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MEMORANDUM FOR MS MARCY LEAVITT, CHIEF
GROUNDWATER QUALITY BUREAU
NEW MEXICO ENVIRONMENT DEPARTMENT
PO BOX 26110
SANTA FE NM 87502

FROM: 377 CES/CEVR
2050 Wyoming Blvd SE, Suite 126
Kirtland AFB NM 87117-5270

SUBJECT: Phase 1 Stage 1 Abatement Plan for Nitrate Impacted Groundwater at WP-26, Sewage Lagoons and Golf Course Pond (WP-26); and City of Albuquerque Sanitary Sewer Line Break

1. We are submitting our response to your 3 Jan 01 Request for Further Information (RFI) for the subject abatement plan. Attached are replacement pages for the subject document that incorporate the required changes based on our response and an electronic copy of the revised document.

2. Please contact Mr. Mark Holmes at 505-846-9005 or me at 505-846-9122, if you have any questions on this matter.

CHRISTOPHER B. DEWITT, GS-13
Restoration, Branch Chief
Environmental Management Division

Atchs:
1. RFI Response
2. Selected Replacement Pages
3. Electronic Version of Revised Document (CD)

KAFB2234

cc:
NMED-HRMB (Mr. Kieling) w/ atchs 1 and 2
NMED-HRMB KAFB (Mr. Moats) w/o atchs
EPA Region 6 (Ms. Tellez) w/ atchs 1and 2
AFMC/CEVC (Mr. Fort) w/ atchs 1 and 2
AFCEE (Mr. Arnold) w/o atchs
AFCEE (Maj Cornell) w/ atchs 1 and 2
Montgomery Watson (Ms. Jarocki) w/o atchs
377 CES/CEC (Mr. Richardson) w/ atchs 1 and 2
SNL (Mr. Skelley) w/ atchs 1 and 2

Response to Comments
from
State of New Mexico Environment Department, Groundwater Quality Bureau
for the
Phase 1 Stage 1 Abatement Plan for Nitrate Impacted Ground Water
Kirtland Air Force Base, New Mexico
February 7, 2001

1. *KAFB should submit to NMED a revised schedule of Phase 1 Stage 1 AP activities. This schedule should provide for completion of the proposed activities described in Section 12 of the Phase 1 Stage 1 AP by May 31, 2002.*

   Funding for Kirtland Air Force Base (AFB) Environmental Management projects for the 2001 fiscal year (FY01) was requested in May 2000, prior to the completion of this Phase 1 Stage 1 Abatement Plan. Based on current funding for FY01, it is not possible to complete all proposed Phase 1 Stage 1 activities by May 31, 2002. Funding for FY01 will only permit completion of the tasks scheduled for 2001. In May 2001, Environmental Management will request the necessary funds to complete the project as proposed. Environmental Management will attempt to accelerate the Phase 1 Stage 1 Abatement Plan schedule by capturing FY01 fall-out funding, if available.

2. *KAFB should submit to NMED a limited soil investigation plan for the Albuquerque sanitary sewer line break. This plan should address impacts to the vadose zone within the temporary diversion and retention ponds used to contain the domestic wastewater. The plan should describe, at a minimum, the location, depth, and frequency of soil samples to be collected, the constituents to be analyzed from samples collected, soil sample collection methods, and a description of lithology collection methods to be used.*

   A limited soil investigation of the city of Albuquerque sanitary sewer line break was proposed as part of the Phase 1 Stage 1 Abatement Plan. This investigation is described in detail in Section 8 of the plan and describes the elements listed above. The proposed investigation is adequate to determine if this break impacted the vadose zone or the underlying groundwater. If this investigation determines that the vadose zone and/or groundwater was impacted by the city of Albuquerque sanitary sewer line break, further investigation should be pursued by the New Mexico Environment Department (NMED) through the city of Albuquerque.

3. *KAFB should submit to NMED an investigation plan to determine the extent of suspected sanitary sewer line leakage and the degree of impact to ground water from these leaks, if any.*

   Subsurface soil sampling, monitoring well installation, and groundwater sampling, as proposed in the Phase 1 Stage 1 Abatement Plan for KAFB-0512 and KAFB-0513, should provide adequate information to determine if groundwater was impacted from a sanitary sewer line leak. Any further investigation of the area should be pursued by the NMED through the city of Albuquerque.

4. *KAFB should submit to NMED a plan for the Golf Course Pond that determines whether the current pump and land application remediation system is sized appropriately to contain and capture that nitrate plume.*

   Based on current information concerning the groundwater nitrate plume near the golf course pond, it is not possible to determine if the current pump and land application remediation system is sized to contain and capture that nitrate plume. Further data concerning the source and extent of the nitrate plume is needed to make this determination. Implementation of the Phase 1 Stage 1 Abatement Plan will provide data concerning the source of nitrate at the golf course pond. Installation of upgradient and downgradient perched and regional aquifer monitoring wells will provide data to help determine the extent of the nitrate plume in the area. Based on data collected during the Phase 1 Stage 1 Abatement Plan, the current pump and land application remediation system can be evaluated as part of the final data analysis of the Phase 1 results.

5. *KAFB should submit to NMED a plan for the Golf Course Pond that defines total nitrogen loading at the golf course. This plan should show that the nitrogen loading at the golf course is not contributing to the nitrate-contaminated ground water.*

   This plan is beyond the scope of a Stage 1 Abatement Plan as outlined by NMED regulations. Additional data collection is necessary to define total nitrogen loading at the golf course. Data concerning site-specific soil parameters, total nitrogen application from all sources, and water application for the golf course is needed to make this evaluation. Site-specific soil parameters will be collected during the drilling of KAFB-0612 as proposed by the Phase 1 Stage 1 Abatement Plan.

6. *KAFB should submit to NMED a plan for identifying other potential sources of nitrate-impacted ground water throughout the base as proposed in the introduction of the Phase 1 Stage 1 AP. This plan should include a sampling from at least the following wells from the following areas: North of sewage lagoons (KAFB-14), golf course pond area (RG-1598-S-4), technical area 2 (TA1-W-01, TA2-NW1-325, TA2-NW-1-595, TA2-W-01, TA2-SW1-320, KAFB-0308, KAFB 0309, TJA-3, TJA-4, WYO-1, WYO-2), LF-20 area (KAFB-2003, KAFB-2001, KAFB-9, RW-06-01), north technical area 5 (LWDS-MW2, LWDS-MW1, TA5-MW4, TA5-MW5, TA5-MW3, TA5-MW1, KAFB-10, NWTA-3), central technical area 5 (MWL-BW1, MWL-MW1, MWL-MW3), south technical area 5 (one regional and one perched well from CWL wells), the McCormick Ranch area (KAFB-1003), and water supply wells KAFB-11 and 15. This plan should include sampling locations, a schedule for sampling, and descriptions of screened intervals from each sampling location. Analytical parameters and testing methods should be in accordance with Table 8-4 of the submitted Phase 1 Stage 1 AP.*

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The Phase 1 Stage 1 Abatement Plan was not intended to address all nitrate concerns across the entire area of Kirtland AFB. Instead, it was intended to address the areas specifically outlined by the NMED letter dated July 2, 1999. Those areas included the former sewage lagoons, the golf course pond, and the City of Albuquerque sanitary sewer line break.

The Phase 1 Stage 1 Abatement Plan does propose the investigation of other areas of Kirtland AFB and Sandia National Laboratories/New Mexico (SNL/NM) where the nitrate standard has been exceeded. This includes groundwater sampling of several areas NMED has requested (specifically, north of the sewage lagoons at proposed monitoring wells KAFB 0510 and 0511 and one production well; at four monitoring wells at the golf course pond; at one monitoring well at SNL/NM technical area 1; at one monitoring well at SNL/NM technical area 2; at six monitoring wells at LF-08; at one production well adjacent to LF-08; and at one monitoring well at LF-20). The plan also proposes that other areas of KAFB, not including SNL/NM, may require investigation with respect to nitrate-impacted groundwater, but it is premature to propose a second phase investigation prior to initiation of the Phase 1 Stage 1 Abatement Plan. Substantial groundwater information will be gathered as part of the Phase 1 investigation and can be used to design a technically sound and cost effective Phase 2 investigation.

Many of the monitoring wells mentioned in comment 6 above are regularly analyzed for nitrate and other constituents by Kirtland AFB through the long-term monitoring program and by SNL/NM. Active production wells are regularly analyzed for nitrate by the Kirtland AFB bioenvironmental office. Historical nitrate data for these wells was used to compile background information for the Phase 1 Stage 1 Abatement Plan. Further information concerning the nitrate analyses for these wells is outlined in the Table 1.

