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REPORTS

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JAN. 2002

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RECEIPT ACKNOWLEDGMENT TRANSMITTAL FORM

To: Denny G. Foust
NMOCD, Aztec, NM

January 30, 2002

From: A. B. Russell

Subject: **Cancellation of the Site Characterization Work Plan for Gasbuggy, New Mexico, Revision 0**

Since you are not on the controlled distribution list for the Site Characterization Work Plan for Gasbuggy, New Mexico, Revision 1, this memo constitutes notification of cancellation for your Rev. 0 work plan, issued February 2001, Controlled Copy No. 9.
Please stamp your document uncontrolled or destroy it.

Please sign and date this receipt acknowledgment form and return to Angelica Russell within ten working days at the address below:

IT Corporation
P. O. Box 93838
Las Vegas, NV 89193-3838
M/S 439

JAN 2002

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IT Corporation
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North Las Vegas, NV 89030-4129
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January 30, 2002

Project No.: 831842.02080005

Ms. Monica Sanchez
Offsites Project Manager
National Nuclear Security Administration Nevada Operations Office
P. O. Box 98518
Las Vegas, NV 89193-8581

Contract No. DE-AC08-97NV13052
Transmittal of the Site Characterization Work Plan
for Gasbuggy, New Mexico, Revision 1

Dear Ms. Sanchez:

Enclosed is a copy of the subject document. This version incorporates comments received from the Office of Public Affairs and Information. Copies are also being provided to the Desert Research Institute, the New Mexico Environment Department, the U.S. Forest Service, New Mexico Oil Conservation Division, and the Jicarilla Apache Nation.

If you have any questions or wish to discuss the contents of the document, please contact Rob Boehlecke at 295-2099 or me at 295-2501.

Sincerely,

IT CORPORATION

David Stahl, PE
Offsites Project Manager

JAN 2002

Enclosure: As stated

cc w/encl:
S. D. Lawrence, NNSA/NV
B. Wilborn, NNSA/NV
→ D. G. Foust, New Mexico Oil Conservation Division
M. S. Catron, U.S. Forest Service
C. J. Vigil-Muniz, Jicarilla Apache Nation
J. Chapman, Desert Research Institute

Nevada
Environmental
Restoration
Project

DOE/NV--690-REV. 1

National Nuclear Security Administration

Site Characterization Work Plan for Gasbuggy, New Mexico

Controlled Copy No.: UNCONTROLLED
Revision No.: 1

January 2002

Environmental Restoration
Division

U.S. Department of Energy
National Nuclear Security Administration
Nevada Operations Office

DOE/NV--690-REV. 1

SITE CHARACTERIZATION WORK PLAN FOR GASBUGGY, NEW MEXICO

U.S. Department of Energy
National Nuclear Security Administration
Nevada Operations Office
Las Vegas, Nevada

UNCONTROLLED

Controlled Copy No.: ____

Revision No.: 1

January 2002

SITE CHARACTERIZATION WORK PLAN
FOR GASBUGGY, NEW MEXICO

Approved by: ______________________ Date: 1/25/02

Monica Sanchez, Project Manager
Offsites Project

Approved by: ______________________ Date: 1/25/02

Runore C. Wycoff, Division Director
Environmental Restoration Division

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List of Acronyms and Abbreviations

AEC	U.S. Atomic Energy Commission
ALARA	As-low-as-reasonably-achievable
AOC	Area of concern
Ar-37	Argon-37
Ar-39	Argon-39
bgs	Below ground surface
BLM	U.S. Bureau of Land Management
C-13	Carbon-13
C-14	Carbon-14
CEDE	Committed effective dose equivalent
CERCLA	*Comprehensive Environmental Response Compensation and Liability Act*
CFR	*Code of Federal Regulations*
CLP	Contract Laboratory Program
CNF	Carson National Forest
COPC	Contaminants of potential concern
CP	Control Point
CRDL	Contract-required detection limit
Cs-137	Cesium-137
CSM	Conceptual Site Model
CV	Coefficient of Variation
DOE	U.S. Department of Energy
DQO	Data Quality Objective
DRI	Desert Research Institute
DRO	Diesel-range organics
EIC	Eberline Instrument Corporation
EM	Electromagnetic

List of Acronyms and Abbreviations *(Continued)*

EPA	U.S. Environmental Protection Agency
EPNG	El Paso Natural Gas Company
ERD	Environmental Restoration Division
°F	Degree Fahrenheit
FEHM	Finite Element Heat Mass Simulator
ft	Foot (feet)
ft^2	Square foot (feet)
GC	Gas chromatography
GC/MS	Gas chromatography/mass spectrometry
GPR	Ground-penetrating radar
gpd/ft	Gallon per day per foot
GPS	Global Positioning System
GRO	Gasoline-range organics
HP	Helicopter pad
HPLC	High performance liquid chromatography
ICP	Inductively coupled plasma
ICRP	International Commission on Radiological Protection
IDW	Investigation-derived waste
ILCR	Incremental lifetime cancer risk
in.	Inch(es)
IO	Isolated occurrence
ITLV	IT Corporation, Las Vegas
kt	Kiloton
Kr-85	Krypton-85
LCS	Laboratory control sample
LLD	Lower limit of detectability

List of Acronyms and Abbreviations *(Continued)*

LLNL	Lawrence Livermore National Laboratory
LQC	Laboratory quality control
LRL	Lawrence Radiation Laboratory
LTHMP	Long-Term Hydrologic Monitoring Program
m^2/d	Square meter per day
µg/kg	Microgram per kilogram
md	Millidarcie
mCi	Millicurie
mg/kg	Milligram per kilogram
mg/L	Milligram per liter
mR	Milliroentgen
mrem	Millirem
mrem/yr	Millirem per year
MS	Matrix spike
MSD	Matrix spike duplicate
M&TE	Measurement and testing equipment
NCP	National Contingency Plan
NCR	Nonconformance Report
NEPA	*National Environmental Policy Act*
NIST	National Institute for Standards and Technology
NMAC	*New Mexico Administrative Code*
NMED	New Mexico Environment Department
NM OCD	New Mexico Oil Conservation Division
NM QAPP	*New Mexico Quality Assurance Project Plan*
NM WQCC	New Mexico Water Quality Control Commission
NNSA/NV	National Nuclear Security Administration Nevada Operations Office

List of Acronyms and Abbreviations (Continued)

NRC	U.S. Nuclear Regulatory Commission
NTS	Nevada Test Site
NTSWAC	Nevada Test Site Waste Acceptance Criteria
NV ERP	Nevada Environmental Restoration Project
PAL	Preliminary Action Level
PB	Preparation blank
%R	Percent recovery
PCB	Polychlorinated biphenyl
pCi/g	Picocurie per gram
pCi/mL	Picocurie per milliliter
pCi/L	Picocurie per liter
PHS	U.S. Public Health Service
PID	Photoionization detector
ppm	Part per million
PRG	Preliminary remediation goal
psi	Pound per square inch
QA	Quality assurance
QAC	Quality Assurance Coordinator
QAPP	Quality Assurance Project Plan
QC	Quality control
RAMS	Remote area monitoring system
RESRAD	Residual Radioactivity
RCRA	*Resource Conservation and Recovery Act*
RME	Reasonable maximum exposure
RPD	Relative percent difference
RTP	Recording Trailer Park

List of Acronyms and Abbreviations *(Continued)*

SF	Slope factor
Sr-90	Strontium-90
SGZ	Surface Ground Zero
SSHASP	Site-specific health and safety plan
STALLKAT	System to analyze low levels of krypton and tritium
SVOC	Semivolatile organic compounds
TAL	Target Analyte List
TCLP	Toxicity Characteristic Leaching Procedure
TEDE	Total effective dose equivalent
TLD	Thermoluminescent dosimeter
TOUGH2	Transport of unsaturated groundwater heat simulator
TPH	Total petroleum hydrocarbons
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
UST	Underground storage tank
VOA	Volatile organic analyses
VOC	Volatile organic compounds
Xe-133	Xenon-133
<	Less than

1.0 Introduction

The scope of this work plan is to document the environmental sample collection objectives and the proposed technical site investigation strategies that will be utilized during the Gasbuggy Site characterization. This investigation is being conducted by the U.S. Department of Energy (DOE), National Nuclear Security Administration Nevada Operations Office (NNSA/NV).

Project Gasbuggy was the first of three joint government-industry experiments conducted under the Plowshare program to test the effectiveness of nuclear explosives to fracture low-permeability natural gas reservoirs to stimulate production. Gasbuggy consisted of one 29-kiloton (kt) nuclear device (DOE/NV, 2000) emplaced in a boring at a depth of 4,240 feet (ft) below ground surface (bgs) in the Pictured Cliffs sandstone formation and detonated on December 10, 1967 (AEC, 1971). The Gasbuggy Site is located approximately 55 air miles east of Farmington, New Mexico, in Rio Arriba County within the Carson National Forest (Figure 1-1). Six major natural gas production tests were conducted after reentry drilling was completed in January 1968. Long-term production testing was completed in November 1973 and pressure monitoring activities were completed in late 1976 (DOE/NV, 1978).

Site restoration activities were conducted in August and September 1978, and included well plugging and abandonment, decontamination and disposal of equipment, and soil sampling and analysis. No soil or soil moisture samples collected during the 1978 restoration exceeded established release criteria for radioactivity; therefore, no soil remediation was required (DOE/NV, 1983).

1.1 Purpose

Although previous characterization and restoration activities were performed for the surface and shallow subsurface (<20 ft bgs), there was not formal closure of the site. In addition, these efforts did not adequately address the potential for chemical contamination at the surface/shallow subsurface. Additionally, the subsurface hazards have not been evaluated for potential migration outside of the current site subsurface intrusion restrictions. The goal of this environmental investigation at the Project Gasbuggy Site is to collect data of sufficient quantity and quality to establish current site conditions, and to use the data to identify and evaluate if further remedial action is required to achieve

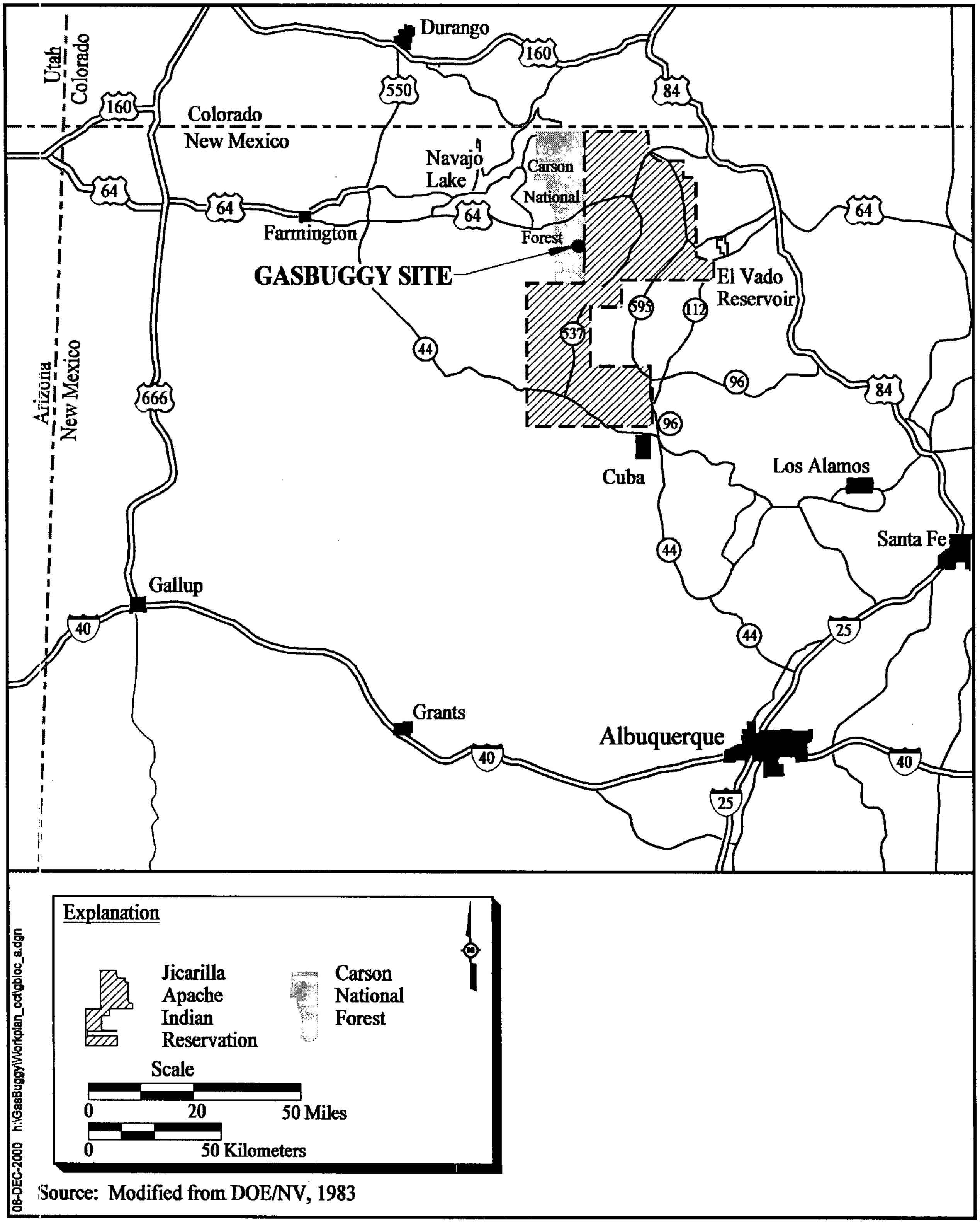


Figure 1-1
Gasbuggy Site Location Map

permanent closure of the site that is protective of human health and the environment. This investigation will utilize available data, documented historical knowledge, and process knowledge from similar sites to the extent possible. Historical and/or new data collected will be of sufficient quantity and quality to be used in addressing the following data quality objectives (DQOs), as required:

- Determine the nature and extent of potential contamination at the surface/shallow subsurface.
- Support a risk-based decision on the need to perform corrective actions for the surface/shallow subsurface.
- Support a corrective action alternative analysis for the surface/shallow subsurface.
- Support the use of subsurface transport models to determine if future resource development could impact the extent of subsurface contamination.
- Determine if existing subsurface intrusion restrictions need to be adjusted to ensure they are protective of human health and the environment.

