configuration includes EPA-approved optical dissolved oxygen, pH/ORP, turbidity, conductivity, temperature, and pressure. Integrate with In-Situ telemetry systems and HydroVu™ Data Services for real-time feedback on your remote monitoring sites.

Be Mobile

- **Use the Aqua TROLL 600 anywhere:** Titanium components and vented or non-vented options make it perfect for challenging environments and long-term deployments in fresh and salt water. Every detail has been engineered to be easy, reliable, and cost-effective.
- **Save time in the field:** Intuitive software simplifies instrument configuration, data analysis, and reporting. No training required, and no waiting for sensor warm-up or set-up.
- **Streamline data management**: Set up logs and manage data from the field using the VuSitu™ Mobile App. Consolidate all site information on your mobile device and tag sites with photos and GPS coordinates. Log data to your smartphone and download results in a standard file format for profiling, low-flow sampling, and more.

Be Smart

- **Status in an instant**: LCD display gives you an instant visual indication of sensor status, data log, battery life, and overall functionality to give confidence during deployment. The onboard SD card allows for quick and easy data backup and transfer.
- **No fuss antifouling**: Antifouling to protect all sensors. The only multiparameter sonde to have a sub-2 inch active antifouling system with cleanable conductivity.
- **Get accurate results**: Self-compensating tubidity/RDO/level, smart diagnostics, and stable sensor technology provide minimal drift and increased accuracy with NIST-traceable factory calibration report. Smart sensors store information internally, maintaining data and calibration within the sensor for traceable results.

Be In-Situ

- Receive 24/7 technical support and online resources.
- Order products and accessories from the In-Situ website.
- Get guaranteed 7-day service for maintenance (U.S.A. only).

Applications

- **Lake, stream and wetland monitoring**
- **Stormwater management**
- **Coastal deployments**
- **Dam monitoring**
- **Low-flow groundwater sampling**
- **Remediation and mine water monitoring**

Aqua TROLL® 600 Multiparameter Sonde

Spec Sheet

In-Situ

General

Operating Temperature (non-freezing)	-5 to 50° C (23 to 122° F) ISE: Ammonium & Nitrate 0 to 40° C ; Chloride 0 to 50° C	***Reading Rates***	1 reading every 2 seconds
Storage Temperature	Components w/o fluid: -40° C to 65° C (non-freezing water); pH/ORP: -5° C to 65° C; Ammonium/Nitrate: 0 to 40 ° C; Chloride: 0 to 50° C	***Data Logging***	50 logs (defined, scheduled to run, or stored)
Dimensions	4.7 cm (1.85 in.) OD x 60.2 cm (23.7 in.) (includes connector) With bail: 72.9 cm (28.7 in.)	***Logging Modes***	Linear, Linear Average, Event
Weight	1.45 kg / 3.2 lbs (includes all sensors, batteries, and bail)	***Logging Rate***	1 minute to 99 hours
Wetted Materials	PC, PC alloy, Delrin™, Santoprene™, Inconel™, Viton™, Titanium, Platinum, Ceramic, Nylon	***Hex Screw Driver***	0.050, 1.3 mm
Environmental Rating	IP68 with all sensors and cable attached IP67 without the sensors, battery cover or cable attached	***Communication Device***	TROLL Com or Wireless TROLL Com
Max Pressure Rating	Up to 350 PSI	***Cable Options***	Vented or non-vented polyurethane or vented Tefzel®
Output Options	RS-485/MODBUS, SDI-12, Bluetooth®	***LCD Display***	Integrated display shows status of sonde, sensor ports, data log, battery and connectivity.
Internal Memory[1] ***Micro SD Card[2]***	16 MB; 8+ GB micro SD card included, user replaceable	***Software***	Android™: VuSitu through Google Play™, Windows®: Win-Situ 5, Data Services: HydroVu
Internal Power ***Battery Life[3]***	2 internal user-replaceable Alkaline D batteries >6 months typical with wiping >9 months typical with no wiping	***Interface***	Android 4.4, requires Bluetooth 2.0; Win-Situ 5 Software
External Power Voltage ***External Power Current[4]***	8-36 VDC (not required for normal operation) Sleep: 0.10 mA typical Measurement: 16 mA typical, 45 mA max	***Certifications***	CE, FCC, WEEE, RoHS Compliant