Table 1. Recent Nitrate Results for Monitoring and Production Wells Around Kirtland Air Force Base

Well Designation	Monitored by:	Sampling Interval	Nitrate Concentration (date sampled)
KAFB-14	Bioenvironmental	Annual	<0.5 mg/L (05/28/97)
RG-1598-S-4	KAFB EM	Not Sampled	---
TA1-W-01	SNL/NM	Quarterly	2 mg/L (7/22/99)
TA2-NW1-325	SNL/NM	Quarterly	3 mg/L (9/15/99)
TA2-NW1-595	SNL/NM	Quarterly	2.8 mg/L (6/15/99)
TA2-W-01	SNL/NM	Quarterly	5.3 mg/L (9/15/99)
TA2-SW1-320	SNL/NM	Quarterly	27 mg/L (9/13/99)
KAFB-0308	KAFB EM	Biannual	6.3 mg/L (10/00)
KAFB-0309	KAFB EM	Biannual	4.5 mg/L (10/00)
TJA-3	SNL/NM	Quarterly	2.2 mg/L (6/16/99)
TJA-4	SNL/NM	Quarterly	25 mg/L (7/12/99)
WYO-1	SNL/NM	Quarterly	2.6 mg/L (7/14/99)
WYO-2	SNL/NM	Quarterly	2.3 mg/L (9/16/99)
KAFB-2003	KAFB EM	Quarterly	6.4 mg/L (10/00)
KAFB-2001	KAFB EM	Quarterly	8.4 mg/L (10/00)
KAFB-9	Abandoned (1980)	---	---
RW-06-01	KAFB EM	Quarterly	6.1 mg/L (10/00)
LWDS-MW2	SNL/NM	Quarterly	4.6 mg/L (08/18/99)
LWDS-MW1	SNL/NM	Quarterly	16 mg/L (08/12/99)
TA5-MW4	SNL/NM	Quarterly	5.3 mg/L (08/12/99)
TA5-MW5	SNL/NM	Quarterly	13 mg/L (08/18/99)
TA5-MW3	SNL/NM	Quarterly	4 mg/L (08/18/99)

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Table 1. Recent Nitrate Results for Monitoring and Production Wells Around Kirtland Air Force Base (concluded)

Well Designation	Monitored by:	Sampling Interval	Nitrate Concentration (date sampled)
TA5-MW1	SNL/NM	Quarterly	4.3 mg/L (08/19/99)
KAFB-10	Plugged and Abandoned (1996)	---	---
NWTA-3	SNL/NM	Annual	7.53 mg/L (05/17/99)
MWL-BW1	SNL/NM	Biannual	6.15 mg/L (04/13/99)
MWL-MW1	SNL/NM	Biannual	5.19 mg/L (04/14/99)
MWL-MW3	SNL/NM	Biannual	4.08 mg/L (04/12/99)
CWL (regional)	SNL/NM	Quarterly	No nitrate data
CWL (perched)	SNL/NM	Quarterly	No nitrate data
KAFB-1003	KAFB EM	Not Sampled[a]	9.1 mg/L (04/93)
KAFB-11	Bioenvironmental	Annual	8.2 mg/L (12/03/98)
KAFB-15	Bioenvironmental	Annual	<0.5 mg/L (04/29/99)

Notes:
[a] Five other wells in the McCormick Ranch area are monitored as part of the Long-term Monitoring Program.
KAFB EM = Kirtland Air Force Base Environmental Management
SNL/NM = Sandia National Laboratory/New Mexico
mg/L = milligrams per liter

7. *KAFB should include in table 8-4 of the submitted Phase 1 Stage 1 AP bicarbonate and total dissolved solids as analytical parameters.*

Bicarbonate and total dissolved solids will be added to Table 8-4.

8. *KAFB's long term ground water monitoring plan, as described in section 10 of the submitted Phase 1 Stage 1 AP, should be modified to exclude turbidity and nitrite, and to include total Kjeldahl nitrogen, ammonia, and total dissolved solids. This plan should also include a description of sample filtration prior to sample analysis. KAFB's semi-annual long term ground water monitoring results should be submitted to NMED no later than April 31 and October 31 of each year beginning in October 2001. These reports shall include ground water analytical results, water level measurements, a water level potentiometric map, and description of activities performed during that quarter.*

Section 9 of the Phase 1 Stage 1 Abatement Plan describes the Groundwater Monitoring Program. Total Kjeldahl nitrogen, ammonia, and total dissolved solids will be added to the groundwater analytes. Turbidity and nitrite will not be excluded. Sample filtration will not be performed on any of the groundwater samples collected (that is, all analyses will be performed on unfiltered groundwater samples).

The schedule laid out by NMED in comment 8 above is significantly shorter than what is typically required for Kirtland AFB to produce a groundwater monitoring report. Based on the schedule described in Section 12 of the Phase 1 Stage 1 Abatement plan, biannual groundwater samples will be collected in March and September of each year during the implementation of the Phase 1 Stage 1 Abatement Plan. Reports for the biannual groundwater sampling will be submitted to NMED by July 1 and January 1 of each year, beginning in January 2002, following the first biannual groundwater monitoring event in September 2001.

The schedule has been modified to outline the dates of the groundwater sampling, the list of analytes, and the dates of the biannual monitoring reports. It should be noted that the Draft Phase 1 Stage 1 Abatement Plan Report has been deleted from the schedule and replaced with the first biannual groundwater monitoring report. The Draft Phase 1 Report was deleted because it would include the same elements as the biannual groundwater monitoring reports as described by the NMED in comment 8. All biannual groundwater monitoring reports will include groundwater analytical results, water level measurements, a water level potentiometric map, and description of activities performed during the previous six months.

EXECUTIVE SUMMARY

This Stage 1 Abatement Plan for Nitrate-Impacted Groundwater at the Sewage Lagoons (WP-26), Golf Course Pond (WP-26), and City of Albuquerque Sanitary Sewer Line Break was prepared to support the investigation of nitrate-impacted groundwater at Kirtland Air Force Base (AFB), New Mexico. The purpose of the Stage 1 Abatement Plan is to design and conduct a site investigation that will adequately define site conditions (that is, the extent of nitrate-impacted groundwater) and provide the data necessary to select and design an effective abatement option.

In a letter dated July 2, 1999, the Assessment and Abatement Section of the Groundwater Quality Bureau of the New Mexico Environment Department (NMED) required Kirtland AFB to complete a Stage 1 Abatement Plan to investigate nitrate-impacted groundwater (NMED, 1999). The NMED specifically named three areas of the base suspected to be sources of nitrate-impacted groundwater: former sewage lagoons (WP-26), the Tijeras Arroyo Golf Course pond (WP-26), and a City of Albuquerque sanitary sewer line break. Nitrate concentrations in monitoring wells at the former sewage lagoons, the golf course pond, and at one production well (KAFB-7) have been measured above the New Mexico Water Quality Control Commission (NMWQCC) standard of 10 milligrams per liter (mg/L). The United States Environmental Protection Agency (EPA) maximum contaminant level (MCL) for nitrate is also 10 mg/L.

Since NMED issued this letter (NMED, 1999), two additional monitoring wells (KAFB-0312 and KAFB-2002) have shown nitrate concentrations above the NMWQCC standard of 10 mg/L in areas not associated with the former sewage lagoons, golf course pond, or sanitary sewer line break. Data analysis conducted during the preparation of this plan has lead to the conclusion that nitrate-impacted groundwater occurs in several plumes originating from multiple sources at Kirtland AFB. Therefore, a phased approach will be used to investigate areas of nitrate-impacted groundwater at Kirtland AFB. The focus of the Phase 1 work of the Stage 1 Abatement Plan will remain the areas specifically named by NMED in the July 2, 1999, letter (that is, production well KAFB-7, former sewage lagoons, golf course pond, and City of Albuquerque sanitary sewer line break). Additional phases and areas of investigation will be proposed for other nitrate-impacted groundwater areas at a later date.

In September 1995, Kirtland AFB production well KAFB-7 was taken off line due to the presence of nitrate at concentrations above the NMWQCC standard of 10 mg/L. Nitrate concentrations were measured in KAFB-7 at 21 mg/L in January 2000. Nitrate-impacted groundwater near KAFB-7 may originate from perched and regional aquifers affected by several potential sources including the former sewage lagoons (located 2,500 ft southeast) that make up part of the Installation Restoration Program (IRP) site WP-26 and a 1994 City of Albuquerque sanitary sewer line break (located 2,200 ft south) near the sewage lagoons. It is unlikely that nitrate-impacted groundwater located near the golf course pond affects KAFB-7 because of the distance between the locations (approximately 2.6 miles southeast).

The former sewage lagoons (part of IRP site WP-26, Sewage Lagoons and Golf Course Pond) were used as settling ponds for raw sewage from April through October of 1962 through 1987 and received approximately 330 million gallons annually. Sewage effluent was transferred from the sewage lagoons to the golf course pond through a 15-inch gravity-draining effluent line. The sewage lagoons were investigated on a number of occasions. Sampling results show nitrate-impacted soil in the vadose zone beneath the sewage lagoons, and nitrate above 10 mg/L has been detected in three monitoring wells

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installed in the regional aquifer around the perimeter of the sewage lagoons. Nitrate concentrations in the recently installed perched aquifer monitoring well, KAFB-0506, range from 2.2. to 2.7 mg/L. Nitrate concentrations in the recently installed regional aquifer monitoring well, KAFB-0505, range from 1.6 to 2.1 mg/L. Infiltration of raw sewage and sewage effluent are the expected sources of nitrate in groundwater near the sewage lagoons. The three-dimensional nitrate-impacted groundwater plume boundaries are not known for this area and will be investigated as part of this Stage 1 Abatement program.

The golf course pond (part of IRP site WP-26, Sewage Lagoons and Golf Course Pond) was used to store sewage effluent from 1962 through 1987. Sewage effluent was transferred from the sewage lagoons to the golf course pond through a 15-inch gravity-draining effluent line. Sewage effluent was combined with water from a production well and then used as irrigation water for the Tijeras Arroyo Golf Course. In 1998, the golf course pond was redesigned and brought back into use. Currently, the golf course pond is used to store nitrate-impacted groundwater recovered from near the pond. The nitrate-impacted groundwater is mixed with water from a production well and applied to the Tijeras Arroyo Golf Course.