1.2 Scope of Work

The details of the scope of work are divided into two sections: the *Surface and Shallow Subsurface Work Plan* (Section 4.0), and the *Subsurface Work Plan* (Section 5.0).

In order to complete the scope of work for the Gasbuggy investigation, the following activities have been or will be carried out: a surface geophysical investigation, surface/shallow subsurface sampling, sampling of an on-site deep groundwater monitoring well and development of a deep subsurface transport model.

The first portion of the investigation consisted of researching historical documents, photos, diagrams, and engineering drawings. The objective of this research was to identify suspect areas and corresponding contaminants of potential concern (COPCs), correlate the suspect areas with their actual locations at the Gasbuggy Site, and identify historical data gaps.

The second portion of the surface/shallow subsurface investigation consisted of a preliminary field investigation. This work, completed in August and September of 2000, consisted of a surface geophysical investigation and a preparative soil sampling effort. The geophysical investigation included surveys to accurately identify and place shallow subsurface features. The results of the geophysical investigation coupled with historical records were used to identify and delineate potential areas of concern (AOCs) from which shallow subsurface soil samples were collected. The results of the preliminary field investigation were used to identify remaining data gaps. Further field surface/shallow subsurface investigations will concentrate on filling the remaining data gaps.

Additional investigation for the surface/shallow subsurface will consist of: (1) collecting additional soil samples to fill data gaps and define the nature and extent of potential contamination in each AOC; (2) determining if there is a potential path for COPCs to migrate to shallow groundwater; and (3) determining the nature and extent of potential contamination in the shallow groundwater, if applicable. Background conditions will be established by collecting soil samples and shallow groundwater samples, if applicable, at nonimpacted areas near the site.

The subsurface investigation will include sampling of a deep groundwater monitoring well on site and development of a deep subsurface transport model. The groundwater monitoring well will be sampled to provide additional data on the source of low-level radiological contamination in the well, and to provide information for plugging and abandoning the well. The modeling effort will result in a conceptual model of flow and transport of deep subsurface contamination. The model will focus on the natural gas reservoir in the area of the Gasbuggy test site. Although a deep aquifer exists within the Ojo Alamo Formation under the Gasbuggy Site, existing data are sufficient to determine the absence of risk in this aquifer as an exposure pathway. This aquifer will only be investigated as a potential transport pathway.

The subsurface modeling effort will consist of locating and evaluating subsurface data, and identifying numerical models capable of handling the necessary physical processes involved. Once the numerical model of flow and transport under current conditions is developed, stressed conditions simulating nearby gas production wells will be applied. Results of the model will be evaluated to determine if existing subsurface intrusion restrictions are sufficient to protect human health and the environment, with consideration of uncertainty.

1.3 Investigation Work Plan Contents

This document provides a detailed description of past and present site conditions, a description of the DQO process results, and a description of the methods and procedures to be used for future investigation activities. This work plan has been organized as follows:

- Section 1.0 - Introduction
- Section 2.0 - Facility Description
- Section 3.0 - Data Quality Objectives
- Section 4.0 - Surface and Shallow Subsurface Work Plan
- Section 5.0 - Subsurface Work Plan
- Section 6.0 - Schedule
- Section 7.0 - References
- Appendix A - Gasbuggy Historical Radiological Monitoring and Sampling Results
- Appendix B - New Mexico Quality Assurance Project Plan (NM QAPP)
- Appendix C - Results of Gasbuggy Preliminary Field Investigation (August and September, 2000)
- Appendix D - Gasbuggy Site Surface Radiological Dose/Risk Assessment
- Appendix E - New Mexico Environment Department Review Sheets

Measurements are presented in English units except where data was specifically measured in metric units.

2.0 Facility Description

2.1 Physical Setting

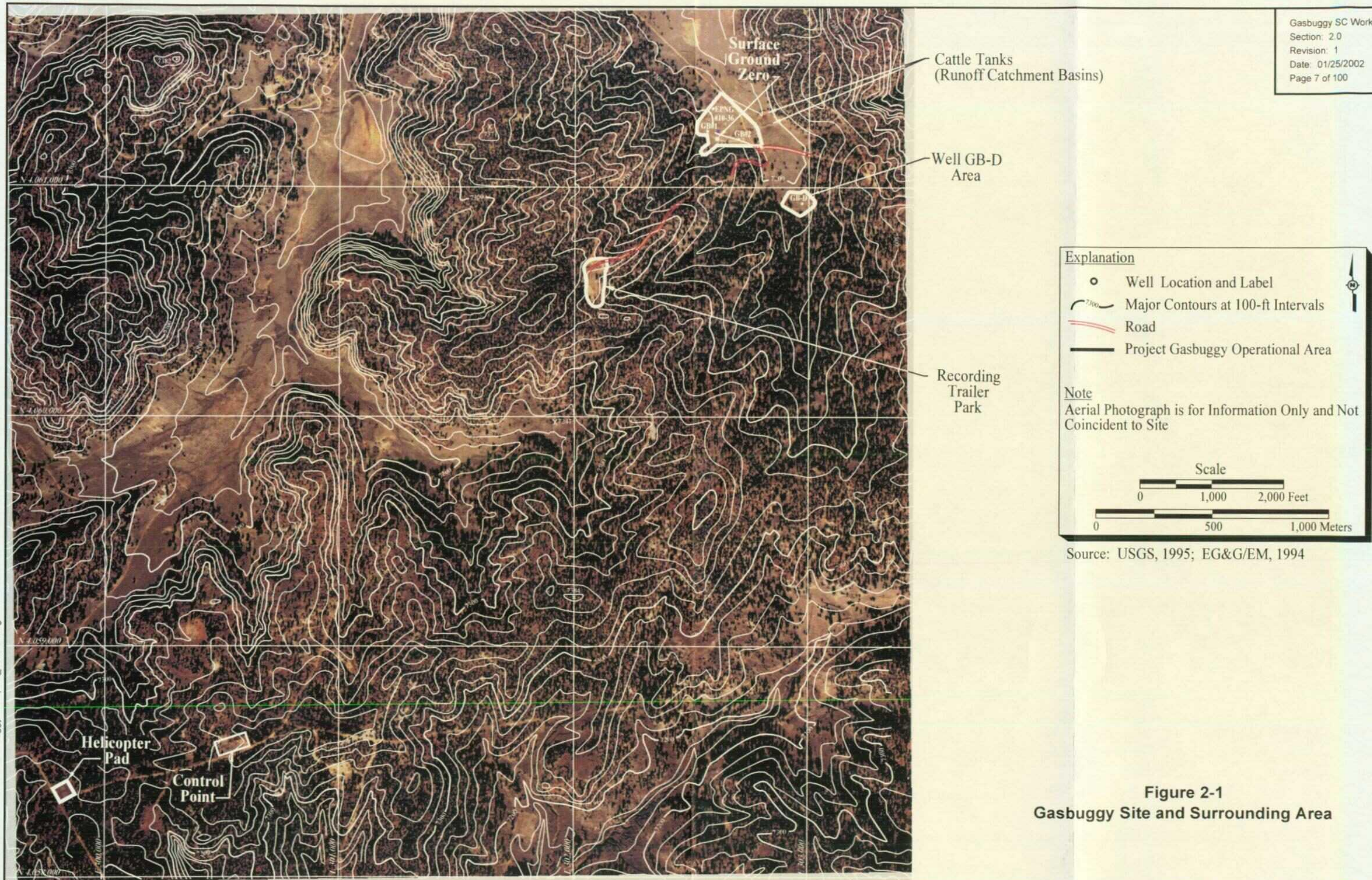
This section describes the location of the Gasbuggy Site, land status, and environmental setting which includes topography, vegetation, and description of the surface waters, wetlands, and floodplains present at the Gasbuggy Site.

2.1.1 Land Status

The Gasbuggy Site is located within the Carson National Forest (CNF), Jicarilla Ranger District. The CNF currently supports multiple uses including recreation, livestock grazing, and resource development.

The project installations consist of the surface ground zero (SGZ) area, the Well GB-D area, the recording trailer park (RTP), the control point (CP), and the helicopter pad (HP) (see Figure 2-1). The use of these lands for Project Gasbuggy was established in a Memorandum of Understanding, dated March 23, 1967, between the U.S. Department of Agriculture's U.S. Forest Service (USFS) and the U.S. Atomic Energy Commission (AEC) (predecessor to the U.S. Department of Energy [DOE]).

Additionally, by land withdrawal action of Public Land Order 4232, dated June 22, 1967, the U.S. Department of the Interior, Bureau of Land Management (BLM) withdrew from all forms of appropriation, including mining and mineral leasing laws, and reserved for use by the AEC the surface and subsurface of lands within Section 36, Township 29 north, Range 4 west, New Mexico Principal Meridian. Surface and subsurface operating rights to lands within the southwest 1/4 of the described section were reserved for the use of the AEC under stipulations of Contract AT(04-3)-711, dated January 31, 1967, signed by the AEC, U.S. Department of Interior, and the El Paso Natural Gas Company (EPNG) (DOE/NV, 1983). It should be noted that of the five operational areas, only the SGZ area is within this 1/4 section. The Well GB-D area is outside of this 1/4 section, although still in Section 36, and the RTP, CP, and HP are outside of Section 36.



Source: USGS, 1995; EG&G/EM, 1994

Figure 2-1
Gasbuggy Site and Surrounding Area

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For the purposes of the work plan, the Gasbuggy Site is defined as the SW 1/4 section of Section 36, Township 29 north, Range 4 west, and disturbed areas outside these boundaries (i.e., Well GB-D area, RTP, CP, and HP), which were impacted by DOE operations.

A plaque at SGZ states the following (DOE/NV, 1978):

"Project Gasbuggy
Nuclear Explosive Emplacement/Reentry Well (GB-ER)

Site of the first United States underground nuclear experiment for the stimulation of low productivity natural gas reservoir. A 29-kiloton nuclear explosive was detonated at a depth of 4,227 feet below this surface location on December 10, 1967.

No excavation, drilling, and/or removal of subsurface materials to a true vertical depth of 1,500 feet is permitted within a radius of 100 feet of this surface location, nor any similar excavation, drilling, and/or removal of subsurface materials between the true vertical depths of 1,500 feet and 4,500 feet is permitted within a 600 foot radius of this surface location in the SE quarter of the SW quarter of Section 36, T 29 N, R 4 W, New Mexico Principal Meridian, Rio Arriba County, New Mexico, without U.S. Government permission.

United States Department of Energy
November 1978"

2.1.2 Environmental Setting

The Gasbuggy Site is located in the northeast portion of the San Juan Basin, a structural feature of the Colorado Plateau Province covering northwestern New Mexico and southwestern Colorado. The Gasbuggy Site is surrounded by typical canyon and plateau topography of the Colorado Plateau Province. Elevations range from 6,800 to 7,500 ft in the surrounding area, and from 7,000 to 7,300 ft in the immediate test area (DOE/NV, 1988). Surface ground zero is located at an elevation of 7,211 ft above sea level (DOE/NV, 1983). Figure 2-1 is a topographical map of the Project Gasbuggy location and surrounding area.