Standard Sensors	Accuracy	Range	Resolution/Precision	Response Time	Units of Measure	Method
Temperature[5]	± 0.1° C	-5 to 50° C (23 to 122° F)	0.01° C	T63<2s, T90<15s, T95<30s	Celsius or Fahrenheit	EPA 170.1
Barometric Pressure	± 1.0 mbars	300 to 1,100 mbar	0.1 mbar	T63<1s, T90<1s, T95<1s	Pressure: psi, kPa, bar, mbar, inHg, mmHg	Silicon strain gauge
pH[6]	±0.1 pH unit or better	0 to 14 pH units	0.01 pH	T63<3s, T90<15s, T95<30s	pH, mV	Std. Methods 4500-H+/ EPA 150.2
ORP[7]	±5 mV	±1,400 mV	0.1 mV	T63<3s, T90<15s, T95<30s	mV	Std. Methods 2580
Conductivity[8]	+/-0.5% of reading plus 1 µS/cm from 0 to 100,000 µS/cm; +/-1.0% of reading from 100,000 to 200,000 µS/cm	0 to 350,000 µS/cm	0.1 µS/cm	T63<1s, T90<3s, T95<5s	Actual conductivity (µS/cm, mS/cm); Specific conductivity (µS/cm, mS/cm); Salinity (PSU); Total dissolved solids (ppt, ppm); Resistivity (Ohms-cm); Density (g/cm3)	Std. Methods 2510/ EPA 120.1
TDS (derived from conductivity and temp)	-	0 to 350 ppt	0.1 ppt	-	ppt, ppm	-
Salinity (derived from conductivity and temp)	-	0 to 350 PSU	0.1 PSU	-	PSU, ppt	Std. Methods 2520A
Rugged Dissolved Oxygen (RDO) with RDO-X[9]	±0.1 mg/L ±0.2 mg/L ±10% of reading	0 to 8 mg/L 8 to 20 mg/L 20 to 50 mg/L	0.01 mg/L	T63<15s, T90<45s, T95<60s	mg/L, % saturation, ppm	EPA-approved In-Situ Methods: 1002-8-2009, 1003-8-2009, 1004-8-2009
Turbidity	±2% of reading or ±2 NTU, FNU, whichever is greater	0 to 4,000 NTU	0.01 NTU (0 to 1,000); 0.1 NTU (1,000 to 4,000)	T63<1s, T90<1s, T95<1s	NTU, FNU	ISO 7027
TSS (derived from turbidity)[10]	-	0 to 1,500 mg/L	0.1 mg/L	-	ppt, mg/L	-
Ammonium (NH_4^+ - N)[11,12] ***Rated to 25m depth***	±10% or ±2 mg/L w.i.g.	0 to 10,000 mg/L as N	0.01 mg/L	T63<1s, T90<10s, T95<30s	mg/L, ppm, mV	-
Unionized Ammonia, Total Ammonia (derived from Ammonium & pH sensor)		0 to 10,000 mg/L as N	0.01 mg/L	-	mg/L, ppm	-
Nitrate (NO_3^- - N)[11] ***Rated to 25m depth***	±10% or ±2 mg/L w.i.g.	0 to 40,000 mg/L as N	0.01 mg/L	T63<1s, T90<1s, T95<1s	mg/L, ppm, mV	Std. Methods 4500 NO_3 D
Chloride (Cl)[11]	±10% or ±2 mg/L w.i.g.	0 to 150,000 mg/L as Cl	0.01 mg/L	T63<1s, T90<10s, T95<30s	mg/L, ppm, mV	Std. Methods 4500 Cl^- D
Pressure[13] ***(Optional)***	±0.1% full scale (FS)	Non-Vented or Vented 9.0 m (30ft) (Burst: 27 m; 90 ft) 30 m (100 ft) (Burst: 40 m; 130 ft) 76 m (250 ft) (Burst: 107 m; 350 ft) 200 m (650 ft) (Burst: 229 m; 750 ft)	0.01% full scale	T63<1s, T90<1s, T95<1s	Pressure: psi, kPa, bar, mbar, inHg, mmHg Level: in, ft, mm, cm, m, cmH20, inH20	Piezoresistive; Ceramic

Warranty[14]	***2 year - Sonde, RDO and sensor cap, temperature/conductivity, temperature only, turbidity (excluding pH/ORP)*** ***1 year - pH/ORP, accessories*** ***90 days - ISE Sensors; Other: see warranty policy (www.in-situ.com/warranty)***
Notes ***Specifications are subject to change without notice.***	1) For 30 parameters >100,000 data records, > 3 years at 15 min. interval. A single data record includes timestamp, temperature, RDO, pH, ORP, turbidity and conductivity logged in Linear or Linear Average mode. 2) Log data recorded to SD card in comma delimited variable (CSV) file format. Greater than 32 GB not supported. 3) Logging all sensors at 15 min interval on 2 D Alkaline batteries. Battery life dependent on site conditions and wiping. 4) Dependent on display and wiping. 5) Sensor only, when transferring from air to ambient water temperature. Typical system response time with all sensors and restrictor: T63<30s, T90<3.5m, T95<7.5m. 6) Response time at thermal equilibrium. 7) Accuracy from calibration standard @ 25C, response-at thermal equilibrium immediately following calibration measuring from air to +400 mV. 8) Accuracy at calibration points. 9) RDO sensor full range 0-50mg/L, 0-500% sat. EPA-approved under the Alternate Test Procedure process. 10) User-defined reference. 11.) Between 2 calibration points immediately following proper conditioning and calibration. Varies on site conditions and environmental interferents. See sensor summary sheet for potential interferences. 12.) Average response; can be longer with increasing concentrations of ammonium. 13) Typical performance across full temperature and pressure calibrated range. 14) Extended warranty option for sonde only (1 to 3 year extension for up to 5 years total).