The golf course pond was investigated on a number of occasions. Sampling results show nitrate-impacted soil in the vadose zone (down to 100 ft below ground surface where sampling stopped) below the golf course pond. Four perched aquifer monitoring wells, installed around the perimeter of the golf course pond, all show nitrate concentrations above 10 mg/L. There are several potential sources of nitrate in groundwater for the golf course pond area, including sewage effluent historically stored in the pond, fertilization of the Tijeras Arroyo Golf Course, and explosive residuals from explosives used extensively in the eastern portion of the base. The sources of nitrate in groundwater and the three-dimensional nitrate-impacted groundwater plume boundaries will be investigated as part of this Stage 1 Abatement program.

In September 1994, a City of Albuquerque sanitary sewer line, which crosses Kirtland AFB, ruptured, and approximately 100 million gallons of raw sewage were released to the ground surface before a temporary diversion was installed. Raw sewage was ponded on the Tijeras Arroyo floodplain and allowed to infiltrate and evaporate. No data concerning possible nitrate contamination have been collected at this site. The vadose zone and groundwater affected by nitrate will be investigated at the location where the sewer line ruptured and in the ponding area as part of this Stage 1 Abatement program.

Phase 1 of the Stage 1 Abatement Plan for Nitrate-Impacted Groundwater at Kirtland AFB focuses on identifying areas of nitrate-impacted groundwater near the sewage lagoons, golf course pond, and sanitary sewer line break; determining sources (such as sewage, fertilizer, and explosives) of nitrate in groundwater; and monitoring the potential for denitrification in the subsurface. Fourteen additional monitoring wells (both regional and perched, as applicable) will be installed in selected areas to assess the distribution of nitrate-impacted groundwater. Subsurface soil samples will be collected during drilling near KAFB-7, the City of Albuquerque sanitary sewer line break, the sewage ponding area on the Tijeras Arroyo floodplain, and upgradient of the golf course pond to evaluate nitrate in the vadose zone.

Groundwater samples will be collected from 37 monitoring wells, installed in both the perched and regional aquifers, and analyzed for a variety of parameters to assess nitrate concentrations, nitrate sources, and other pertinent parameters. Nitrogen species, including ammonia, total Kjeldahl nitrogen, nitrate, and nitrite, will be analyzed to assess nitrate-impacted groundwater. Stable isotopes of nitrogen, oxygen, and hydrogen; major anions; and nitroaromatics will be analyzed to determine sources of nitrate. Conditions

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for denitrification will be determined by analysis of dissolved oxygen, oxidation-reduction potential, ferrous iron, total iron, and dissolved organic carbon. Additional parameters for general groundwater conditions will also be measured, including groundwater elevation, pH, and temperature.

A biannual groundwater monitoring program will be established as part of the Phase 1 Stage 1 Abatement Plan. Groundwater samples will be collected from 37 monitoring wells installed in the perched and regional aquifers. These groundwater samples will be analyzed for field parameters, including groundwater elevation, dissolved oxygen, temperature, pH, specific conductivity, oxidation-reduction potential, and turbidity. Laboratory analysis for these samples will include total dissolved solids, nitrate, nitrite, ammonia, and total Kjeldhal nitrogen. Surface water samples will be collected biannually at the golf course pond and analyzed for the same parameters as the groundwater monitoring samples.

Additional phases and areas of investigation will be proposed for other potential source areas identified based on data collected though the Long-Term Monitoring (LTM) Program, the results of the Phase 1 program outlined in this Stage 1 Abatement Plan, and other investigations conducted by Environmental Management at Kirtland AFB.

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8.0 Site Investigation Work Plan

This Stage 1 Abatement Plan for Nitrate-Impacted Groundwater is part of the environmental restoration activities being conducted at Kirtland AFB. Environmental restoration activities are conducted under the general guidance of the Base-Wide Plans (BWP) for the Installation Restoration Program, as interpreted and implemented by the Kirtland AFB EM Division, Restoration Branch Chief (or his representatives). The BWP were completed in March 1995 and revised in May 1996 (USAF, 1996). Applicable sections of the BWP are incorporated into this Stage 1 Abatement Plan by reference.

Phase 1 of the Stage 1 Abatement Plan for Nitrate-Impacted Groundwater at Kirtland AFB focuses on identifying areas of nitrate-impacted groundwater near the sewage lagoons, golf course pond, and sanitary sewer line break; determining sources (such as sewage, fertilizer, and explosives) of nitrate in groundwater; and monitoring the potential for denitrification in the subsurface. Monitoring wells (both regional and perched, as applicable) will be installed in selected areas to assess the distribution of nitrate-impacted groundwater in areas of sparse well coverage; subsurface soil samples will be collected during drilling in suspected source areas to evaluate nitrate-impacted subsurface soil; groundwater samples will be collected and analyzed for a variety of parameters to assess nitrate concentrations, nitrate sources, and other pertinent parameters; and surface water samples will be collected at the golf course pond and analyzed for nitrogen species.

Subsequent phases of investigation may be required to address other identified areas of nitrate-impacted groundwater at Kirtland AFB. A Phase 2 investigation might include additional monitoring wells and/or soil borings necessary to define the extent of vadose zone contamination and three-dimensional groundwater plume boundaries near the sewage lagoons and golf course pond and to fill any data gaps identified by the Phase 1 investigation. A Phase 2 investigation might also include monitoring well installations near other possible sources of nitrate in groundwater such as: KAFB-0312, LF-08, LF-20, and the McCormick Ranch area. A Phase 3 investigation might include additional monitoring wells and/or soil borings to complete data gaps identified in Phase 2. The specific scope and extent of these investigations will be identified based on the results of the Phase 1 Stage 1 Abatement Plan investigation and other data collected at Kirtland AFB.

8.1 Monitoring Well Drilling and Installation

To obtain groundwater samples and analytical results in areas surrounding the sewage lagoons, golf course pond, and sanitary sewer line break, seven regional aquifer and seven perched aquifer monitoring wells will be installed. These monitoring wells will be installed in areas where monitoring well coverage is limited. Installation of the perched aquifer monitoring wells is contingent upon identifying perched groundwater in the borehole during drilling. The proposed monitoring well installation locations for the Phase 1 investigation are shown on Figure 8-1. The location, rationale, and drilling depths for each proposed monitoring well are provided in Table 8-1. Monitoring well locations were chosen to fill identified data gaps and to provide a broader area of monitoring well coverage for the potential source areas of interest. Historical data were used to determine target zones for perched groundwater and to determine sampling depth intervals for tracking the potential infiltration of contaminants into the vadose zone soil.

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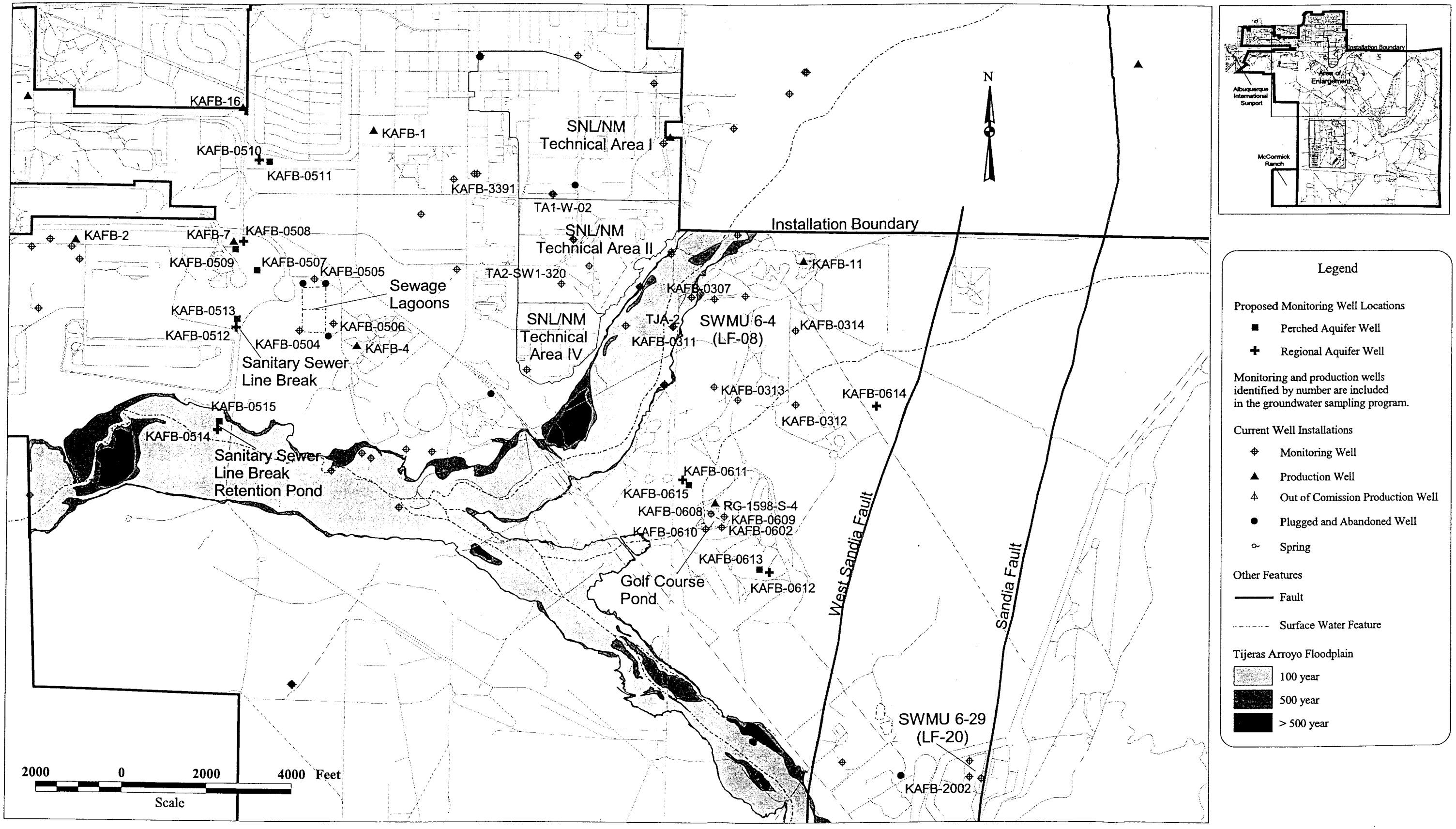