The Gasbuggy Site lies within the Cold Temperate climatic zone. Three basic vegetation communities (i.e., forest, scrubland, and grassland) are represented at the site. The forest community is classified as Rocky Mountain Montane Conifer Forest, which is dominated by Ponderosa pine.

This community is typically found along the steeper slopes of the site, forming a band around the drainage areas. The scrubland community is Great Basin Montane Scrub and is found along hilltops, above the forest. Although classified as a scrubland, this community may support Ponderosa and Pinyon pines. The grassland community is further subdivided into two distinct series, the Great Basin Shrub-Grassland, Sagebrush Grass Series, and the Great Basin Shrub-Grassland, Wheatgrass Series (DOE/NV, 1993c).

Based on site surveys completed in 1993, the SGZ area and Well GB-D area are within the Grassland communities (DOE/NV, 1993c). Based on interpretation of aerial photos taken in 1994 (EG&G/EM, 1994), the RTP, CP, and HP are located within artificially cleared areas in either the forest or scrubland communities.

2.1.3 Surface Water, Wetlands, and Floodplains

The Gasbuggy Site has no naturally standing water, streams, springs, or seeps. A survey of state wetland inventories and the flood insurance map for Rio Arriba County did not indicate either wetlands or floodplain areas occurring at the Gasbuggy Site (DOE/NV, 1993d). However, during a site survey conducted in 1993, it was noted that there are four artificially created seasonal ponds within the vicinity of the Gasbuggy Site. Three are constructed cattle tanks and one is the result of water ponding at the upstream end of a culvert under the elevated main access road (DOE/NV, 1993b). Two of the cattle tanks and the berms used to construct them are visible east of SGZ in the 1994 aerial photo of the site (EG&G/EM, 1994) provided in Figure 2-1. The survey also concluded that the areas within the drainage channels upstream of the bermed tanks, the area upstream of the elevated road, as well as the center of the drainage channel, should be considered as a floodplain area (DOE/NV, 1993b). No field work is currently proposed in these areas.

2.1.4 Geology and Hydrology

The Gasbuggy Site is situated in the San Juan Basin, a large structural basin containing approximately 12,000 ft of sedimentary rocks. The natural contour of the site slopes northeast into Leandro Canyon. Leandro Canyon is an ephemeral drainage and tributary of the ephemeral La Jara Creek.

The surficial alluvium, the San Jose Formation, the Nacimiento Formation, and the Ojo Alamo Sandstone are the principle aquifers in the Gasbuggy area. A detailed discussion of the geology and hydrology, as they relate to the subsurface investigation, is presented in Section 5.0. The Nacimiento and San Jose Formations are continental flood plain deposits and are the predominant surface formations in the Gasbuggy area. They comprise a 3,500-ft sequence of fine- to medium-grained, locally conglomeratic sandstone, interbedded with claystone- and sandy-variegated shale. The beds of sandstone commonly contain water throughout the central San Juan Basin (DOE/NV, 1988).

Descriptions documented during the preliminary field investigation indicate the shallow stratigraphy is dominated by poorly graded, red-brown to brown silty sand, poorly graded sand, and silt, to a minimum of 30 ft bgs. Weathered sandstone bedrock was encountered between 14 to 24 ft bgs in the northwest portion of the SGZ area.

Depth to the shallow groundwater table at the Gasbuggy Site has not been established. Prior to the Gasbuggy experiment, wells within a 10 miles radius of SGZ were inventoried. The 13 wells inventoried range in depth from 54 to 229 ft, and the depth to the water in the wells ranges from 22 to 174 ft bgs. The shallow wells were completed in the alluvium, which occurs in the valleys of the intermittent streams draining the area. The deeper wells tap either the lower part of the alluvium or the underlying sandstones (Mercer, 1968). The alluvial areas are not contiguous throughout the area; therefore, the water level in these wells may not be representative of conditions at the Gasbuggy Site. Shallow groundwater was not encountered during the preliminary field investigation. The maximum depth of any boring during the preliminary field investigation was 36 ft bgs.

2.2 Operational History

Project Gasbuggy was the first of three United States underground nuclear experiments for the stimulation of low-productivity natural gas reservoirs. The other two sites are the Project Rulison Site and the Project Rio Blanco Site, both in Colorado. Information from characterization efforts at these sites, as well as other underground test area investigations, has been used in conjunction with historical documentation to determine potential AOCs and chemical and radiological COPCs.

The following five Project Gasbuggy operational areas will be discussed in more detail in the following sections (Figure 2-1):

- Surface Ground Zero
- Well GB-D
- Recording Trailer Park
- Control Point
- Helicopter Pad

Based on available historical documentation, no chemical release sites other than the mud pits were identified. Additionally, there was no material buried at the Gasbuggy Site other than drilling fluids and construction debris. Process knowledge as documented in Appendix A indicates the only radiological releases at the site surface consisted of short-lived radioactive gases and tritium. Except as otherwise noted, all operational support equipment and infrastructure were removed from the site as part of the site restoration activities in 1978.

As part of the on-going investigation of the site, field activities including geophysical surveys and soil sampling were conducted in August and September of 2000. These activities are briefly discussed in this section, where appropriate. Appendix C provides a detailed discussion of these activities.

2.2.1 Surface Ground Zero Area

This area is irregularly shaped and approximately 8 to 10 acres in size (Figure 2-1). Prior to AEC/DOE activities, a single natural gas-producing well existed at the site. This well, EPNG 10-36 (also referred to as San Juan 29-4, Unit #10-36, or Well 29-4, No. 10, in other documents), had been in production for approximately 10 years. This well was converted to a groundwater monitoring well for the Ojo Alamo aquifer in 1968 (AEC, 1971) and was purchased by the DOE from the EPNG Co. in 1978. The SGZ area also includes four other wells. Two test wells (i.e., wells GB-1 and GB-2) were drilled prior to the nuclear detonation to test the geologic formations. Well GB-2 was reentered after the detonation and renamed Well GB-2R to signify this reentry. A third well, Well GB-E, was used as the emplacement well. This well was also reentered after the detonation and renamed Well GB-ER. A fourth well, Well GB-3, was drilled after the detonation to test changes in the geologic formations.

There were several phases of AEC/DOE activities at the SGZ area. Predetonation activities included construction and drilling in 1967. Postdetonation activities included reentry into several of the project wells in late 1967 and throughout 1968, gas production experiments from 1968 to 1973, and pressure monitoring until 1976. Site restoration was conducted in 1978.

The AOCs are identified as bold, italic text in the following paragraphs. These AOCs will be referred to in later parts of this Work Plan by the names indicated.

Construction and Drilling

Based on historical aerial photographs, at least one sump/mud pit associated with Well EPNG 10-36 was constructed and used prior to Project Gasbuggy (see Figure 2-2). It is unclear if this sump/mud pit (***Well EPNG 10-36 Sump***) was used during Project Gasbuggy or if later mud pits may have been constructed overlapping this pit. Based on historical photos, this pit remained open during the drilling of Well GB-E, but was closed sometime prior to the detonation. Identified sumps/mud pits that can be determined to have been closed prior to DOE's use of the site will not be addressed by this investigation.

Based on a SGZ area site plan dated May 26, 1967 (Figure 2-3), prior to initiation of drilling the emplacement well, two mud pits were constructed to contain fluids from the drilling of wells GB-1 and GB-2. According to the drawing, these mud pits (***Well GB-1 Mud Pit and Well GB-2 Mud Pit***) were backfilled prior to commencement of drilling Well GB-E on June 25, 1967 (AEC, 1971).

Based on interpretation of photographs taken during the drilling of Well GB-E, up to five additional mud pits were constructed to contain fluids from this well. Figure 2-4 shows the large reserve mud pit (***Well GB-E Mud Pit A***). Also visible in this picture are two smaller features, which are assumed to be mud pits (***Well GB-E Mud Pit B*** and ***Well GB-E Mud Pit C***) used during drilling of Well GB-E, but may be surface depressions which have caught rainwater. Based on the site drawings and photographs, Well GB-E Mud Pits B and C were likely constructed partially on top of the Well GB-1 Mud Pit. Figure 2-5 shows a small surface impoundment assumed to be a mud pit (***Well GB-E Mud Pit D***) at the base of the fill used to construct the contractor's yard. This position appears to be the same as the mud pit for Well GB-2, as indicated in Figure 2-3. Figure 2-6 is a photograph taken on the day of the detonation. This photograph shows a trench (***Well GB-E Mud Pit E***) described in historical documentation as a mud pit (Wofford, 2000a).

Based on interpretation of daily drilling logs and available photographic documentation, it appears that the main drilling mud pits were backfilled with native soil beginning on or around November 12, 1967, when drilling was suspended in order to make preparations for placing the

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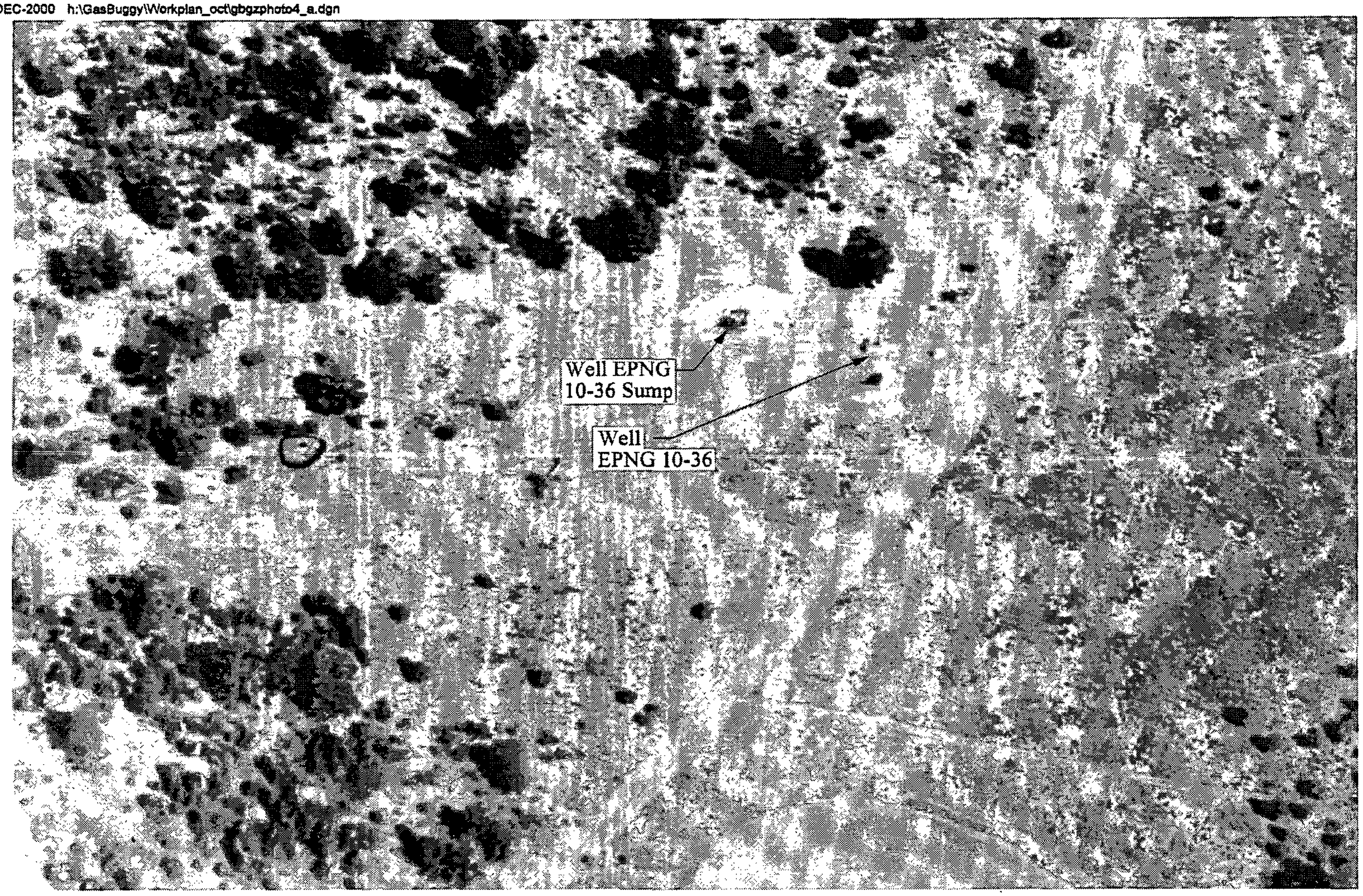

Source: Unknown DOE Contractor, 1967

Note: View is to the Northwest,
Photograph Taken in 1967

Figure 2-2
Oblique Photograph of Surface Ground Zero Area
Prior to AEC/DOE Use of Site (1967)