EPA-Approved RDO Method

RoHS compliant

CALL OR CLICK TO PURCHASE OR RENT

1-800-446-7488 (toll-free in U.S.A. and Canada)
1-970-498-1500 (U.S.A. and international)

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221 East Lincoln Avenue, Fort Collins, CO 80524 USA

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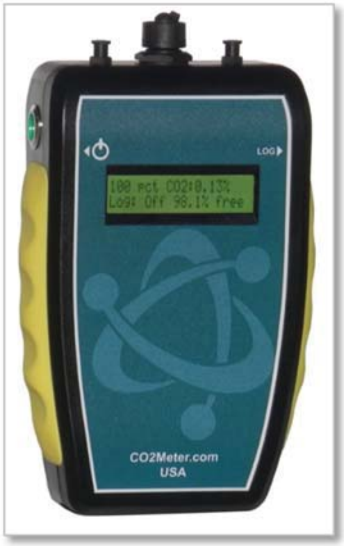
EMAIL: SALES@CO2METER.COM | WWW.CO2METER.COM

Datasheet: CO2 Data Loggers



This portable battery-powered CO2Meter, Inc. meter is designed to measure carbon dioxide (CO2) in real-time in inaccessible areas for applications like fermentation vats & barrels, biological incubators, and CO2 leak detection. Its internal memory allows the user to record CO2 concentration level data over time.

Features

- Portable meter with lightweight handheld easy-grip design
- Various measuring ranges to choose from
- Back-lit LCD display with programmable CO2 level-responsive 3-color alarm
- Built-in 1,000-hour micro pump
- Fully compatible with Windows 7, 8, XP or later[1]
- Includes impact-resistant case, power supply, tubing/filter kit, and USB cable
- Records up to 60,000 data points in internal memory

CO2 Sensor Ratings

	1% CO2	5% CO2	10% CO2	30% CO2	60% CO2	100% CO2
Measurement Range	0-10,000 ppm	0-50,000 ppm	0-100,000 ppm	0-30% of volume	0-60% of volume	0-100% of volume
Repeatability	± 20 ppm, ± 1 % of measured value	± 0.1% vol. ± 2 % of measured value				
Accuracy	± 30 ppm, ± 5 % of value	±70 ppm ± 5% of value		± 0.5% vol. ± 3 % of measured value		
Detection Method	Sampling (drawn through tubing or inlet)					
Response Time (T1/e)	< 20 seconds tube IN/OUT (0.2 l/min gas flow)					
Life Expectancy	> 15 years					
Pressure Dependence	± 1.6% reading deviation per k Pa (from atmospheric pressure, 100 k Pa) / 0.13% of reading per mm Hg					

General Performance

Operating Temperature Range........ 0 to +50 °C
Operating Humidity Range........ 0 to 95% RH (non-condensing)
Maintenance Interval........ No maintenance required

Models Available

- **CM-0001:** 1% CO2 Data Logger
- **CM-0056:** 5% CO2 Data Logger
- **CM-0010:** 10% CO2 Data Logger
- **CM-0002:** 30% CO2 Data Logger
- **CM-0050:** 60% CO2 Data Logger
- **CM-0003:** 100% CO2 Data Logger

Pump Characteristics

Max. Flow Rate........500 ml/min (STP)
Max. Pressure........50 kPa
Max. Vacuum........15 kPa
Life Expectancy........1,000 hours (depending on sampling interval)

Power

Input Voltage........6 VDC
Source........International wall power supply (included)
Battery Type........Four (4) AA Alkaline (not included)
Consumption........~0.5 Watt Avg. (pump running)

Communication

Cable Type........USB cable, Type A to Mini-B, 6-foot long
Software[1]........Compatible with our complimentary GasLab® software, as well as our legacy DAS software

Physical

Material........Black polycarbonate enclosure with yellow rubber side grips
Display........Back-lit liquid crystal display (LCD), dual character row (shows CO2 level, data logging, and % free memory)
Ports........Protected Mini-USB connector, inlet/outlet Lure-type fittings, Power & Log Latching switches, Power jack
Operating Environment........Non-corrosive. Indoors: laboratory, residential, commercial or industrial. Outdoors optional.
Dimensions (WxHxD)........4.82 x 7.10 x 2.05 inches (122 x 181 x 52 mm)

[1] For minimum system requirements, please visit our website at http://www.co2meter.com/pages/downloads.