Figure 8-1. Proposed Phase 1 Monitoring Well Installation Locations and Groundwater Sampling Locations

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Table 8-1. Proposed Phase 1 Drilling Locations and Depths for the Sewage Lagoons, Golf Course Pond, and Sanitary Sewer Line Break

Well Identification	Well Location	Rationale	Estimated Depth (feet)
KAFB-0507	Perched aquifer, between sewage lagoons and KAFB-7	Will be used to determine local flow direction in perched aquifer and identify extent of nitrate-impacted groundwater	280
KAFB-0508	Regional aquifer, near KAFB-7	Will be used to determine if regional aquifer nitrate-impacted groundwater is contributing to KAFB-7	530
KAFB-0509	Perched aquifer, near KAFB-7	Will be used to determine if perched aquifer nitrate-impacted groundwater is contributing to KAFB-7	280
KAFB-0510	Regional aquifer, downgradient of sewage lagoons, between sewage lagoons and KAFB-16	Will be used to identify extent of regional aquifer nitrate-impacted groundwater and potential impact to KAFB-16	530
KAFB-0511	Perched aquifer, downgradient of sewage lagoons, between sewage lagoons and KAFB-16	Will be used to identify extent of perched aquifer nitrate-impacted groundwater and potential impact to KAFB-16	280
KAFB-0512	Regional aquifer, near sanitary sewer line break	Will be used to identify nitrogen species in the vadose zone and determine if the City of Albuquerque sewer line contributed to nitrate-impacted groundwater at KAFB-7	530
KAFB-0513	Perched aquifer, near sanitary sewer line break	Will be used to determine if the City of Albuquerque sewer line contributed to nitrate-impacted groundwater at KAFB-7	280
KAFB-0514	Regional aquifer, within sanitary sewer line break retention pond	Will be used to identify nitrogen species in the vadose zone and determine if raw sewage held in the retention ponds contributed to nitrate-impacted groundwater at KAFB-7	530
KAFB-0515	Perched aquifer, within sanitary sewer line break retention pond	Will be used to determine if raw sewage held in the retention ponds contributed to nitrate-impacted groundwater at KAFB-7	280
KAFB-0611	Regional aquifer, downgradient of golf course pond	Will be used to define area hydrogeology and identify the extent of regional aquifer nitrite-impacted groundwater	530
KAFB-0612	Regional aquifer, upgradient of the golf course pond	Will be used to define area hydrogeology and identify the extent of regional aquifer nitrite-impacted groundwater	530
KAFB-0613	Perched aquifer, downgradient of golf course pond	Will be used to identify the extent of perched aquifer nitrite-impacted groundwater	400
KAFB-0614	Regional aquifer, cross-gradient of the golf course pond and upgradient of KAFB-0312	Will be used to assess nitrate-impacted groundwater upgradient of monitoring well KAFB-0312	530
KAFB-0615	Perched aquifer, upgradient of the golf course pond	Will be used to identify the extent of perched aquifer nitrate-impacted groundwater	400

8.1.1 Drilling Method and Sequence

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The soil borings for monitoring well installation will be drilled using a percussion-hammer, dual-casing drill rig. Pressurized air flow will be used to remove drill cuttings. The initial borings will be approximately 12 inches in diameter and will be drilled to depths of approximately 280 to 300 ft bgs. The remaining depth in the deep borings will be drilled by telescoping within the 12-inch boring using a 10-

inch drilling assembly. This method will reduce sidewall friction from the 500-ft drill casing and allow the perched zone, if present, to be cased off from the deeper interval.

In areas where both regional aquifer and perched aquifer monitoring wells will be installed in close proximity, the regional aquifer monitoring well will be drilled and installed first to help determine the target depth and screened interval for the perched aquifer monitoring well. Careful observations of the drilling conditions and drill cuttings will be made, particularly at intervals where perched groundwater is projected. At intervals where the presence of perched groundwater is suggested, the drive casing may be raised for an interval of time to allow water to enter the boring. The duration allowed for water to enter the well will be determined in the field.

8.1.2 Subsurface Soil Sampling

All boreholes will be lithologically logged by drill cuttings and/or soil samples. Soil samples will be collected by split spoon from boreholes KAFB-0507, KAFB-0508, KAFB-0512, KAFB-0514, and KAFB-0612 to assess the presence of nitrogen species in the vadose zone near production well KAFB-7, the sanitary sewer line break, within the ponding area of the sanitary sewer line break, and on the Tijeras Arroyo Golf Course.

Samples collected from these boreholes will be submitted for chemical analyses as outlined in Table 8-2. Soil samples will not be collected for analysis from the remaining nine boreholes. Drilling and sampling will be completed in accordance with Standard Operating Procedures (SOPs) A1.6 and A1.7 of the BWP Field Sampling Plan (FSP) (USAF, 1996).

Table 8-2. Proposed Frequency and Analysis for Phase 1 Environmental Subsurface Soil Samples

Sample Depth (ft bgs)	Nitrate/ Nitrite	Ammonium	Total Kjeldahl Nitrogen	Total Organic Carbon
KAFB-0507 (perched aquifer) 2, 5, 10, 25, 50, 100, 150, 200, 250, 280	10	10	10	10
KAFB-0508 (regional aquifer) 2, 5, 10, 25, 50, 100, 150, 200, 250, 300, 350, 400, 450, 500, 525	15	15	15	15
KAFB-0512 (regional aquifer) 2, 5, 10, 25, 50, 100, 150, 200, 250, 300, 350, 400, 450, 500, 525	15	15	15	15
KAFB-0514 (regional aquifer) 2, 5, 10, 25, 50, 100, 150, 200, 250, 300, 350, 400, 450, 500, 525	15	15	15	15
KAFB-0612 (regional aquifer) 2, 5, 10, 25, 50, 100, 150, 200, 250, 300, 350, 400, 450, 500, 525	15	15	15	15
Total Environmental Samples	**70**	**70**	**70**	**70**

Notes:
ft bgs =feet below ground surface

1397 015

8.1.3 Geophysical Logging

Geophysical logging, including neutron, natural gamma, resistivity, and conductivity, will be performed in both regional and perched aquifer wells to further assess the presence of lithologic intervals that may cause perched groundwater.

8.1.4 Monitoring Well Construction

Monitoring wells (both perched and regional aquifers) will be completed at the surface in accordance with Kirtland AFB specifications as presented in SOP A1.8 of the BWP FSP; however, the monitoring wells will not be cased off in the manner described in this SOP. A brief outline of the monitoring well construction is provided in the following paragraphs.

The wells will be constructed using 5-inch-diameter schedule 80 polyvinyl chloride (rather than stainless steel) and have 1-ft silt traps, 25 ft of slotted screen, and approximately 2 to 3 ft of stickup at the surface. Centralizers will be used to stabilize the well casing within the borehole at intervals to be determined in the field. Well completions will be as follows:

- The sand filter pack type will be determined based on field observations and will extend from the bottom of the silt trap to about 2 to 4 ft above the top of the screen. The filter pack sand will be placed through a tremie pipe. If necessary, a small amount of distilled water may be used to flush the sand down the tremie pipe during placement of the filter pack.

- A bentonite seal, at least 2 ft thick, will be installed above the filter pack through a tremie pipe. The seal will be hydrated with clean potable water in 6-inch lifts. Setup time for the bentonite will be at the discretion of the field geologist.

- The annular space above the hydrated bentonite seal will be backfilled with bentonite slurry instead of bentonite-cement grout as specified in the SOP. Bentonite slurries are effective in sealing off groundwater units above the screened and sand packed intervals of a well and are less likely to damage the well casing than grout. The bentonite slurry will be installed through a tremie pipe. The bentonite slurry will extend from the bentonite seal to approximately 50 ft bgs.

- The remaining 50 ft of annular space will be filled with bentonite-cement grout consisting of 94 pounds of Portland cement, 3 percent by weight sodium bentonite powder, and 7 gallons of contaminant-free water. The bentonite-cement grout will be placed using a grout pump and tremie pipe to within 5 ft of the land surface. The grout will be allowed to set for at least 24 hours before well development begins.

Each monitoring well will be developed in accordance with Kirtland AFB and NMED specifications. The drilling contractor will develop the monitoring wells by using a suitable surge block, bailer, and/or submersible pump under the direction of the field hydrogeologist. The well will be developed until the

field parameters (pH, electrical conductivity) for groundwater have stabilized and the water is clear and substantially free from sediments. At that point, monitoring well development will be considered complete.

The field hydrogeologist will certify that a 10-ft-long section of pipe, ½ inch less in diameter than the inner diameter of the well riser pipe, is able to pass freely from the top to the bottom of each new monitoring well (SOP A1.8). The well must also be capable of producing water that is substantially free from suspended sediments. If these criteria are not met, the monitoring well may be rejected.

Following completion and development of the wells, a well installation report will be prepared and submitted to the New Mexico Office of the State Engineer, Kirtland AFB EM, and NMED.