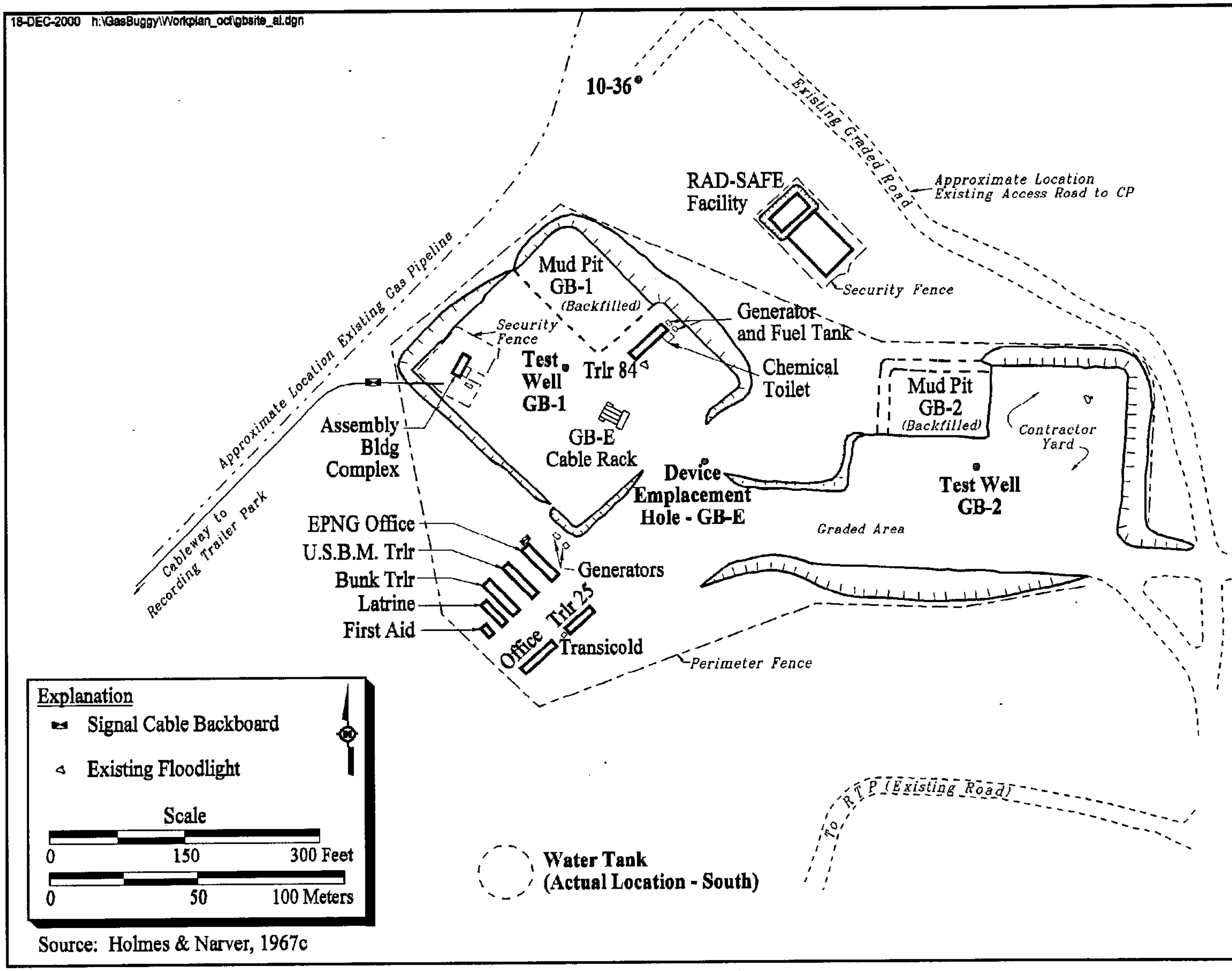

Figure 2-3
Surface Ground Zero Site Plan Gasbuggy, New Mexico

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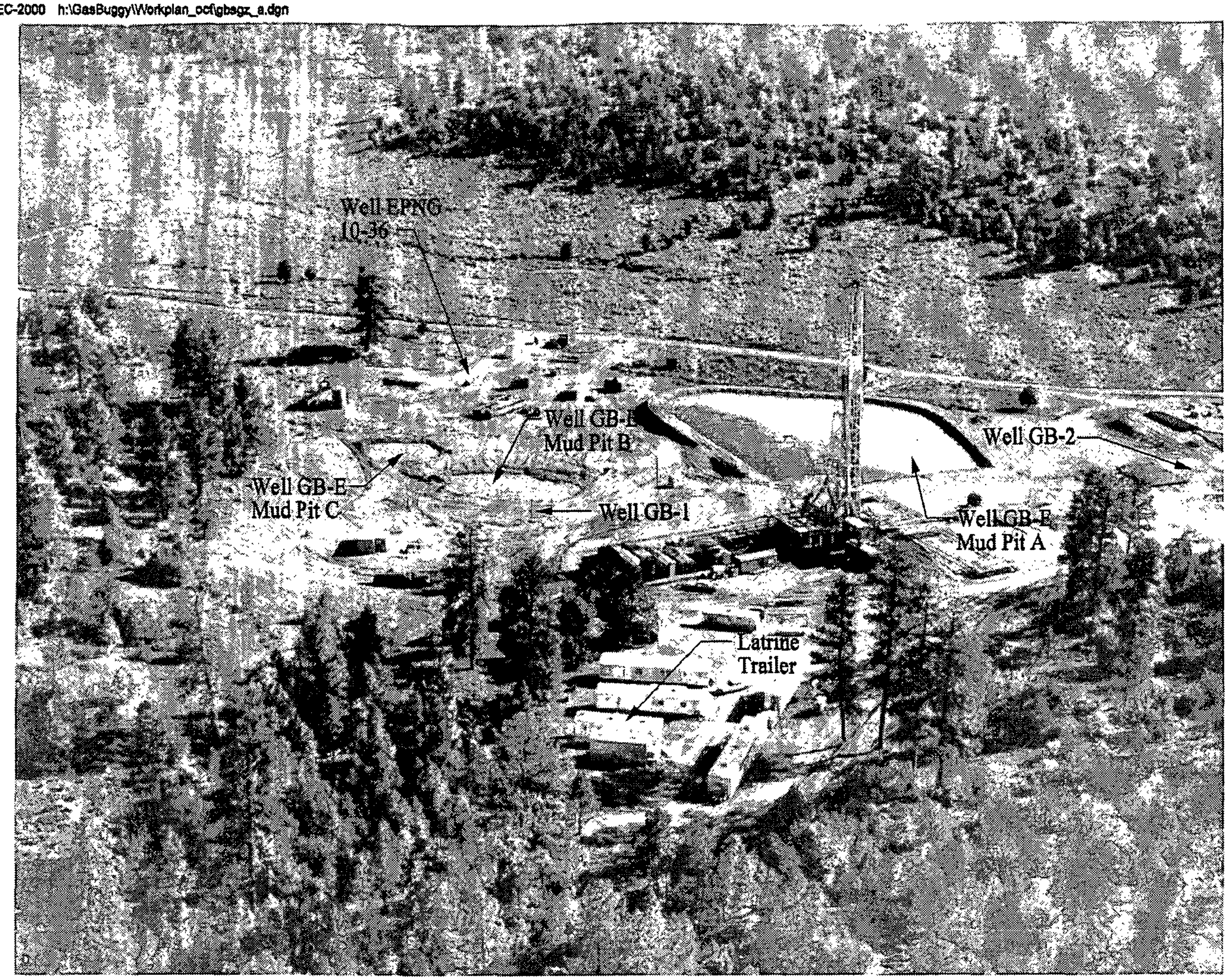

Source: LRL, 1967b

Note: View is to Northeast, Photograph Taken in 1967; Drill rig is set up over GB-E

Figure 2-4
Oblique Photograph of Surface Ground Zero Area During Drilling of Well GB-E

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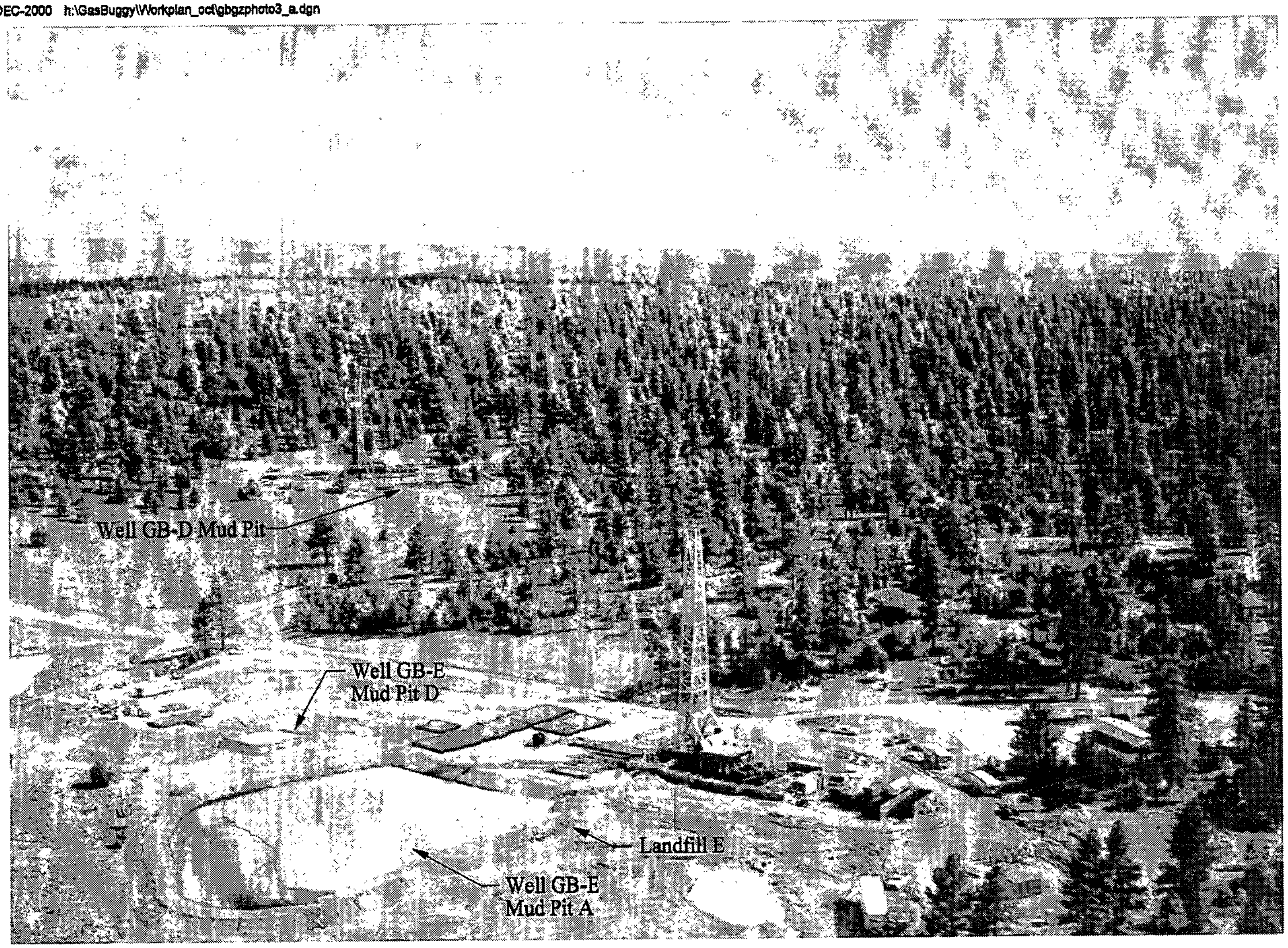

Source: Wofford, 2000a

Note: View is to the Southeast,
Photograph Taken in 1967

Figure 2-5
Oblique Photograph of Surface Ground Zero Area with Well GB-D in Background