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P001-1105/4000

ONE TO SIX GAS PORTABLE MONITOR

Gas Detection For Life | **EAGLE™ Model**

Features

- Simultaneous detection of up to 6 different gases
- Over 400 gas monitoring configurations
- Wide range of toxic gases
- PPM / LEL hydrocarbon detection
- Powerful long-life pump up to 125' range with filters
- Low flow pump shut off and alarm
- Methane elimination switch for environmental use
- Security "Adjustment Lockout Switch"
- Up to 30 hours of continuous operation
- Alkaline or Ni-Cad capability
- IR Sensors available for CO2, % LEL CH4 or HC, % volume CH4 or HC
- Transformer testing version available
- Datalogging option
- Autocalibration / single gas calibration
- Dual hydrophobic filters (most versions)
- Ergonomic RFI / EMI / chemical / weather resistant enclosure
- Intrinsically safe design, CSA (C / US) & UL classified (most versions)
- Complies with EPA Method 21

RKI is proud to offer the most versatile portable gas detector on the market. Equipped with features that are not available on most competitive units, the EAGLE is a powerful instrument that does more than just offer the standard confined space protection for LEL, O2, H2S and CO. Detection combinations never before offered in a portable gas monitor are now available featuring the industry's widest selection of high quality, long life and field proven sensors.

Unique EAGLE features include PPM or LEL hydrocarbon detection at the push of a button; infrared sensors for CO2, methane or hydrocarbons in LEL and % volume ranges; a methane elimination switch for environmental applications, a long list of super toxic gases and measurable ranges, and dual hydrophobic filters that increases its water resistant performance. The EAGLE has a strong internal pump with a low flow auto shut off and alarm, which can draw samples from up to 125 feet even with the dual hydrophobic filters in place. This allows for quick response and recovery from distant sampling locations. The EAGLE will continuously operate for over 30 hours on alkaline batteries or 18 hours on Ni-Cads. A variety of accessories are also available to help satisfy almost any application such as long sample hoses, special float probes for tank testing, datalogging, continuous operation adapters, remote alarms and strobes, and dilution fittings, just to name a few.

With its ergonomic design and large glove friendly buttons, the EAGLE offers easy access to controls such as autocalibration, alarm silence, demand zero, peak hold and a wide variety of other features. Each channel has two alarm levels plus TWA and STEL alarms for toxic channels. The two alarm levels are user adjustable and can be latching or self resetting. Rugged, reliable, easy to operate and maintain, the EAGLE is the solution for just about any portable gas monitoring situation.

EAGLE™ Model

Enclosure	Weatherproof, chemical resistant, RFI / EMI coated high impact polycarbonate-polyester blend. Can operate in rain or set into 2.0” of water without damage. Ergonomically balanced with rugged top mounted handle.
Dimensions	10.5” L x 5.9” W x 7” H
Weight	5 lbs (standard 4 gas with batteries)
Detection Principle	Catalytic combustion, electrochemical cell, galvanic cell, infrared.
Sensor Life	2 years under normal conditions.
Sampling Method	Powerful, long-life pump (over 6,000 hours) can draw samples over 125 feet. Flow rate approximately 2.0 SCFH.
Display	4 x 20 LCD readout. Viewed through window in case top. Displays readings & status of 4 channels simultaneously. Backlight, automatic for alarms and by demand with adjustable time.
Alarms	2 alarms per channel plus TWA and STEL alarms for toxics. The two alarms are fully adjustable for levels, latching or self reset and silenceable.
Alarm Method	Buzzer 85 dB at 30 cm, dual high intensity LED’s, and flashing display.
Controls	6 External glove friendly push buttons for operation, demand zero, and autocalibration. Buttons also access LEL / ppm, alarm silence, peak hold, TWA / STEL values battery status and many other features.
Continuous Operation	30 Hrs min. using alkaline batteries, or 18 hrs using Ni-Cad.
Power Source	4 Alkaline or Ni-Cad, size D batteries (Charger has alkaline recognition to prevent battery damage if charging is attempted with alkalines).
Operating Temp. & Humidity	-10°C to 40°C (14°F to 104°F), 0 to 95% RH, non-condensing.
Response Time	30 Seconds to 90% (most gases) using standard 5 ft hose.
Safety Rating	Intrinsically Safe, Class I, Division 1, Groups A, B, C, D. CSA (C / US) and UL classified (most versions).
Standard Accessories	Shoulder strap, alkaline batteries, hydrophobic probe and 5 foot hose, Internal hydrophobic filter (most versions) (certain toxic versions equipped with special probe, inlet fitting and 3’ teflon hose. For HF and O3 versions, 3’ PTFE hose used without probe).
Optional Accessories	• Datalogging of up to 4 gases (No datalogging possible on 5 or 6 gas versions or versions with more than 2 toxic sensors) • Remote alarms • Dilution fitting (50/50) • Ni-Cad batteries • Battery charger, 115 VAC, 220 VAC, or 12 VDC • Continuous operation adapter, 115 VAC or 12 VDC • Extra loud buzzer • Extension probes • Large internal hydrophobic filter
Warranty	Two year material and workmanship