8.2 Groundwater Sampling

Groundwater samples will be collected from the production and monitoring wells listed in Table 8-3 and shown on Figure 8-1. The production and monitoring wells were selected to provide more comprehensive data for the areas of interest around the sewage lagoons, golf course pond, and sanitary sewer line break. Monitoring wells completed in both the regional and perched aquifers were selected. Groundwater samples will be analyzed for a variety of field and laboratory parameters (Table 8-4). Only monitoring wells located at the golf course pond, LF-08, and LF-20 will be analyzed for nitroaromatics. The selected analytes will provide data on general groundwater parameters, nitrate concentrations, and the potential for *in situ* denitrification and will potentially identify sources of nitrate. All analyses will be performed on unfiltered groundwater samples.

Groundwater sampling will follow the procedures outline in SOP A1.2 of the BWP FSP (USAF, 1996). Field parameters, including dissolved oxygen (DO), temperature, pH, conductivity, and oxidation-reduction potential, will be measured using appropriate probes in flow-through cells.

1397 017

Table 8-3. Production and Monitoring Wells for Phase 1 Groundwater Sampling

Well Identification	Location	Well Type	Aquifer	Screen Interval (ft above msl)
KAFB-0504	Sewage Lagoons	Monitoring	Regional	4884.2 to 4864.2
KAFB-0505	Sewage Lagoons	Monitoring	Regional	4865.14 to 4840.14
KAFB-0506	Sewage Lagoons	Monitoring	Perched	5160.8 to 5140.8
KAFB-0507	Sewage Lagoons	Monitoring	Perched	TBD
KAFB-0508	Sewage Lagoons	Monitoring	Regional	TBD
KAFB-0509	Sewage Lagoons	Monitoring	Perched	TBD
KAFB-0510	Sewage Lagoons	Monitoring	Regional	TBD
KAFB-0511	Sewage Lagoons	Monitoring	Perched	TBD
KAFB-0512	Sanitary Sewer Line Break	Monitoring	Regional	TBD
KAFB-0513	Sanitary Sewer Line Break	Monitoring	Perched	TBD
KAFB-0514	Sanitary Sewer Line Break	Monitoring	Regional	TBD
KAFB-0515	Sanitary Sewer Line Break	Monitoring	Perched	TBD
KAFB-0602	Golf Course Pond	Production	Perched	4925.8 to 4905.8
KAFB-0608	Golf Course Pond	Monitoring	Perched	5051.5 to 5031.5
KAFB-0609	Golf Course Pond	Production	Perched	5047.2 to 5027.2
KAFB-0610	Golf Course Pond	Production	Perched	5023.8 to 5003.8
KAFB-0611	Golf Course Pond	Monitoring	Regional	TBD
KAFB-0612	Golf Course Pond	Monitoring	Regional	TBD
KAFB-0613	Golf Course Pond	Monitoring	Perched	TBD
KAFB-0614	LF-08 (KAFB-0312)	Monitoring	Regional	TBD
KAFB-0615	Golf Course Pond	Monitoring	Perched	TBD
TA1-W-02	Sandia North	Monitoring	Regional	4874.0 to 4854.0
TA2-SW1-320	Sandia North	Monitoring	Perched	5107.8 to 5087.8
KAFB-0307	LF-08	Monitoring	Regional	4956.9 to 4911.9
KAFB-0311	LF-08	Monitoring	Regional	4917.6 to 4892.6
KAFB-0312	LF-08	Monitoring	Regional (semi-confined)	4926.5 to 4901.5
KAFB-0313	LF-08	Monitoring	Perched	5068.3 to 5048.3
KAFB-0314	LF-08	Monitoring	Perched	5025.1 to 5005.1
TJA-2	LF-08	Monitoring	Perched	5074.8 to 5054.8
KAFB-2002	LF-20	Monitoring	Regional	5319.3 to 5299.3
KAFB-3391	Contractor's Yard	Monitoring	Perched	5133.9 to 5113.9
KAFB-1	North of Sewage Lagoons	Production	Regional	4413.8 to 4184.8
KAFB-2	Northwest of Sewage Lagoons	Production	Regional	4830.4 to 4324.4
KAFB-4	Southeast of Sewage Lagoons	Production	Regional	4863.5 to 4357.5
KAFB-7	Northwest of Sewage Lagoons	Production	Regional	4899.7 to 4501.5
KAFB-11	North of Golf Course Pond	Production	Regional	4756.4 to 4099.4
KAFB-16	North of Sewage Lagoons	Production	Regional	4650 to 3960

Notes : TBD = to be determined ft = foot/feet msl = mean sea level

1397 018

Table 8-4. Analytical Parameters and Testing Methods for Phase 1 Groundwater Samples

Analysis	Method	Testing Location	Data Use
Groundwater Elevation	Groundwater probe	Field	Groundwater flow direction
pH	pH probe	Field, flow-through cell	General groundwater parameter
Specific Conductivity	Conductivity meter	Field, flow-through cell	General groundwater parameter
Temperature	Digital thermometer	Field, flow-through cell	General groundwater parameter
Turbidity	Turbidity meter	Field, flow-through cell	General groundwater parameter
Dissolved Oxygen (DO)	DO probe	Field, flow-through cell	Assess aerobic or anaerobic conditions for denitrification
Ferrous Iron (Fe^{2+})	Hach test kit	Field	Assess conditions for denitrification
Oxidation-Reduction Potential	EH meter	Field, flow-through cell	Assess conditions for denitrification
Ammonia (NH_3)	EPA Method 350.2	Laboratory	Assess nitrogen species
Nitrate (NO_3)	EPA Method 300	Laboratory	Assess nitrate-impacted groundwater
Nitrite (NO_2)	EPA Method 300	Laboratory	Assess nitrite-impacted groundwater
Total Kjeldahl Nitrogen (TKN)	EPA Method 351.2	Laboratory	Assess nitrogen species
Major Anions (bromide, chloride, sulfate)	EPA Method 300	Laboratory	Identify nitrate sources and conditions for denitrification
Nitroaromatics	EPA Method 8330	Laboratory	Identify nitrate sources
Stable Isotopes (Nitrogen, Oxygen, and Hydrogen)	Standard Methods by Mass Spectrometry	Laboratory	Identify nitrate sources
Dissolved Organic Carbon	EPA Method 415.1	Laboratory	Assess conditions for denitrification
Iron, Total	EPA Method 6010B	Laboratory	Assess conditions for denitrification
Manganese	EPA Method 6010B	Laboratory	Assess conditions for denitrification
Alkalinity	EPA Method 310.1	Laboratory	General groundwater parameter
Bicarbonate	EPA Method 310.1	Laboratory	General groundwater parameter
Total Dissolved Solids	EPA Method 160.1	Laboratory	General groundwater parameter

Method References:

EPA, 1993. *EPA 100-400 Series—Methods for the Determination of Inorganic Substances in Environmental Samples.* EPA/600R-93-100. U.S. Environmental Protection Agency, Office of Research and Development, Environmental Monitoring Systems Laboratory, Cincinnati, Ohio. August 1993.

EPA, 1996. Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846), Third Edition, September 1986; Final Update I, July 1992; Final Update IIA, August 1993; Final Update II, September 1994; Final Update IIB, January 1995; Final Update III, December 1996. U.S. Environmental Protection Agency, Office of Solid Waste. December 1996.

1397 019

8.3 Investigation-Derived Waste

Handling and disposition of investigation-derived waste will follow SOP requirements included in the BWP (USAF, 1996).

Soil cutting produced during drilling of the monitoring wells will be staged onsite and covered to prevent dispersal by wind or precipitation. Composite samples of the drill cuttings will be analyzed for full suite TCLP constituents, including VOCs, SVOCs, eight RCRA metals, and selected pesticides and herbicides to determine disposal requirements.

Wastewater produced from equipment decontamination, well development, and groundwater sampling will be staged onsite in 55-gallon drums. A composite water sample from each drum will be analyzed for nitrate, VOCs, SVOCs, and eight RCRA metals to determine disposal requirements.

1397 020

9.0 Groundwater Monitoring Program

The groundwater monitoring program will monitor nitrate concentrations in groundwater for the duration of the Phase 1 Stage 1 Abatement Plan. The 37 monitoring wells identified in Table 8-3 will be sampled on a biannual basis for the parameters outlined in Table 9-1. All analyses will be performed on unfiltered groundwater samples. Groundwater sampling, site management, and record keeping procedures outlined in the QAPP (Appendix B) will be followed throughout the groundwater monitoring program.

Additional monitoring wells may be added to the groundwater monitoring program at any time. Specifically, new monitoring wells installed at sites not included in this Stage 1 Abatement Plan could be included based on location or other relevance to this program. Additional analytes to those included in Table 9-1 may also be added based on relevance to this program.

Surface water samples will be collected from the golf course pond during the biannual groundwater monitoring sampling events. These samples will be analyzed for the parameters outlined in Table 9-1.