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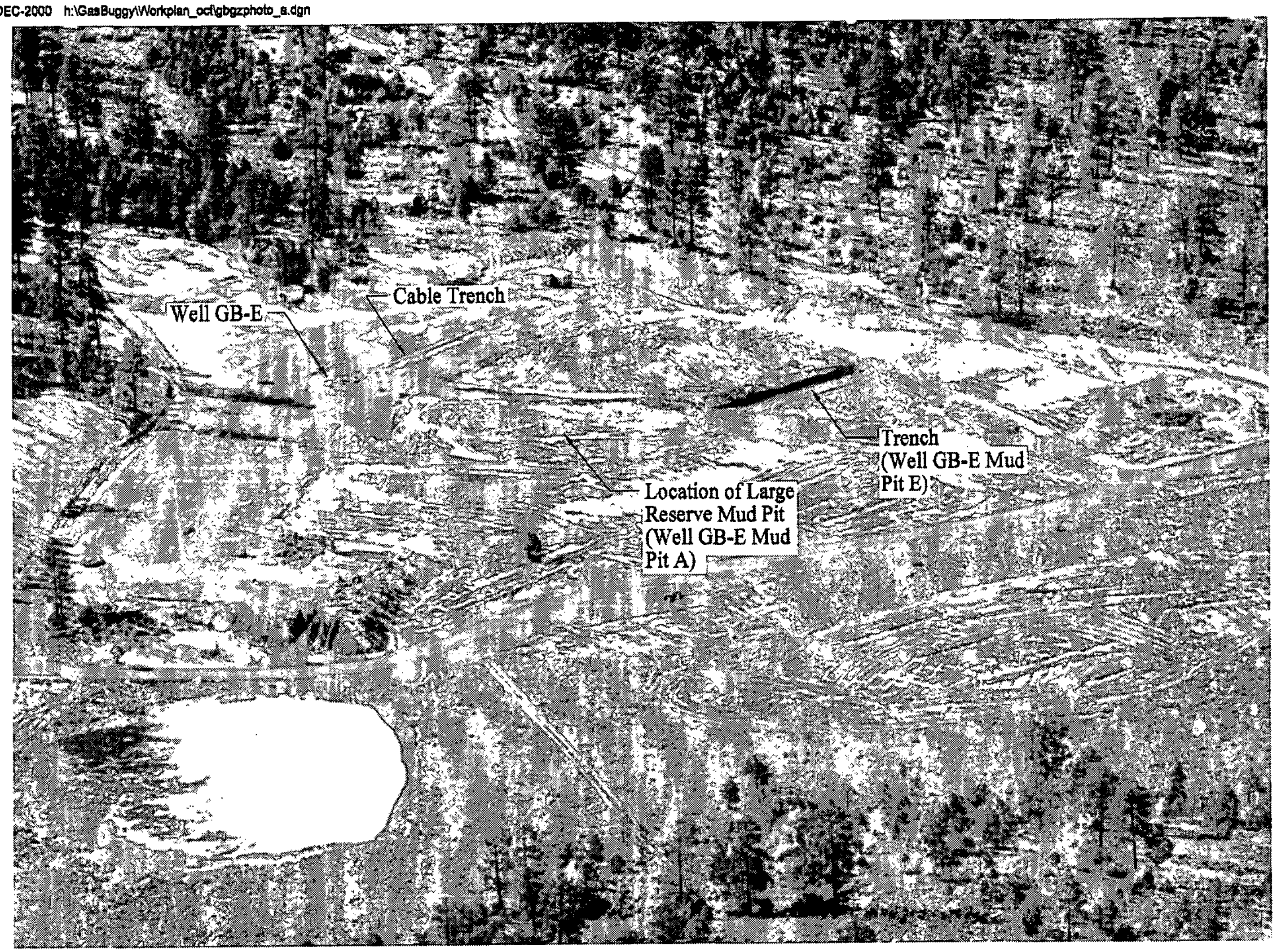

Source: Wofford, 2000b

Note: View is to the West, Photograph Taken December 10, 1967

Figure 2-6
Oblique Photograph of Surface Ground Zero Area December 10, 1967

nuclear device in the well (F&S, 1968). The soil used for backfilling appears to have come from the east side of the main road, as evidenced by the surface scrapings that are apparent in Figure 2-6 and Figure 2-7. During stemming operations initiated on November 18, 1967, and continued through December 9, 1967, it was necessary to pump large amounts of water from the emplacement hole (F&S, 1968). It is assumed this water and possibly cement and grout from stemming operations were pumped into the trench shown in Figure 2-6.

The historical documentation does not indicate where mud pits for Well GB-3 were constructed.

Other potential sources of contamination in the SGZ area include product storage areas, potential releases, septic tanks, potential landfills, and potential laboratory facilities. One potential landfill (***Landfill E***) used during drilling is evident in Figure 2-5. It appears this landfill was used for construction debris. The location(s) of on-site laboratories are not known.

The locations of two septic tanks are shown in Figure 2-8. Neither this diagram or any other documentation found indicates the engineering of the tanks. The septic tank shown in Figure 2-8 in the southwestern corner of the site (***Septic Tank A***) corresponds with the location of the latrine trailer, as shown in Figure 2-3 and Figure 2-4. The historical documentation does not indicate what the septic tank near Well GB-E (***Septic Tank B***) was used for, nor can any inferences be made based on historical site photographs or diagrams.

The combination of observable surface features and data generated by the geophysical surveys conducted in August 2000 identified the locations of the mud pits and Landfill E. The geophysical surveys did not, however, conclusively identify the locations of the septic tanks. For details on the geophysical surveys, see Appendix C.

Detonation

The detonation itself had little or no impact on the surface. Discussions on the subsurface impacts of the investigation are provided in Section 5.0.

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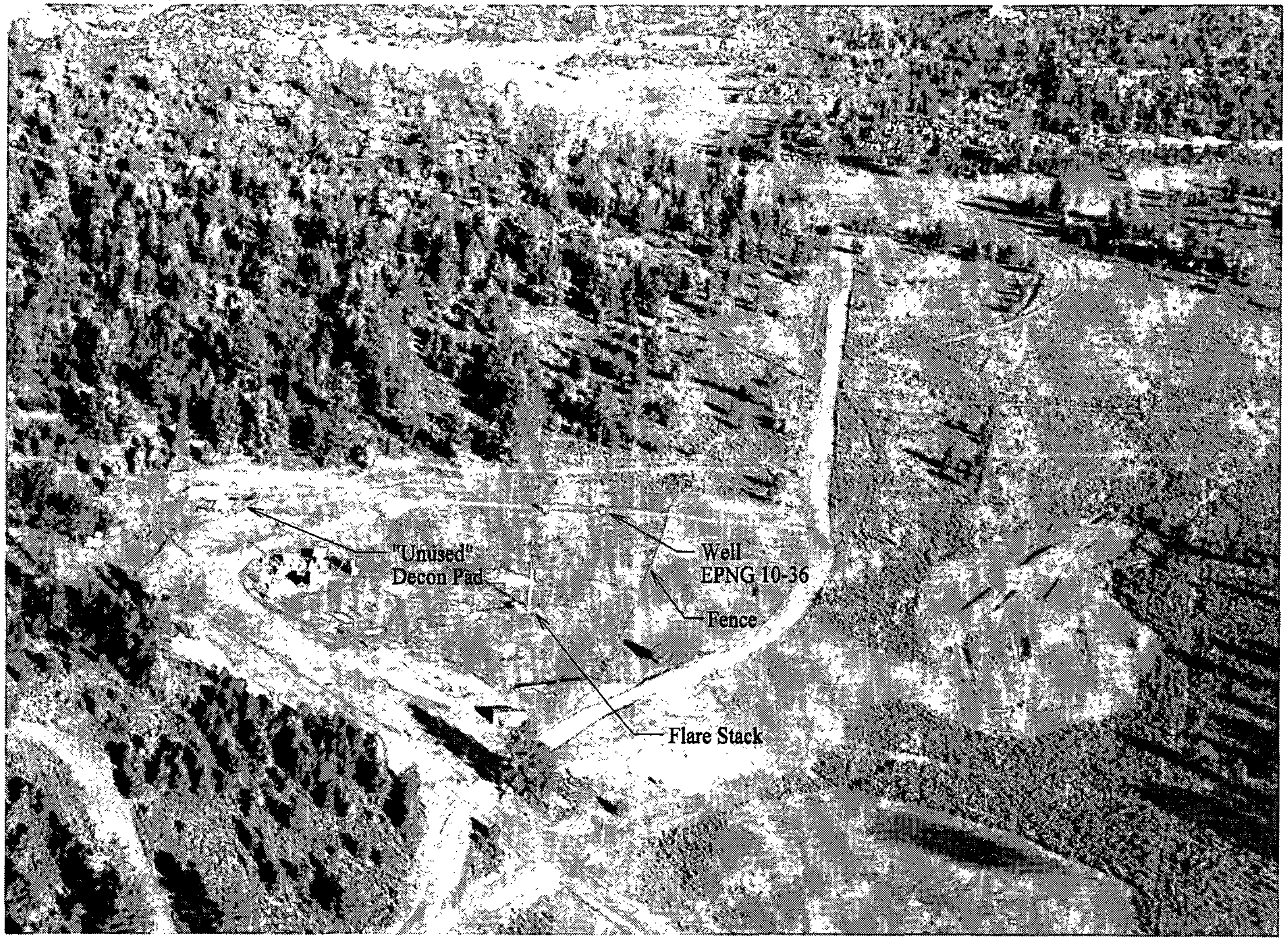


Source: Wofford, 2000a

Note: View is to the North,
Date of Photograph is Unknown

Figure 2-7
Oblique Photograph of Surface Ground Zero Area Prior to Restoration

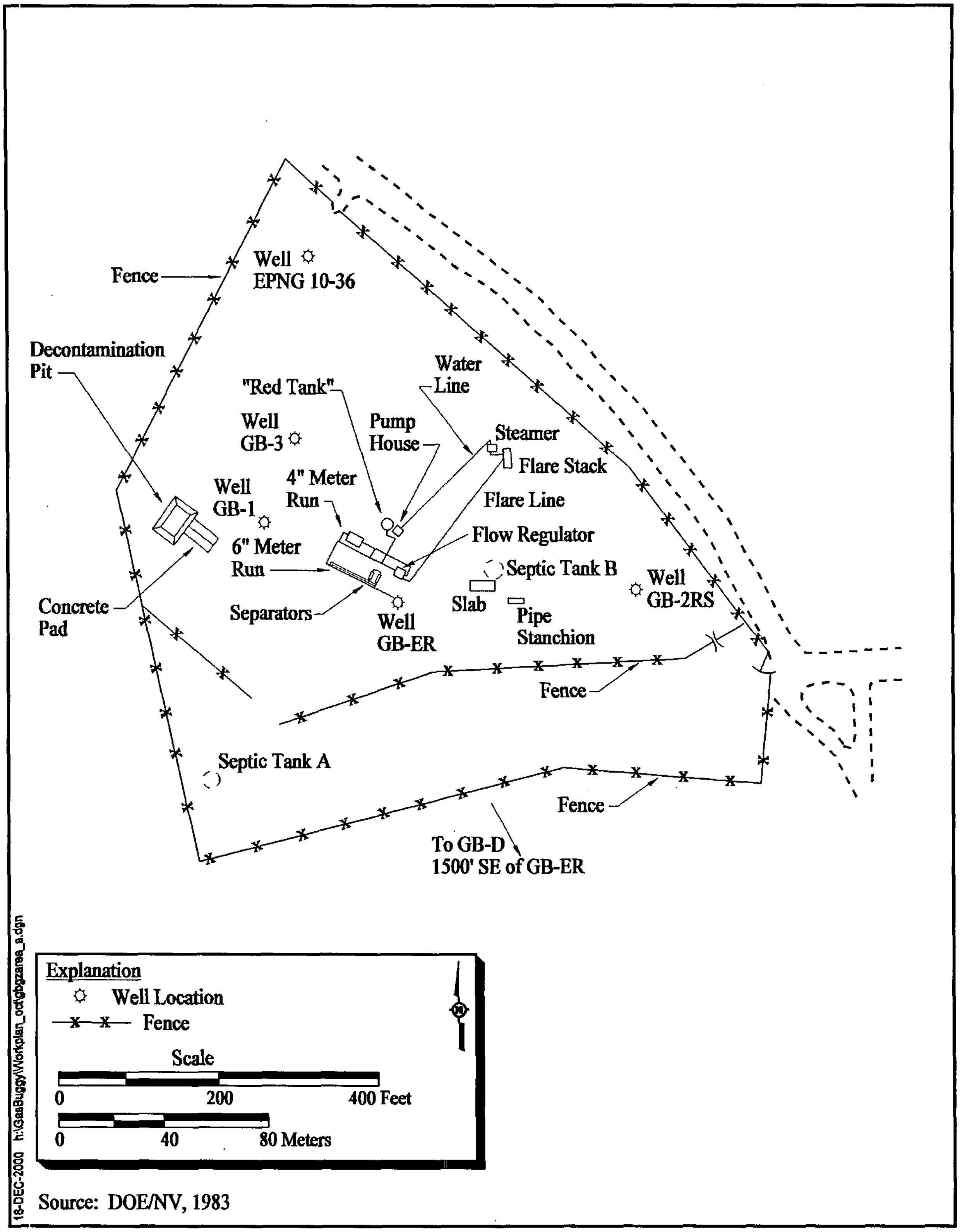


Figure 2-8
Surface Ground Zero Area Status as of December 1976

Post-Detonation Operations

Post-detonation operations in the SGZ area included reentry drilling and gas production. Reentry of Well GB-ER was begun on December 13, 1967. On January 10, 1968, at a depth of 3,097 ft (333 ft above the detonation point), communication with the chimney (i.e., zone of fractured rock above the detonation point) was established. Reentry drilling was also conducted in Well GB-2R and Well EPNG 10-36. Well GB-2R was completed to a depth of 4,224 ft; however, the hole apparently collapsed and prevented the use of the hole for production testing. The stemming was removed from Well EPNG 10-36 to a depth of 3,612 ft, where casing damage prevented further penetration. The well was then completed in the Ojo Alamo sandstone formation as an aquifer monitoring well (DOE/NV, 1988). Well GB-3 was drilled to a depth of 4,800 ft to investigate changes to the subsurface.