Gas	Measuring Range	Accuracy * Which ever is greater
Gases & Detectable Ranges		
Standard Confined Space Gases		
Hydrocarbons (CH_4, std)	0 - 100% LEL	± 5% of reading or ± 2% LEL (*)
	0 - 50,000 ppm	± 50 ppm or ± 5% of reading (*)
Oxygen (O_2)	0 - 40% Vol.	± 0.5% O2
Carbon Monoxide (CO)	0 - 500 ppm	± 5% of reading or ± 5 ppm CO (*)
Hydrogen Sulfide (H_2S)	0 - 100 ppm	± 5% of reading or ± 2 ppm H2S (*)
Super Toxics and Other Gases		
Ammonia (NH_3)	0 - 75 ppm	± 10% of reading or ± 5% of full scale (*)
Arsine (AsH_3)	0 - 1 ppm 0 - 200 ppb	
Chlorine (Cl_2)	0 - 3 ppm	
Chlorine Dioxide (ClO_2)	0 - 1 ppm	
Fluorine (F_2)	0 - 5 ppm	
Hydrogen Fluoride (HF)	0 - 9 ppm	
Hydrogen Chloride (HCl)	0 - 15 ppm	
Hydrogen Cyanide (HCN)	0 - 30 ppm	
Hydrogen Selenide (H_2Se)	0 - 0.2 ppm	
Hydrogen Sulfide (H_2S)	0 - 1 ppm 0 - 30 ppm	
Nitrogen Dioxide (NO_2)	0 - 15 ppm	
Ozone (O_3)	0 - 1 ppm	
Nitric Oxide (NO)	0 - 100 ppm	
Phosphine (PH_3)	0 - 1 ppm	
Silane (SiH_4)	0 - 15 ppm	
Sulfur Dioxide (SO_2)	0 - 6 ppm	
IR Sensors		
Carbon Dioxide (CO_2) (IR Sensor)	0 - 5,000 ppm 0 - 10,000 ppm 0 - 5% Vol. 0 - 20% Vol. 0 - 60% Vol.	± 5% of reading or ± 2% of full scale (*)
Methane (CH_4) (IR Sensor)	0 - 100% LEL 0 - 100% Vol.	
Isobutane (iC_4H_{10}) (IR Sensor)	0 - 100% LEL 0 - 30% Vol.	

Specifications subject to change without notice.

RKI INSTRUMENTS

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Authorized Distributor:

ALTAIR® Pro Single-Gas Detector

The Safety Company™

The ALTAIR Pro Single-Gas Detector has a wide range of features, including simple intuitive operation, small rugged design, and dependable technology.

These innovative toxic gas and oxygen detectors are based upon the design of the popular ALTAIR Single-Gas Detector, but with added features and functionality.

- Tough rubberized housing
- One-button operation
- Accurately measures gas concentration or percent oxygen
- Displays information on a large, clear, backlit LCD.
- Superior dust and water protection (rated IP67 except O_2-R)
- Event-logging and data-logging
- Excellent impact resistance

The ALTAIR Pro Single-Gas Detector provides worry-free performance and stands up to the roughest handling in even the toughest industrial environments. Sensors and battery are easily replaced to keep the unit performing for years.

- Versions available for CO, H_2S, O_2, NH_3, Cl_2, ClO_2, NO_2, SO_2, HCN, and PH_3
- Great RFI performance
- Adjustable alarm set points are offered for LOW, HIGH, TWA, and STEL
- Alarms are indicated by flashing LEDs, audible alarm, and internal vibrating alarm
- Replaceable battery and sensor

The ALTAIR Pro Single-Gas Detector is designed and built with MSA's superior quality and is part of MSA's ALTAIR Detector family of products.

The ALTAIR Pro Single-Gas Detector's unique design combined with its highly competitive price makes it the clear choice when selecting a single-gas detection instrument. It is accurate, reliable, durable, easy to use, easy to maintain, and packed with features. The ALTAIR Pro Single-Gas Detector is designed and manufactured by MSA, the most trusted name in the safety products industry.