Table 9-1. Analytical Parameters and Testing Methods for the Phase 1 Long-Term Groundwater Monitoring Program

Analysis	Method	Testing Location
Groundwater Elevation	Groundwater probe	Field
Dissolved Oxygen (DO)	DO probe	Field, flow-through cell
Temperature	Digital thermometer	Field, flow-through cell
pH	pH probe	Field, flow-through cell
Specific Conductivity	Conductivity meter	Field, flow-through cell
Oxidation-Reduction Potential	EH meter	Field, flow-through cell
Turbidity	Turbidity meter	Field, flow-through cell
Total Dissolved Solids	EPA Method 160.1	Laboratory
Nitrate (NO_3)	EPA Method 300	Laboratory
Nitrite (NO_2)	EPA Method 300	Laboratory
Ammonia	EPA Method 350.2	Laboratory
Total Kjeldahl Nitrogen (TKN)	EPA Method 351.2	Laboratory

Method Reference:
EPA, 1993. *EPA 100-400 Series—Methods for the Determination of Inorganic Substances in Environmental Samples.* EPA/600R-93-100. U.S. Environmental Protection Agency, Office of Research and Development, Environmental Monitoring Systems Laboratory, Cincinnati, Ohio. August 1993.

1397 021

12.0 Schedule of Activities

The anticipated schedule for Phase 1 of the Stage 1 Abatement Plan for Nitrate-Impacted Groundwater is presented in Table 12-1. The proposed drilling program will be completed in two years, with seven monitoring wells installed in 2001 and the remaining seven wells installed in 2002. Biannual groundwater monitoring will be initiated in September 2001 and will be performed every six months (March and September, annually) for the duration of the Phase 1 Stage 1 Abatement Plan. Biannual groundwater samples will be analyzed for the parameters outlined in Table 9-1. Groundwater samples will be analyzed for the parameters outlined in Table 8-4 during the third biannual groundwater monitoring event in September 2002, following the completion of the proposed monitoring well installations.

Additional phases of investigation will be proposed at a later date for areas of nitrate-impacted groundwater not specifically named by NMED in their letter dated July 2, 1999 (NMED, 1999).

Table 12-1. Phase 1 Project Schedule

Task	Start Date	Duration
Submit Phase 1 Stage 1 Abatement Plan to NMED for review	31 August 2000	90 days
Receive comments from NMED on Stage 1 Abatement Plan	3 January 2001	
Prepare response to NMED Stage 1 Abatement Plan comments	01 March 2001	60 days
Implement Phase 1 of the Stage 1 Abatement Plan	01 March 2001	
Initiate drilling program for the installation of seven monitoring wells	01 April 2001	180 days
First biannual groundwater monitoring event (Table 9-1)	01 September 2001	150 days
Submit first biannual groundwater monitoring report	01 January 2002	
Initiate drilling program for the installation of remaining seven monitoring wells	01 March 2002	180 days
Second biannual groundwater monitoring event (Table 9-1)	01 March 2002	150 days
Submit second biannual groundwater monitoring report	01 July 2002	
Third biannual groundwater monitoring event (Table 8-4)	01 September 2002	150 days
Submit third biannual groundwater monitoring report	01 January 2003	
Prepare Final Stage 1 Abatement Report for all Phase 1 activities	01 December 2002	150 days
Submit Final Phase 1 Stage 1 Abatement Plan Report to NMED	01 April 2003	

Notes:
NMED New Mexico Environment Department

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ACRONYMS

AFB	Air Force Base
AFCEE	Air Force Center for Environmental Excellence
bgs	below ground surface
BWP	Base-Wide Plan
DO	dissolved oxygen
DOC	dissolved organic carbon
DQO	data quality objective
EMR	Environmental Management, Restoration Branch
EPA	U.S. Environmental Protection Agency
ERPIMS	Environmental Resource Program Information Management Systems
FSP	field sampling plan
ft	foot/feet
IDW	investigation derived waste
PARCC	precision, accuracy, representativeness, completeness, and comparability
PQL	practical quantition limit
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
QCSR	quality control summary report
SOP	standard operating procedures
SSHP	site safety and health plan
TDS	total dissolved solids
TKN	total Kjeldahl nitrogen
TOC	total organic carbon
USACE	U.S. Army Corps of Engineers
USAF	United States Air Force

1397 023

Table B-2. Data Quality Objectives and Data Types/Issues

Sampling Program	Data Quality Objectives and Rationale	Data	Method[a]	Data Type	Data Uses
Subsurface soil sampling	Collect soil samples during drilling to determine nitrate-impacted sediments.	Nitrate/Nitrite	E300	Definitive	Site characterization
		Total Kjeldahl nitrogen	E351.2	Definitive	
		Total organic compound	Walkley Black	Definitive	
Groundwater sampling	Collect groundwater samples to determine the three-dimensional plume boundaries of nitrate-impacted groundwater and determine sources of nitrate to groundwater.	Dissolved oxygen	Dissolved oxygen probe	Screening	Site characterization
		Temperature	Digital thermometer	Screening	
		pH	pH probe	Screening	
		Specific conductivity	Conductivity meter	Screening	
		Oxidation-reduction potential	EH meter	Screening	
		Turbidity	Turbidity meter	Screening	
		Ferrous iron	Hach test kit	Screening	
		Stable isotopes (nitrogen, oxygen, and hydrogen)	Mass spectrometry	Screening	
		Anion (nitrate, nitrite, bromide, chloride, sulfate)	E300	Definitive	
		Total Kjeldahl nitrogen	E351.2	Definitive	
		Dissolved organic carbon	E415.1	Definitive	
		Iron/manganese	SW-846 6010B	Definitive	
		Nitroaromatics	SW-846 8330	Definitive	
		Alkalinity as carbonate and bicarbonate	E310.1	Definitive	
		Ammonia	E350.2	Definitive	
		Total dissolved solids	E160.1	Definitive	
Groundwater monitoring program and surface water sampling	Collect groundwater and surface water samples biannually during the abatement plan to monitor nitrate concentrations.	Dissolved oxygen	Dissolved oxygen probe	Screening	Site characterization
		Temperature	Digital thermometer	Screening	
		pH	pH probe	Screening	
		Specific conductivity	Conductivity meter	Screening	
		Oxidation-reduction potential	EH meter	Screening	
		Turbidity	Turbidity meter	Screening	
		Nitrate/nitrite	E300	Definitive	
		Ammonia	E350.2	Definitive	
		Total Kjeldahl nitrogen	E351.2	Definitive	
		Total dissolved solids	E160.1	Definitive	

Notes:

[a] Analytical Methods:
EPA Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW 846, EPA Third Edition, September 1986; Final Update I, July 1992; Final Update IIA, August 1993; Final Update II, September 1994; Final Update IIB, January 1995; Final Update III, December 1996.
EPA 100-400 Series - Methods for the Determination of Inorganic Substances in Environmental Samples(EPA/600R-93/100, August 1993).
Methods of Soils Analysis, American Society of Agronomy, 1982.

1397 024

B8.0 ANALYTICAL PROCEDURES

The analytical procedures for this project will be consistent with those outlined in Section 8.0 of the BWP QAPP (USAF, 1996). The following analyses will be used during the Stage 1 Abatement Plan for Nitrate-Impacted Groundwater:

- Nitrate, nitrite, chloride, bromide, and sulfate will be analyzed by U.S. Environmental Protection Agency (EPA) Method 300, as specified in the laboratory SOP (EPA, 1993).
- Ammonia will be analyzed by EPA Method 350.2, as specified in the laboratory SOP (EPA, 1993).
- Total Kjeldahl nitrogen (TKN) will be analyzed by EPA Method 351.2, as specified in the laboratory SOP (EPA, 1993).
- Dissolved organic carbon (DOC) will be analyzed by EPA Method 415.1, as specified in the laboratory SOP (EPA, 1993).
- Total organic carbon (TOC) content in soil will be analyzed by the Walkley-Black method (ASA, 1982) as specified in the laboratory SOP.
- Nitroaromatics will be analyzed by EPA Method SW-846 8330, as specified in the laboratory SOP (EPA, 1996).
- Iron and manganese will be analyzed by EPA Method SW-846 6010B, as specified in the laboratory SOP (EPA, 1996).
- Alkalinity will be analyzed by EPA Method 310.1, as specified in the laboratory SOP (EPA, 1993).
- Stable isotopes of nitrogen, oxygen, and hydrogen will be analyzed by mass spectrometry.
- Total dissolved solids (TDS) will be analyzed by EPA Method 160.1, as specified in the laboratory SOP (EPA, 1993).

The analytical method and the associated performance criteria (control limits, PQLs, and corrective action) to be used for this investigation are presented in Attachment 1 of this project-specific QAPP.

1397 025

Table B1-2. Nitroaromatics by High Performance Liquid Chromatography, SW-846 8330, Calibrations Specifications and Corrective Action Summary

Analytical Method[a]	Parameter	QC Element	Frequency	Acceptance Criteria	Corrective Action
SW-846 8330 Explosives by high performance liquid chromatography (HPLC)	Explosives	Initial calibration (5 point minimum) Lowest standard at or below the practical quantitation limit (PQL)	Prior to analysis and as required	• Relative Standard Deviation (RSD) <20%, average calibration factor may be used; linear calibration required	• Evaluate the system • Repeat initial calibration
		Initial calibration verification (ICV) Mid level standard and continuing calibration verification (CCV)	Prior to each 12 hour shift, after every 10 samples, and at the end of the analytical sequence	• % Difference for average of all daily check standards ≤15% of expected concentration compared to response from ICAL	• Evaluate system/standard • Repeat initial calibration
		Retention time windows	Established by all standards in the analytical sequence	• Retention times must be within established retention time windows for every CCV and every sample	• Reanalyze CCV and affected samples
		Method blank	1 per preparation batch (≤20 samples)	• < ½ PQL	• Reanalyze blank • Re-prep/reanalyze blank and associated samples
		Surrogate spike	Every sample, method blank, LCS and MS/MSD	% Recovery within quality control (QC) acceptance criteria (Refer to Table B1-1)	Re-extract/reanalyze once If still out, report both sets of data Narrate all outliers
		Matrix spike (MS)	1 per preparation batch (≤20 samples)	• % Recovery within QC acceptance criteria (Refer to Table B1-1)	• If surrogate recoveries and LCS OK, matrix interference may be suspected • Reprep/reanalyze if matrix is not a factor • Narrate all outliers
		Matrix spike duplicate (MSD)	1 per preparation batch (≤20 samples)	% Recovery and/or RPD within QC acceptance criteria (Refer to Table B1-1)	• Same as MS
		Laboratory control sample (LCS)	1 per preparation batch (≤20 samples)	• % Recovery within project QC acceptance criteria (Refer to Table B1-1)	• Reanalyze LCS • Re-prep/reanalyze LCS and all associated samples

Notes:

a EPA Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW 846, Third Edition, September 1986; Final Update I, July 1992; Final Update IIA, August 1993; Final Update II, September 1994; Final Update IIB, January 1995; Final Update III, December 1996.