Based on available documentation, it is unclear where drilling wastes generated during reentry drilling and initial drilling of Well GB-3 were disposed. Initial reentry drilling of Well GB-ER was done by gas circulation. At a depth of 3,260 ft bgs, it became necessary to use drilling mud. According to daily drilling reports, mud was placed in polyethylene-lined mud pits and sampled (F&S, 1968). Sample results were unavailable; however, based on the documentation reviewed in Appendix A, it is assumed no radioactivity other than potentially tritium and short-lived radioactive gases was found.

Six major natural gas production tests were conducted, two in 1968, three in 1969, and one in 1973. These tests are known to have brought water, natural gas, and a small amount of oil to the surface, as well as tritium and short-lived radioactive gases (DOE/NV, 1988). During the early production tests, fluids were separated from the gas prior to flaring, containerized, and shipped to the Nevada Test Site (NTS) for disposal. However, the amount of water generated in later tests made this method of disposal impractical. In order to dispose of the large quantities of water produced, the water was first separated from the gas, turned into steam, and then injected into the gas flare (DOE/NV, 1988). This process contaminated the soil in the SGZ area with low-levels of tritium (see Appendix A).

Site Restoration Operations

Figure 2-7 shows the SGZ area as it appeared prior to the 1978 site restoration. The exact date of this photo is not known but appears to have been taken during either the 1968/1969 or 1973 production testing. Site restoration activities were conducted over a six-week period in August and September 1978. Restoration activities included: (1) well plugging and abandonment; (2) decontamination, transport, and disposal of equipment; (3) packaging, transport, and disposal of solid and liquid waste; (4) land surface restoration; and (5) final status sampling and analysis. None of the soil samples collected during the 1978 restoration activities exceeded established release criteria; therefore, no soil was remediated. In addition, no radioactive waste was buried on site (DOE/NV, 1983). For details pertaining to the radiological surveillance program and sampling efforts during the 1978 restoration, refer to Appendix A.

Decontamination of equipment was conducted on a large metal decontamination pan designed to collect the decontamination fluids. Decontamination during the restoration was completed without the use of solvents. Items that could not be decontaminated were shipped to the NTS for disposal as low-level radioactive waste. All decontamination fluid was recaptured and either injected into the Gasbuggy cavity or vaporized and released into the atmosphere (DOE/NV, 1983).

The *Project Gasbuggy Well Plugging and Site Restoration Plan* (DOE/NV, 1978) and the *Project Gasbuggy Site Restoration Final Report* (DOE/NV, 1983) state that all septic tanks were to be backfilled. The site restoration final report states that Septic Tank A was backfilled; however, there is no documentation verifying that this was accomplished for Septic Tank B. It is possible this tank may not have existed.

Engineering drawings (Figure 2-3) show a decontamination pad ("labeled as RAD-Safe Facility") in the central part of the SGZ area. There is no evidence that this pad was ever built. However, "as-built" drawings show the decontamination pad near the western edge of the SGZ area, as shown in Figure 2-8. This location is also supported by historical photographs (Figure 2-7) in which the pad is visible in the western edge of the site. Documentation in the closure reports (EIC, 1979, and DOE/NV, 1983) indicate this pad was never used. This is supported by the fact there was no radiological contamination (other than tritium) of equipment during the project, thus little need for decontamination. During site restoration activities, this decontamination pad and liner were broken up; the depression formed by its removal was enlarged; and the concrete, asphalt, and plastic of the pad were placed into the excavation. Other broken up concrete pads were also placed into the excavation. The excavation was then backfilled with approximately 3 ft of cover (***Landfill B***) (DOE/NV, 1983) (see Figure 2-9). Analysis of soil samples taken in the decontamination pad sump area as well as swipe samples of the decontamination pad liner and concrete pads taken prior to burial indicated concentrations of tritium were less than the lower limit of detectability (LLD).

Five wells (i.e., wells GB-1, GB-2R, GB-3,GB-D and GB-ER) were plugged and abandoned in place. The details of the plugging are described in the *Project Gasbuggy Site Restoration Final Report* (DOE/NV, 1983). Drilling fluids and paraffin accumulated in tanks during well-plugging operations were buried on site at three locations (***Landfills A, C, and D***). Samples of this material registered less than the LLD for tritium (DOE/NV, 1983). The locations of the buried decontamination pad and the three burial sites for the drilling fluids are documented in the *Project Gasbuggy Radiation Clearance Report* (EIC, 1979) and shown in Figure 2-9. Both of the above reports state that no radiological-contaminated waste was buried on site.

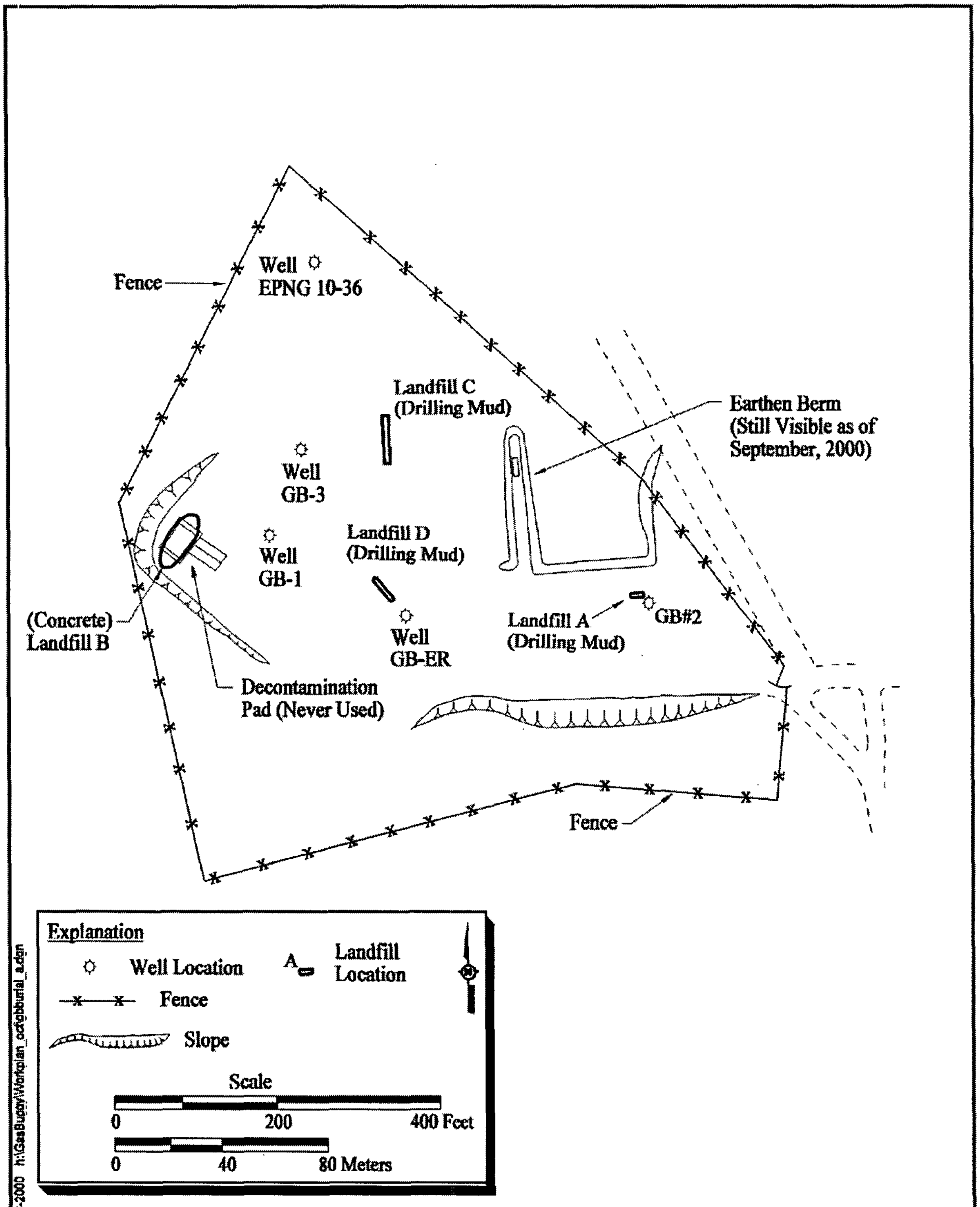
The geophysical surveys did not identify the locations of Landfills A, C, and D. For details on the geophysical surveys, see Appendix C.

Upon completion of all other restoration activities, soil samples were collected and radiological surveys were completed for the SGZ area (see Appendix A for discussion of results). The area was then reshaped, graded, and seeded (DOE/NV, 1983).

Remaining surface features include earthen berms, abandoned well markers, concrete pads, a pipe stanchion, and groundwater monitoring Well EPNG 10-36.

2.2.2 Well GB-D Area

The Well GB-D area is located approximately 1,500 ft southeast of Well GB-E (Figure 2-5). This location included Well GB-D and associated facilities in an area approximately 2 to 3 acres in size. Well GB-D was used for the placement of instruments to measure ground motion during the Gasbuggy experiment. Possible sources of contamination at this location include a single mud pit and potential releases on the drill pad. Geophysical surveys conducted in August of 2000 identified the



Source: EIC, 1979

Figure 2-9
Surface Ground Zero Area Location of On-Site Burials

location of this mud pit. For details of the geophysical surveys, see Appendix C. Based on historical documentation, no postdetonation activities, such as drilling or gas production, were carried out at this location (AEC, 1971). Therefore, radiological contamination is not anticipated.

Well GB-D was plugged and abandoned during the 1978 restoration. Upon completion of all other restoration activities, the area around Well GB-D was reshaped, graded, and seeded (DOE/NV, 1983).

2.2.3 Recording Trailer Park

The RTP is located approximately 2,500 ft southwest of SGZ (Figure 2-1). The RTP consisted of several trailers, generators, and storage tanks set on a graded earthen pad of approximately 30,000 square feet (ft^2) (Figure 2-10 and Figure 2-11). Based on review of historical documentation, no septic systems or underground storage tanks (USTs) were installed at this location. Figure 2-10 shows a pit at the north end of the facility and denotes it as an "existing pit." This pit was likely in use during the Gasbuggy Project as a sump for the natural gas production well (Meridian Oil San Juan 28-4) located at the site and is not associated with AEC/DOE activities.

Structures were removed and the area graded and seeded prior to the 1978 restoration effort (DOE/NV, 1983).