Ease-of-Use

The ALTAIR Pro Single-Gas Detector combines user flexibility and functional simplicity. True single-button operation provides users with a clear path to any function. With a single button, users can:

- turn the unit on.
- activate the backlight.
- activate the infrared link for communication with a computer.
- display information about the unit, such as software version and alarm settings.
- perform a fresh air setup (FAS).
- initiate a bump test.
- change calibration gas concentration.
- initiate calibration.
- reset peak reading display.
- manually change **LOW**, **HIGH**, **TWA**, **STEL** alarm set points (in protected **SETUP** (mode only).
- turn the unit off.

Another ease-of-use feature is the built-in gas delivery adapter; no accessories are needed to conduct gas response tests, eliminating hidden replacement costs.

Distinctive Alarm System

Triple alarm system leaves no doubt for users in alarm situations. Piercing audio alarm averages 95 dB @ 1 foot and is designed to be distinctive from other workplace sounds. Extended frequency range covers a wide sound spectrum. Visual alarm features dual LED displays located on the unit's top, visible from all angles. Internal vibrating alarm is also standard on all units, emitting a pulse that directly calls additional attention to users when in alarm mode.

Easily Replaceable, Commercially Available Battery

The detector runs on a single CR2 camera battery, simple to install and commercially available. Installed battery life is approximately 9,000 hrs (> 1 year). A long wake-up period each time units are activated is avoided by supplying small amounts of power to sensors even when units are powered off.

Remote Oxygen Detector (O2-R)

The remote oxygen version for The ALTAIR Pro Single-Gas Detector's remote oxygen sensor attaches remotely to the end of a ten-foot cable, rather than inside instrument housing. Design allows users to lower the sensor into remote locations and monitor O2 levels from ten feet away.

Sensors

The ALTAIR Pro Single-Gas Detector uses fast-responding 20 Series oxygen and toxic sensors and meets UL, cUL, ATEX, and Australian standards. Sensors simply plug in to the internal circuit board for fast, easy replacement.

Built-In IR Communication (Event & data logging)

Data logging is standard on the Altair Pro Single-Gas Detector. The unit automatically records the 50 latest events in the session log, while simultaneously recording peak gas readings or low O2 readings every three minutes in a periodic data log. Combined, these two tools provide a great way to assess alarm conditions, confirm bump tests or calibration, and verify employee gas concentration exposures.

To access data, simply link the unit to your MSA infrared adapter using standard built-in IR communication. MSA FiveStar® Link™ Software allows you to view various logs, adjust alarm set points, assign the unit a specific name, and disable or activate particular features and options, a one-stop unit control center.

Rugged Design

Thick rubberized housing withstands accidental drops or other impacts and also provides additional water ingress resistance. Metal screw inserts offer stability over the unit's lifetime. A durable suspension clip completes this tough outer shell.

Water and Dust Resistance

The ALTAIR Pro Single-Gas Detector is highly water-and dust-resistant. Simple yet effective design innovatively seals the unit, exceeding the industry average IP rating.

Test and Calibration Stations

MSA is proud to offer the ALTAIR QuickCheck® Station, an easy and cost-effective way to perform daily alarm and gas response tests on your ALTAIR Pro Single-Gas Detectors. The station is available in manual and automatic versions and quickly verifies that the instrument is ready for the upcoming day's use.

MSA also offers the ALTAIR Galaxy® Automated Test System for complete automatic calibration and record-keeping of your ALTAIR Pro Single-Gas Detectors. Please contact MSA for additional information on either of these stations.

ALTAIR® Pro Single-Gas Detector Specifications

Weight :	4.0 oz including clip	
Dimensions	3.4″ x 2.0″ x 1.0″	
Operating T Range	-20 to +50ºC (-4 to +122ºF)	
Humidity	10-95% RH non-condensing	
Gases & Measuring Ranges:		
Gas	***Range***	***Resolution***
Oxygen	**0-25% by vol**	**0.1 Vol.%**
Carbon monoxide	**0-1500 ppm**	**1 ppm**
Hydrogen sulfide	**0-200 ppm**	**1 ppm**
Hydrogen cyanide	**0-30 ppm**	**0.5 ppm**
Chlorine	**0-20 ppm**	**0.1 ppm**
Chlorine dioxide	**0-1.00 ppm**	**0.02 ppm**
Sulfur dioxide	**0-20 ppm**	**0.1 ppm**
Nitrogen dioxide	**0-20 ppm**	**0.1 ppm**
Ammonia	**0-100 ppm**	**1 ppm**
Phosphine	**0-5.00 ppm**	**0.05 ppm**
Remote oxygen (O2-R)	**0-25% by vol**	**0.1Vol.%**
Alarms	Average > 95 dB @ 1 ft, bright LEDs, vibrating alarm standard	