CCV continuing calibration verification
LCS laboratory control sample
QC quality control
HPLC high performance liquid chromatography
MS matrix spike
RPD relative percent difference
ICAL initial calibration
MSD matrix spike duplicate
RSD relative standard deviation
ICV initial calibration verification
PQL practical quantitation limit

Table B1-7. Groundwater Anions and Water Quality, Quality Control Criteria for Laboratory Data Evaluation

Analytical Method[a]	Spiking Compounds	Accuracy[a] Percent Recovery (%)	Precision[a] (RPD %)
Matrix Spike/Matrix Spike Duplicate/Matrix Duplicate[b]			
EPA 300.0	Nitrate	75-125	25
	Nitrite	75-125	25
	Bromide	75-125	25
	Chloride	75-125	25
	Sulfate	75-125	25
EPA 350.3 and mod. EPA 350.3	Ammonium	75-125	25
EPA 351.4 and mod. EPA 351.4	Total Kjeldahl Nitrogen	75-125	25
EPA 415.1/415.2 and Walkley Black	Total Organic Carbon	75-125	25
EPA 310.1	Alkalinity		
	Bicarbonate	75-125	25
	Carbonate	75-125	25
EPA 160.1	Total Dissolved Solids	NA	25
Laboratory Control Samples			
EPA 300.0	Nitrate	80-120	NA
	Nitrite	80-120	NA
	Bromide	80-120	NA
	Chloride	80-120	NA
	Sulfate	80-120	NA
EPA 350.3 and mod. EPA 350.3	Ammonium	80-120	NA
EPA 351.4 and mod. EPA 351.4	Total Kjeldahl Nitrogen	80-120	NA
EPA 415.1/415.2 and Walkley Black	Total Organic Carbon	80-120	NA
EPA 310.1	Alkalinity		
	Bicarbonate	80-120	NA
	Carbonate	80-120	NA
EPA 160.1	Total Dissolved Solids	80-120	NA

Notes:
[a] EPA 100-400 Series - Methods for the Determination of Inorganic Substances in Environmental Samples (EPA/600R-93/100, August 1993). Methods of Soils Analysis, American Society of Agronomy, 1982.
[b] Relative percent difference (RPD) calculated between parent sample and matrix duplicate
NA not applicable

1397 027

Table B1-8. Determination of Anions by Ion Chromatography- EPA 300.0 Calibration Specifications and Corrective Action Summary

Analytical Method[a]	Parameter	QC Element	Frequency	Acceptance Criteria	Corrective Action
EPA 300.0 Ion Chromatography	Chloride, Fluoride, Sulfate, Nitrate/Nitrite	Initial multipoint calibration (minimum of three concentrations plus blank)	Initially and as required	Correlation coefficient (r) ≥ 0.995	• Check calculations • Recalibrate
		Initial calibration verification (ICV)	Daily, prior to sample analysis	± 10% of expected concentration	• Reanalyze ICV • Recalibrate if ICV still out
		Continuing calibration verification (CCV) mid-range	Every 10 samples and at end of run	± 5% of expected concentration	• Reanalyze affected samples back to last acceptable CCV
		Calibration blank- Initial calibration blank (ICB), Continuing calibration blank (CCB)	Daily after each ICV and CCV	< Practical quantitation limit (PQL)	• Reanalyze blank • Clean system • Reanalyze samples back to last clean blank
		Method blank	1 per preparation batch (≤ 20 samples)	< PQL	• Reanalyze blank • Reprep/reanalyze blank and all associated samples
		Matrix spike (MS)	1 per preparation batch (≤ 20 samples)	% Recovery within quality control (QC) acceptance criteria (Refer to Table B1-7)	• Assess data (4x rule) • If LCS recoveries are within acceptance criteria, matrix interference may be suspected • Reanalyze once if matrix is not a factor • Narrate all outliers
		Matrix spike duplicate (MSD) or Matrix duplicate (MD)	1 per preparation batch (≤ 20 samples)	% Recovery and/or RPD within QC acceptance criteria (Refer to Table B1-7)	• Same as MS
		Laboratory control sample (LCS)	1 per preparation batch (≤ 20 samples)	% Recovery within QC acceptance criteria (Refer to Table B1-7)	• Reanalyze LCS • Reprep/reanalyze all associated samples

Notes:

[a] EPA 100-400 Series - Methods for the Determination of Inorganic Substances in Environmental Samples (EPA/600R-93/100, August 1993).

CCB continuing calibration blank; CCV continuing calibration verification; ICB initial calibration blank; ICV initial calibration verification
LCS laboratory control standard; MD matrix duplicate; MS matrix spike; MSD matrix spike duplicate
PQL practical quantitation limit; QC quality control; RPD Relative percent difference

Table B1-9. Determination of Ammonium by Ion Selective Electrode, EPA 350.3 Calibration Specifications and Corrective Action Summary

Analytical Method[a]	Parameter	QC Element	Frequency	Acceptance Criteria	Corrective Action
EPA 350.3 Ion Selective Electrode	Ammonium	Initial multipoint calibration (3 standards + 1 blank)	Initially and as required	Correlation coefficient (r) =0.995	• Recalibrate
		Initial calibration verification (ICV)	Prior to sample analysis	90-110% of initial calibration response	• Reanalyze standard • Recalibrate
		Continuing calibration verification (CCV)	After every 10 samples and at the end of the run	90-110% of initial calibration response	• Reprep/reanalyze affected samples back to last acceptable CCV
		Calibration blank- Initial calibration blank (ICB) Continuing calibration blank (CCB)	After each ICV and CCV	<Practical quantitation limit (PQL)	• Reanalyze all affected samples • Reanalyze blank
		Method Blank	1 per preparation batch (≤20 samples)	< Practical quantitation limit (PQL)	• Reanalyze blank • Reprep/reanalyze all affected samples back to last acceptable CCV
		Matrix Spike (MS)	1 per preparation batch (≤ 20 samples)	% recovery within quality control (QC) acceptance criteria (Refer to Table B1-7)	• Assess data (4x rule) • Rerun once, report both sets of data • Narrate outliers
		Matrix Spike Duplicate (MSD) or Matrix duplicate (MD)	1 per preparation batch (≤ 20 samples)	% Recovery and/or relative percent difference (RPD) within QC acceptance criteria (Refer to Table B1-7)	• Assess data • Rerun once, report both sets of data • Narrate all outliers
		Laboratory Control Sample (LCS)	1 per preparation batch (≤ 20 samples)	% recovery within QC acceptance criteria (Refer to Table B1-7)	• Rerun LCS • Reprep/reanalyze all affected samples

Notes:

[a] EPA 100-400 Series - Methods for the Determination of Inorganic Substances in Environmental Samples (EPA/600R-93/100, August 1993).

CCB	continuing calibration blank	CCV	continuing calibration verification	ICB	initial calibration blank	ICV	initial calibration verification
LCS	laboratory control standard	MD	matrix duplicate	MS	matrix spike	MSD	matrix spike duplicate
PQL	practical quantitation limit	QC	quality control	RPD	Relative percent difference		

Table B1-10. Determination of Total Kjeldahl Nitrogen by Ion Selective Electrode, EPA 351.4 Calibration Specifications and Corrective Action Summary

Analytical Method[a]	Parameter	QC Element	Frequency	Acceptance Criteria	Corrective Action
EPA 351.4 Ion Selective Electrode	Total Kjeldahl Nitrogen	Initial multipoint calibration (3 standards + 1 blank)	Initially and as required	Correlation coefficient (r) =0.995	• Recalibrate
		Initial calibration verification (ICV)	Prior to sample analysis	90-110% of initial calibration response	• Reanalyze standard • Recalibrate
		Continuing calibration verification (CCV)	After every 10 samples and at the end of the run	90-110% of initial calibration response	• Reprep/reanalyze affected samples back to last acceptable CCV
		Calibration blank- Initial calibration blank (ICB) Continuing calibration blank (CCB)	After each ICV and CCV	<Practical quantitation limit (PQL)	• Reanalyze all affected samples • Reanalyze blank
		Method Blank	1 per preparation batch (≤20 samples)	< PQL	• Reanalyze blank • Reprep/reanalyze all affected samples back to last acceptable CCV
		Matrix Spike (MS)	1 per preparation batch (≤ 20 samples)	% recovery within quality control (QC) acceptance criteria (Refer to Table B1-7)	• Assess data (4x rule) • Rerun once, report both sets of data • Narrate outliers
		Matrix Spike Duplicate (MSD) or Matrix duplicate (MD)	1 per preparation batch (≤ 20 samples)	% Recovery and/or RPD within QC acceptance criteria (Refer to Table B1-7)	• Assess data • Rerun once, report both sets of data • Narrate all outliers
		Laboratory Control Sample (LCS)	1 per preparation batch (< 20 samples)	% recovery within Hill Air Force Base QC acceptance criteria (Refer to Table B1-7)	• Rerun LCS • Reprep/reanalyze all affected samples

Notes:
[a] EPA 100-400 Series - Methods for the Determination of Inorganic Substances in Environmental Samples (EPA/600R-93/100, August 1993).