2.2.4 Control Point

The CP is located approximately 2.5 miles southwest of the SGZ area (Figure 2-1). The CP consisted of approximately 20 to 25 temporary structures, generators, and storage tanks set on a graded earthen pad of approximately 2 acres (Figure 2-12). Additional facilities set up around the perimeter of the pad included backup generators, various small structures, and a cleared area of approximately 4,200 ft^2 used as a weather balloon inflation area. Based on site drawings, a septic system consisting of a tank, influent lines, and approximately 150 ft of clay leaching pipe was installed (Figure 2-13). The system serviced the operations coordination center trailer and a latrine trailer. Geophysical surveys conducted in August of 2000 identified what appears to be the leaching pipe; however, other features of the septic system (e.g., septic tank) were not conclusively identified. For details on the geophysical surveys, see Appendix C. Based on historical photographs (Wofford, 2000b), a mobile

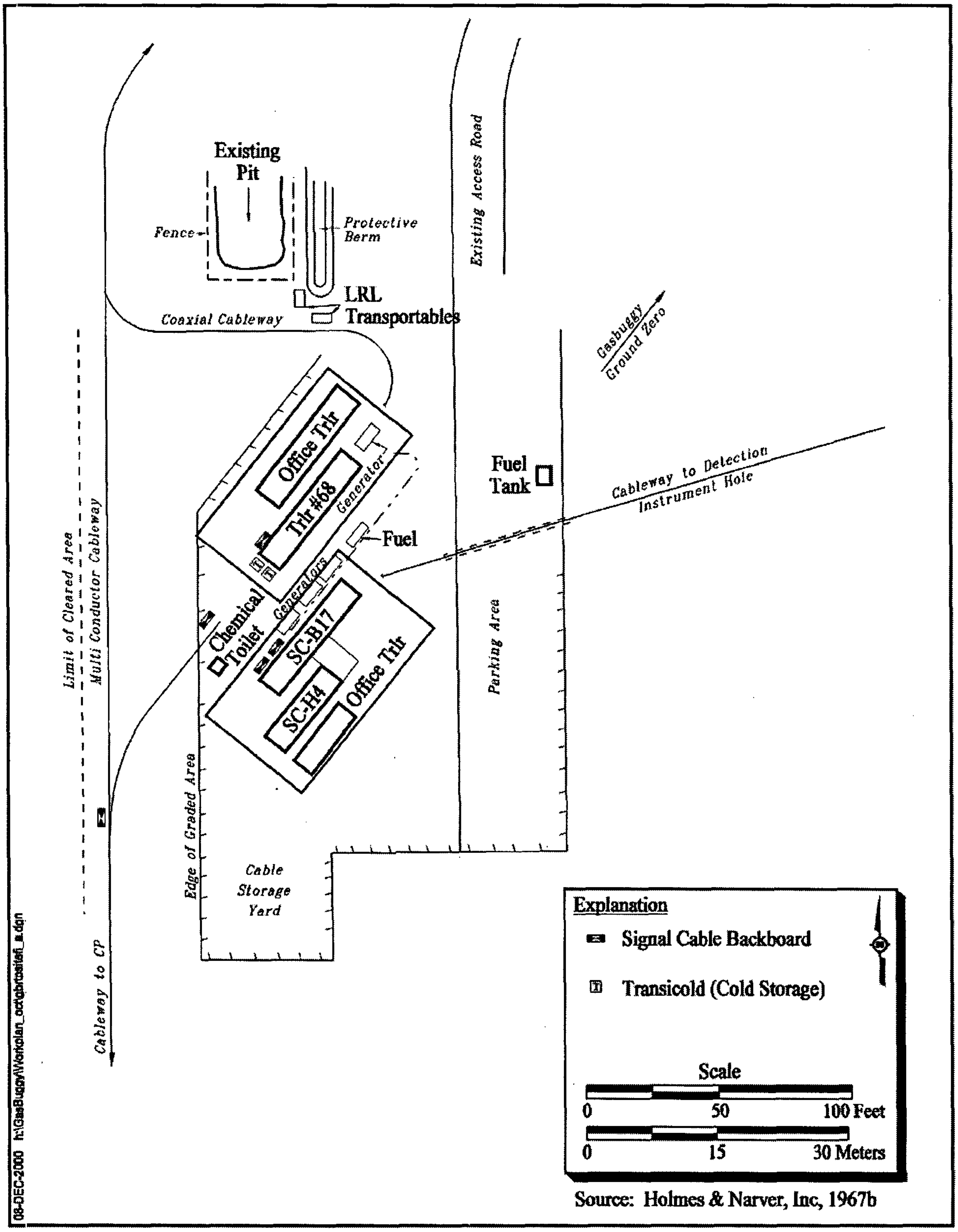
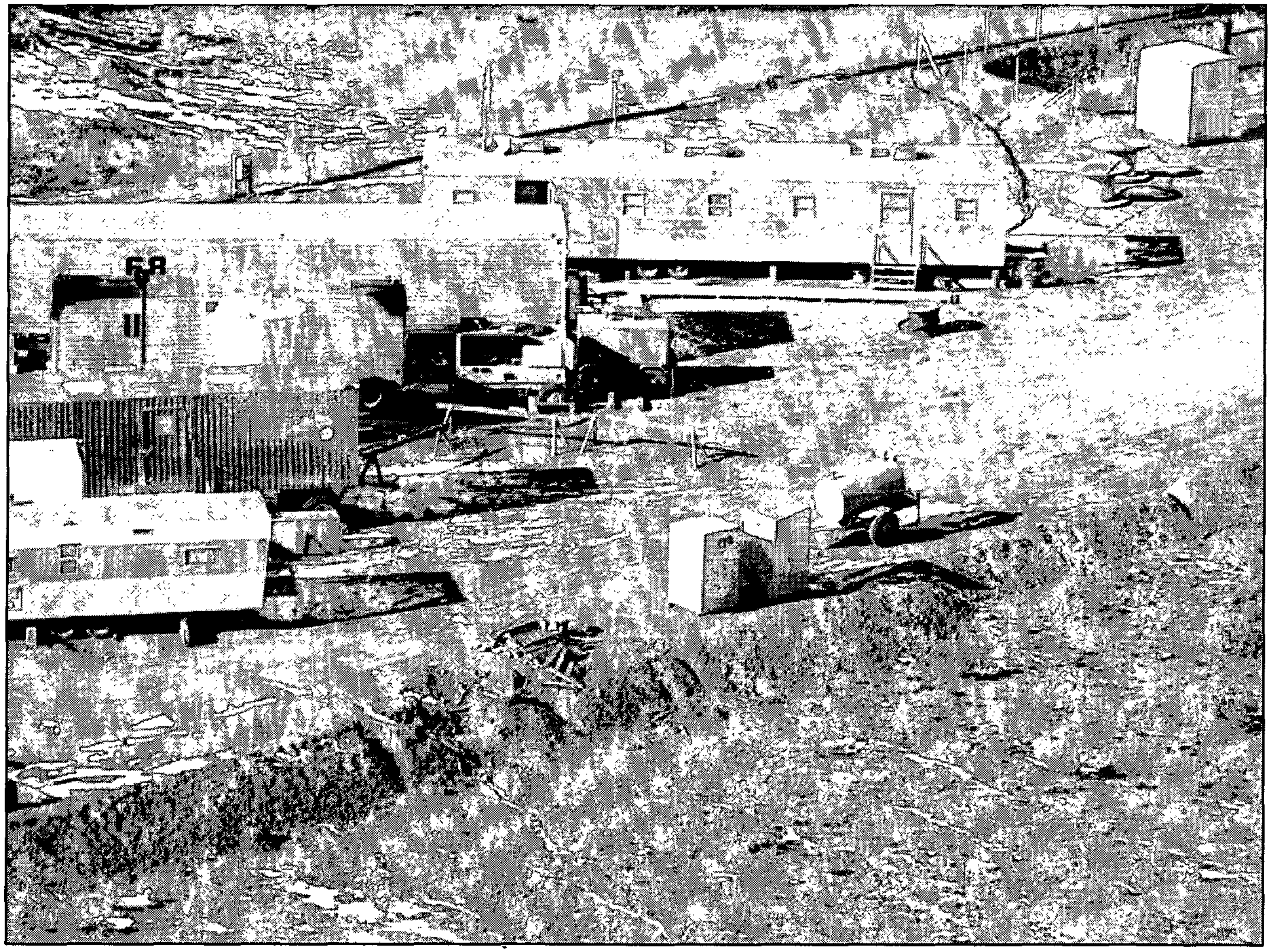


Figure 2-10
Recording Trailer Park Site Plan Gasbuggy, New Mexico



Source: Wofford, 2000a

Note: View is to the Northwest,
Photograph taken December 10, 1967

Figure 2-11
Oblique Photograph of the Recording Trailer Park

Source: Wofford, 2000a

Note: View is to the North
Date of Photograph is Unknown

Figure 2-12
Oblique Photograph of the Control Point

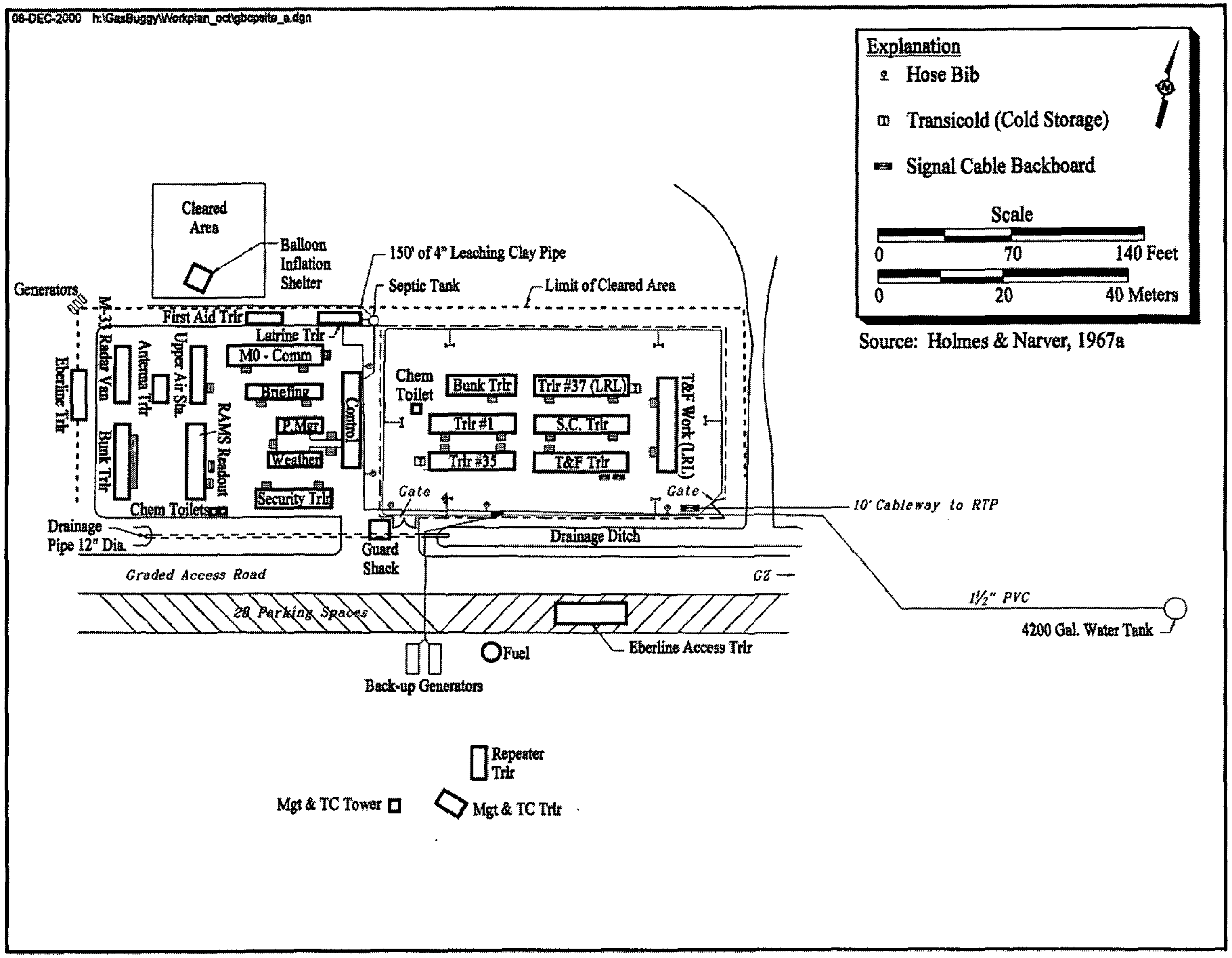


Figure 2-13
Control Point Site Plan Gasbuggy, New Mexico

radiological laboratory was located at the southern end of the CP. Other possible sources of contamination at this site include fuel storage tanks and generator locations.

All structures were removed and the area graded and seeded prior to the 1978 restoration effort (DOE/NV, 1983).

2.2.5 Helicopter Pad

The helicopter pad is located approximately one-half mile southwest of the CP (Figure 2-1). No historical drawings of the HP could be located. However, based on Figure 2-1, the helicopter pad appears to consist of two compacted earthen pads set in a larger cleared area of approximately two acres. No documentation has been found indicating if fuel was stored at this location. Based on process knowledge from other underground test areas, fuel was stored above ground, typically in 55-gallon drums.

2.3 Previous Investigations

A summary of previous investigations is listed on Table 2-1. A summary and discussion of available radiological data for the site surface is provided in Appendix A. In addition, details on the preliminary field investigation conducted by DOE in August and September, 2000, and the results of that investigation are presented in Appendix C.