Warranty	See instruction manual for full warranty information
Instrument life	Indefinite with sensor and battery replacement as needed
Battery	CR2 lithium camera battery (9000 hour installed life - typical)
Case	Polycarbonate with rubberized shell
Display	Large LCD with backlight
Humidity	10-95% RH non-condensing
Ingress Protection	IP67 (except O2-R is IP54)
Data Logging	50 latest events in session log Peak value every 3 minutes in periodic log
Certifications:	
US and Canada	Class I, Div. 1, Groups A, B, C and D; Class II, Div. 1, Group G
Europe	Ex ia IIC T4
USA	AEx ia IIC T4
European Union	ATEX II 2G Ex ia IIC T4
Australia	Ex ia IIC T4 (Ta = 50˚C)

See website for additional approvals:
http://www.msanorthamerica.com/approvals_and_standards.html#AltairPro

Instrument Type	P/N	Low Alarm	High Alarm	STEL	TWA
Oxygen (O2)	10074137	19.50%	23.00%	N/A	N/A
Carbon monoxide (CO)	10074135	25 ppm	100 ppm	100 ppm	25 ppm
Carbon monoxide (CO) fire	10076723	25 ppm	100 ppm	100 ppm	25 ppm
Carbon monoxide (CO) steel	10076724	75 ppm	200 ppm	200 ppm	75 ppm
Hydrogen sulfide (H2S)	10074136	10 ppm	15 ppm	15 ppm	10 ppm
Hydrogen cyanide (HCN)	10076729	4.7 ppm	10 ppm	10 ppm	4.7 ppm
Chlorine (CL2)	10076716	0.5 ppm	1.0 ppm	1.0 ppm	0.5 ppm
Chlorine dioxide (CLO2)	10076717	0.1 ppm	0.3 ppm	0.3 ppm	0.1 ppm
Sulfur dioxide (SO2)	10076736	2.0 ppm	5.0 ppm	5.0 ppm	2.0 ppm
Nitrogen dioxide (NO2)	10076731	2.0 ppm	5.0 ppm	5.0 ppm	2.0 ppm
Ammonia (NH3)	10076730	25 ppm	50 ppm	35 ppm	25 ppm
Phosphine (PH3)	10076735	0.3 ppm	1.0 ppm	1.0 ppm	0.3 ppm
Oxygen remote (O2-R)	10076733	19.50%	23.00%	N/A	N/A
Alternate Set Point Models	**P/N**	**Low Alarm**	**High Alarm**	**STEL**	**TWA**
Oxygen (O2)	10076732	19.50%	18.00%	N/A	N/A
Carbon monoxide (CO)	10076718	30 ppm	60 ppm	60 ppm	30 ppm
Carbon monoxide (CO)	10076719	35 ppm	100 ppm	100 ppm	35 ppm
Carbon monoxide (CO)	10076720	35 ppm	400 ppm	400 ppm	35 ppm
Carbon monoxide (CO)	10076721	50 ppm	200 ppm	200 ppm	50 ppm
Carbon monoxide (CO)	10076722	100 ppm	300 ppm	300 ppm	100 ppm
Carbon monoxide (CO) steel	10080532	199 ppm	200 ppm	200 ppm	35 ppm
Hydrogen sulfide (H2S)	10076728	10 ppm	20 ppm	10 ppm	10 ppm
Hydrogen sulfide (H2S)	10076725	5 ppm	10 ppm	10 ppm	5 ppm
Hydrogen sulfide (H2S)	10076727	8 ppm	12 ppm	12 ppm	8 ppm
Hydrogen sulfide (H2S)	10076726	7 ppm	14 ppm	14 ppm	7 ppm

Accessories and Parts

Part Number	Description
467895	Regulator, 0.25 lpm
10030325	Tubing, 16" (do not use with NH3, Cl2, and CLO2)
10080534	Tubing, 16" Tygon-lined (NH3, Cl2, and CLO2)
10074132	3V CR2 battery
10069894	Clip, stainless steel

Part Number	Description
10041105	Cellphone Clip
10041107	Lanyard clip
10073346	Hardhat clip
10040002	Clip, suspender (standard)
10088099	MSA Link Software CD-ROM
10082834	IR Adapter for USB

Note: The ALTAIR QuickCheck Station and ALTAIR Galaxy Automated Test System are available for bump testing and calibration of most versions of the ALTAIR and ALTAIR Pro Single-Gas Detector family.

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Offices and representatives worldwide
For further information:

ID 0802-33-MC / Dec. 2010

The Safety Company

Data Sheet

TH-3

Relative Humidity Temperature Meter

- **Dual display**
- **Relative function monitors humidity and temperature changes**
- **Extended probe stem to easily access air ducts**
- **Min/Max readings**
- **Data Hold**
- **Capacitive sensor with protective cover**
- **Auto Power off**
- **Soft Carrying Case**
- **One-year warranty**

No hassle warranty

No waiting.

No shipping charges.