CCB	continuing calibration blank	CCV	continuing calibration verification	ICB	initial calibration blank	ICV	initial calibration verification
LCS	laboratory control standard	MD	matrix duplicate	MS	matrix spike	MSD	matrix spike duplicate
PQL	practical quantitation limit	QC	quality control	RPD	Relative percent difference		

1397 030

Table B1-11. Determination of Total Organic Carbon, EPA 415.1/415.2, Calibration Specifications and Corrective Action Summary

Analytical Method[a]	Parameter	QC Element	Frequency	Acceptance Criteria	Corrective Action
EPA 415.1/415.2 Combustion/Oxidation	Total Organic Carbon	Initial multipoint calibration (minimum of three concentrations + blank)	Initially and as required	Correlation coefficient (r) = 0.995	• Check calculations • Recalibrate
		Initial calibration verification (ICV)	Prior to sample analysis	± 10% of expected concentration	• Reanalyze ICV • Prepare new standard if necessary • Recalibrate if ICV still out
		Continuing calibration verification (CCV) mid-range standard	Every 15 samples and at end of run	± 10% of expected concentration	• Reanalyze ICV • Prepare new standard if necessary • Reanalyze affected samples back to last acceptable CCV
		Calibration blank-Initial calibration blank (ICB), Continuing calibration blank (CCB)	Daily after each ICV and CCV	< Practical quantitation limit (PQL)	• Reanalyze blank • Clean system • Reanalyze samples back to last acceptable CCB
		Method blank	1 per preparation batch (= 20 samples)	< PQL	• Reanalyze blank • Reprep/reanalyze blank and all associated samples
		Matrix spike (MS)	1 per preparation batch (= 20 samples)	% Recovery within QC acceptance criteria (Refer to Table B1-7)	• Assess data (4 x rule) • If LCS recoveries are within acceptance criteria, then matrix interference maybe suspected • Reanalyze once if matrix is not a factors • Narrate all outliers
		Matrix spike duplicate (MSD) or Matrix duplicate (MD)	1 per preparation batch (= 20 samples)	% Recovery and/or RPD within QC acceptance criteria (Refer to Table B1-7)	• Same as MS
		Laboratory control sample (LCS)	1 per preparation batch (= 20 samples)	% Recovery within QC acceptance criteria (Refer to Table B1-7)	• Reanalyze LCS • Reprep/reanalyze all associated samples

Notes:

[a] EPA 100-400 Series - Methods for the Determination of Inorganic Substances in Environmental Samples (EPA/600R-93/100, December 1996).

CCB continuing calibration blank; CCV continuing calibration verification; ICB initial calibration blank; ICV initial calibration verification
LCS laboratory control standard; MD matrix duplicate; MS matrix spike; MSD matrix spike duplicate
PQL practical quantitation limit; QC quality control; RPD Relative percent difference

1397 031

Table B1-12. Determination of Total Organic Carbon, Walkley-Black Method Calibration Specifications and Corrective Action Summary

Analytical Method[a]	Parameter	QC Element	Frequency	Acceptance Criteria	Corrective Action
Walkley-Black-Titration	Total Organic Carbon	Method blank	1 per preparation batch (≤20 samples)	< Practical quantitation limit (PQL)	• Reanalyze blank • Reprep/reanalyze blank and all associated samples
		Matrix spike (MS)	1 per preparation batch (≤20 samples)	% Recovery within QC acceptance criteria (Refer to Table B1-7)	• If LCS recoveries are within QC limits, matrix interference may be suspected • If recovery problems may not be attributed to matrix, reprep/reanalyze one • Narrate all outliers
		Matrix spike duplicate (MSD)	1 per preparation batch (≤20 samples)	% Recovery and/or RPD within QC acceptance criteria (Refer to Table B1-7)	• Same as MS
		Laboratory control sample (LCS)	1 per preparation batch (≤20 samples)	% Recovery within QC acceptance criteria (Refer to Table B1-7)	• Reanalyze LCS • Reprep/reanalyze all associated samples • Narrate all outliers

Notes:
[a] Methods of Soil Analysis, American Society of Agronomy, 1982.
LCS laboratory control standard
MS matrix spike
MSD matrix spike duplicate
QC quality control
RPD Relative percent difference

1397 032

Table B1-13. Titrimetric Determination of Alkalinity, EPA 310.1, Calibration Specifications And Corrective Action Summary

Analytical Method[a]	Parameter	QC Element	Frequency	Acceptance Criteria	Corrective Action
EPA 310.1 Titrimetric	Alkalinity	Initial calibration	Initially and as required	According to manufacturer's instructions	According to manufacturer's instructions
		Initial calibration verification (ICV)	Prior to sample analysis	± 10% of expected concentration	• Reanalyze ICV • Recalibrate if ICV still out
		Continuing calibration verification (CCV)	Every 20 samples and at end of run	± 10% of expected concentration	• Reanalyze affected samples back to last acceptable CCV
		Calibration blank - Initial calibration blank (ICB), Continuing calibration blank (CCB)	Daily after each ICV and CCV	< Practical quantitation limit (PQL)	• Reanalyze blank • Clean system • Reanalyze samples back to last clean blank
		Method blank	1 per preparation batch (≤20 samples)	< PQL	• Reanalyze blank • Reprep/reanalyze blank and all associated samples
		Matrix spike (MS)	1 per preparation batch (≤20 samples)	% Recovery within quality control (QC) acceptance criteria (Refer to Table B1-7)	• Assess data (4 x rule) If LCS recoveries are within acceptance criteria then matrix interference may be suspected • Reanalyze once if matrix is not a factor • Narrate all outliers
		Matrix spike duplicate (MSD) or Matrix duplicate (MD)	1 per preparation batch (≤20 samples)	% Recovery and/or relative percent difference (RPD) within QC acceptance criteria (Refer to Table B1-7)	Same as MS
		Laboratory control sample (LCS)	1 per preparation batch (≤20 samples)	% Recovery within QC acceptance criteria (Refer to Table B1-7)	• Reanalyze LCS • Reprep/reanalyze all associated samples

Notes:

[a] EPA 100-400 Series - Methods for the Determination of Inorganic Substances in Environmental Samples (EPA/600R-93/100, August 1993).

CCB continuing calibration blank; CCV continuing calibration verification; ICB initial calibration blank; ICV initial calibration verification; LCS laboratory control standard; MD matrix duplicate; MS matrix spike; MSD matrix spike duplicate; PQL practical quantitation limit; QC quality control; RPD Relative percent difference

1397 033

Table B1-14. Gravimetric Determination of Total Dissolved Solids – EPA 160.1 Calibration Specifications and Corrective Action Summary

Analytical Method[a]	Parameter	QC Element	Frequency	Acceptance Criteria	Corrective Action
EPA 160.1 Gravimetric	Total Dissolved Solids	Balance calibration (0.5g, 5.0g, 50g Class S weights)	Prior to each batch	Difference between measured and true weights must fall within acceptance limits	• Recalibrate • Service balance if catastrophic
		Method blank	1 per preparation batch (= 20 samples)	< Practical quantitation limit (PQL)	• Reanalyze blank • Reprep/reanalyze blank and all associated samples
		Matrix duplicate (MD)	1 per preparation batch (= 20 samples)	RPD within QC acceptance criteria (Refer to Table B1-7)	• Evaluate LCS
		Laboratory control sample (LCS)	1 per preparation batch (= 20 samples)	% Recovery within QC acceptance criteria (Refer to Table B1-7)	• Reanalyze LCS • Reprep/reanalyze all associated samples • Narrate all outliers

Notes:

[a] EPA 100-400 Series - Methods for Determination of Inorganic Substances in Environmental Samples (EPA/600R-93/100, August 1993).

g gram
LCS laboratory control sample
MD matrix duplicate
PQL practical quantitation limit
RPD Relative percent difference
QC Quality control

1397 034

Table B1-15. Groundwater Anions, Cations, and Water Quality Practical Quantitation Limits

Analysis	Analytical Method[a]	Analyte	Practical Quantitation Limits[a]	
			Water (mg/l)	Soil (mg/kg)
Anions	EPA 300	Nitrate	10	b
		Nitrite	1	b
		Bromide	b	b
		Chloride	b	b
		Sulfate	b	b
Ammonia	EPA 350.2	Ammonia	b	b
Total Kjeldahl Nitrogen	EPA 351.2	Total Kjeldahl Nitrogen	b	b
Dissolved Organic Carbon	EPA 415.1	Total Organic Carbon	1.0	NA
	Walkley-Black	Total Organic Carbon	NA	b
Alkalinity	EPA 310.1	Bicarbonate (HCO3)	b	b
		Carbonate (CO3)	b	b
		Total	b	b
Total Dissolved Solids	EPA 160.1	Total Dissolved Solids	b	NA

Notes:

a EPA Methods for the Determination of Inorganic Substances in Environmental Samples (EPA/600R-93/1--, August 1993). Methods of Soils Analysis, American Society of Agronomy, 1982.

b Contract laboratory practical quantitation limit to be used as the default.

NA not applicable

mg/kg milligrams per kilogram

mg/L milligrams per liter

1397 035