Our commitment to high-quality products and customer service is demonstrated by our industry exclusive "No Hassle" warranty. In the unlikely event that an Amprobe Test Tool requires warranty service, any of our local dealers are authorized to replace it, on the spot.

(note: $500 MSLP limit)

The TH-3 uses a precision capacitance sensor to deliver accurate performance with long term stability. This high accuracy instrument measures the full range of relative humidity from 0% to 100% and features an exceptionally wide ambient temperature measurement range from -20 °C (-4 °F) to 60 °C (140 °F). The sensor is mounted on a long shaft extending from the top surface of the unit, making probing into ductwork and hard to reach areas more easy. The large LCD displays two measurements simultaneously with a full range of display options including Hold, Min, Max, and Relative. The TH-3 is a complete package and comes with soft carrying case, sensor cover, battery and manual.

Included Accessories

Soft carrying case, sensor cover, battery (installed), users manual

TH-3 Relative Humidity Temperature Meter

Data Sheet

General Specifications

Display	Dual display
Operating Conditions:	0 °C to 40 °C
Storage Conditions:	-10 °C to 60 °C; <70 % RH
Altitude	Up to 2000 meters
Sample rate	2.5 times per second
Battery	9 V Battery, NEDA 1604 or JIS 006P or IEC6F22
Battery life	85-hours continuous (with alkaline battery)
Dimension	240 x 54 x 34 mm (9.5 x 2.1 x 1.3 in.)
Weight	Approximately 180 g (6.4 oz.)

Technical Specifications

Function	Range	Accuracy
Measurement Ranges		
Humidity	0 % RH to 100 % RH	
Range accuracy	5 % RH to 95 % RH: <5%RH, >95% RH	±3 % RH @ 23 °C ±5 % RH @ 23 °C
Temperature Coefficient:		0.1 x specified accuracy/ °C <23 °C, >23 °C
Resolution	0.1 %RH	
Temperature (Dry Bulb)	-20 °C to 60 °C:	±0.8 °C
	-4 °F to -140 °F	±1.6 °F
Resolution	0.1 °C/0.1 °F	
Response time (in slowly moving air)		
Humidity	180 sec	
Temperature	10 sec	

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4/2007 PN: 3053426 Rev A

APPENDIX C

Field Forms

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Appendix C
Air-Lift Enhanced Bioremediation Pilot Test Well Data

Job Name & Number: ______________________

Personnel: ______________________

Well ID: ______________________

			Soil Gas							Groundwater Quality						
Time	Depth to Water (ftbtoc)	Vacuum (inches H_2O)	Well Vapor Flow Rate (acfm)	Vapor Concentration Well Head (By PID) (ppmv)	Water Activity Relative Humidity (%)	Vapor Temperature (°F)	Ambient Temperature (°F)	O_2 (%)	CO_2 (%)	Temperature (°C)	pH	ORP	Specific Conductance	DO (mg/L)	Turbidity NTU	Notes

acfm = actual cubic feet per minute
DO = Dissolved oxygen
ftbtoc = feet below top of casing
NTU = Nephelometric turbidity unit
ORP = oxidation-reduction potential
PID = photoionization detector
ppmv = parts per million volume
°C = degree Celsius
°F = degree Farenheit

Appendix C
Bioventing Pilot Test Well Data

Job Name & Number: ____________________
Personnel: ____________________
Well ID: ____________________

Soil Gas											
Time	Depth to Water (ftbtoc)	Vacuum (inches H_2O)	Well Vapor Flow Rate (acfm)	Vapor Concentration TPH (By PID) (ppmv)	Water Activity Relative Humidity (%)	Vapor Temperature (°F)	Ambient Temperature (°F)	Barometric Pressure inHg	O_2 (%)	CO_2 (%)	Notes

acfm = actual cubic feet per minute
DO = Dissolved oxygen
ftbtoc = feet below top of casing
NTU = Nephelometric turbidity unit
ORP = oxidation-reduction potential
PID = photoionization detector
ppmv = parts per million volume
°C = degree Celsius
°F = degree Farenheit

APPENDIX D

Project Schedule

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Project Schedule

Bioventing Pilot Test – Dry Respiration Test	Spring 2018 (3 weeks)
Bioventing Pilot Test – Moisture Addition and Acclimation	Spring 2018 (2 weeks)
Bioventing Pilot Test – Moist Respiration Test	Spring 2018 (3 weeks)
Bioventing Pilot Test – Construction for Long-Term Test	Summer 2018 (3 weeks)
Bioventing Pilot Test – Conduct Dry Long-Term Test[a]	Summer 2018 (2 years)
Bioventing Pilot Test – Conduct Moist Long-Term Test[a]	Summer 2018 (2 years)
Air-Lift Enhanced Bioremediation Pilot Test[a]	Summer 2018 (2 years)

[a] These test will be performed concurrently

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