Table 2-1
Monitoring and Previous Investigations
(Page 1 of 2)

Date	Description of Activity
1965 to 1968	A comprehensive characterization program for the subsurface geologic and hydrogeologic attributes of the Gasbuggy Site was carried out for siting and planning the project. These began with a feasibility study (EPNG et al., 1965) and pretest summary report (LRL, 1967a). Detailed hydrogeologic data from site wells are documented by the U.S. Geological Survey (Koopman et al., 1968a, 1968b; Weir, 1971) and summarized by Mercer (1967, 1969) in an overall evaluation of site hydrology. Geologic conditions and physical data from cores (e.g., porosity) were compiled by Lawrence Radiation Laboratory (LRL) (now Lawrence Livermore National Laboratory [LLNL]) (1967a) in their assessment of the acceptability of the site.
1968 to 1973	Evaluation of the test effectiveness in improving gas recovery from the Pictured Cliffs is the focus of numerous posttest publications (Holzer, 1970; LRL, 1968a; LRL, 1970). The chemical and radiochemical composition of the natural gas was reported by Smith and Moymer (1969). A larger than expected inflow of water to the chimney was evaluated by Power and Bowman (1970). Overall groundwater safety was examined by Sokol (1970). An extensive bibliographic listing of both pretest and posttest reports can be found in the *Gasbuggy Site Restoration Final Report* (DOE/NV, 1983).
August 1967 to June 1968	The Southwestern Radiological Health Laboratory conducted off-site radiological safety operations prior to, during, and after the detonation. Sampling and/or monitoring of milk, water, air, and vegetation were conducted. No release of radioactivity was detected by monitoring or in the analysis of samples collected following detonation (DHEW, 1970).
December 10, 1967	Gasbuggy detonation (AEC, 1971).
December 10, 1967 to January 25, 1968	Gasbuggy detonation, reentry, and initial production testing surveillance program (AEC, 1971). See Appendix A.
June to July, 1968 and November 1968 to November 1969	Radiological surveillance for production testing (AEC, 1971; EIC, 1971). See Appendix A.
November 5, 1969 to November 10, 1970	Natural gas sampling. Production from 28 wells located within a five-mile radius of Project Gasbuggy was resumed on October 30 and 31, 1969. Samples of gas were taken from collection lines. Only naturally occurring Radon-222 was detected (EPA, 1973).
1972 to present	The U.S. Environmental Protection Agency (EPA) conducts annual Long-Term Hydrological Monitoring Program (LTHMP). Samples have been collected since 1972 from the EPNG Well 10-36 and local supply wells, springs, and surface waters (DOE/NV, 1988). Results of the LTHMP sampling are discussed in Section 5.0.
May to November, 1973	Radiological surveillance for 1973 production testing. All air and atmospheric moisture samples collected during flaring operations were either below background levels or below the applicable Concentration Guide levels (EPA, 1974). See Appendix A.
August to September, 1978	During site restoration activities, radiological sampling/analysis and site surveys were conducted including waste, soil, and vegetation sampling. A beta/gamma survey was also conducted (DOE/NV, 1983 and Eberline, 1979). See Appendix A.
1986	Nine soil samples were collected from "operational" areas within the SGZ area and analyzed by the Toxicity Characteristic Leaching Procedure for pesticides, herbicides, metals, and volatile halocarbons. No hazardous substances were detected (REECo, 1986).

Table 2-1
Monitoring and Previous Investigations
(Page 2 of 2)

Date	Description of Activity
April 1988	A *Comprehensive Environmental Response Compensation, and Liability Act* (CERCLA) preliminary assessment was conducted to determine CERCLA hazard ranking. The Hazard Ranking System score was not high enough to be registered on the National Priority List (DOE/NV, 1988).
June 1993	EPA surface gamma survey of Gasbuggy Site. Surveys taken at on-site locations in all cases were similar to those taken at off-site locations (EPA, 1995). See Appendix A.
June 1993	A Class III Cultural resources survey, a floodplains and wetlands survey, and a sensitive species survey was conducted for the surface ground zero and surrounding area. The potential for adverse impacts to sensitive species, wetlands, or cultural resources resulting from the proposed investigation at the Gasbuggy Site was determined to be low (DOE/NV 1993a; b; and c).
October 27, 1994	EG&G Energy Measurements performs an aerial radiological survey of Project Gasbuggy and surrounding area. No significant man-made radioactivity was found (EG&G EM, 1995). See Appendix A.
May 23, 1994	Production tubing from Well EPNG 10-36 pulled to allow casing integrity logging as requested by the BLM (DRI, 1996b).
May 27 to May 30, 1994 and May 19 to May 22, 1995	The Desert Research Institute (DRI) conducts a detailed hydrologic logging and sampling effort of Well EPNG 10-36. Results are used in DRI reports "Assessment of Hydrologic Transport of Radionuclides from the Gasbuggy Underground Nuclear Test Site, New Mexico" and "Tritium Migration at the Gasbuggy Site: Evaluation of Possible Hydrologic Pathways" (DRI, 1996a and b).
September 1994 and September 1999	Casing integrity logging of Well EPNG 10-36 is completed (project files). These studies have been inconclusive as to the integrity of the casing, and further evaluation will be part of the subsurface investigation presented in Section 5.0.
August to September, 2000	DOE conducts a preliminary site investigation including sensitive species surveys, cultural resources surveys, surface geophysical surveys, and limited soil sampling and analysis. Details and results are presented in Appendix C.

3.0 Data Quality Objectives

The DQO process is a strategic planning approach based on the scientific method that is used to prepare for a site characterization data collection activity (EPA, 1994a). Data quality objectives were used for the Gasbuggy Site Characterization Work Plan to develop an effective scientific and resource-efficient data collection design.

The DQOs for the investigation of the Gasbuggy Site are designed to ensure that data of sufficient quantity and quality are collected to establish current site conditions. These data will be used to identify and evaluate if further action is required to achieve long-term closure of the site that is protective of human health and the environment.

3.1 Conceptual Site Model

A site-specific conceptual site model (CSM) for the Gasbuggy Site is provided in Figure 3-1. This model is based on the assumption that current land use (recreational and grazing) will continue. The CSM illustrates the relationships between the identified potential sources of contamination, the mechanism for release and migration away from the potential source, the potential pathways the contamination would follow once released, the exposure routes that potential contamination would travel to affect receptors, and the potential receptors that would be impacted by the potential contamination.

The Gasbuggy Project consisted of five distinct operational areas: SGZ area, Well GB-D pad, RTP, CP, and HP. Within each of these AOCs are potential surface/shallow subsurface sources of contamination such as the flare stack area and associated tritium contamination within the SGZ area, buried drilling mud pits, and/or landfills. Within the deep subsurface, the source of potential contamination is the Gasbuggy test cavity.

As required by the DQO process, a conceptual site model presumes that potential migration of contamination from these potential sources into the soil, groundwater (shallow and/or deep systems), and natural gas resources may occur.

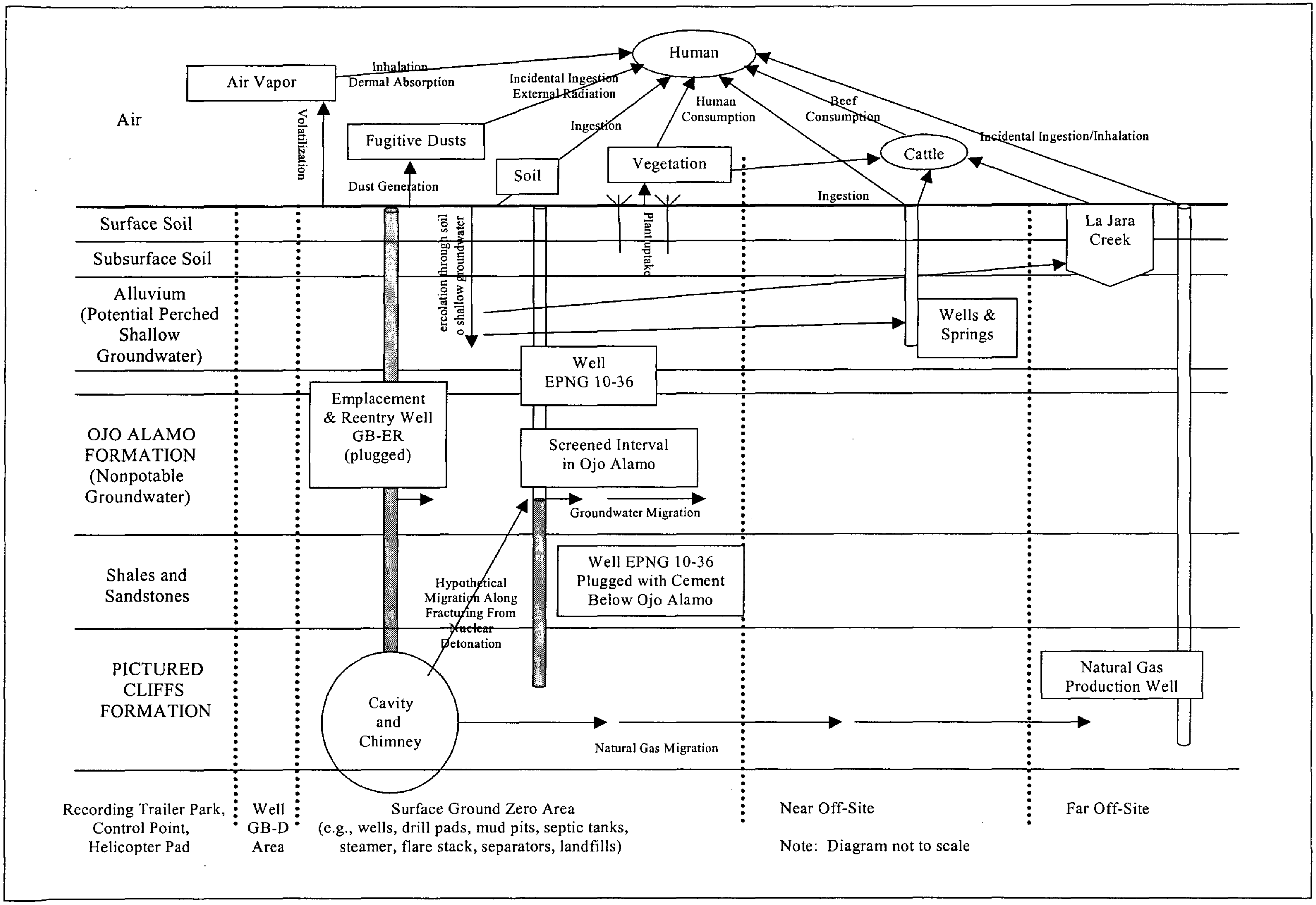


Figure 3-1
Gasbuggy Conceptual Site Model

The field investigation will be conducted to allow for either the modification or termination of characterization activities, when it is determined that sufficient data exists to support or refute the conceptual site model. If, during the planned field investigation, the conceptual model is proven to be incorrect (e.g., the extent of contamination is greater than predicted), a contingency would be implemented to adjust the scope of the field investigation. For example, this contingency may include the modification of the sampling strategies to include areas outside the original study limits to fully identify the extent of contamination.

3.1.1 Surface Conceptual Site Model

Potential migration of contamination in surface/shallow subsurface soils and shallow groundwater may have occurred. The release mechanisms that would facilitate migration include the following:

- Percolation of precipitation through impacted soil and transport of potential contamination into shallow subsurface soil or into the shallow groundwater
- Potential contaminated shallow groundwater migration
- Volatilization of volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), or tritium into the atmosphere
- Surface contaminants entering the atmosphere as fugitive dusts
- Uptake of contaminants by plants from surface/shallow subsurface soils

Potential exposure routes to humans or ecological receptors include ingestion, dermal contact, or inhalation. Pathways include the following, with the route specified:

- Contaminant uptake by plants or animals (ingestion)
- Contaminant migration to shallow groundwater or surface water (ingestion and dermal)
- Contaminants in surface soil (ingestion and dermal)
- Contaminants in fugitive dust (inhalation)
- Contaminant uptake by humans through beef and game animals (ingestion)

These identified potential sources and release mechanisms for potential contaminant migration will formulate the basis for the design of the characterization work plan. The data collected by this characterization program will be utilized to determine if there is contamination and, if so, determine if there is an adverse impact to potential receptors (e.g., human health and the environment) through the preparation of a risk assessment. The risk assessment, if required, will be conducted using the rancher and recreationalist scenarios as well as a Native American scenario using a modified recreationalist scenario. A corrective action alternative analysis will be completed should the risk assessment indicate there is an unacceptable risk to potential receptors. The DQO process for the site surface/shallow subsurface is summarized in Table 3-1.

3.1.2 Subsurface Conceptual Site Model

Potential migration of contamination from the nuclear cavity may have occurred. A site-specific conceptual model for the subsurface at the Gasbuggy Site is provided in Figure 3-1. The possible pathways for potential migration from the source include:

- Migration of natural gas in the Pictured Cliffs Formation
- Fractures or failed borehole seals connecting the cavity and the overlying Ojo Alamo aquifer
- Migration of groundwater in the Ojo Alamo aquifer

The closest water-bearing formation to the underground nuclear test is the overlying Ojo Alamo Sandstone, with its lower boundary approximately 600 ft above the detonation point. It is the only aquifer that conceivably could be affected by the test, although it is actually beyond the fracture radius observed. Fracturing from the Gasbuggy test was predicted to extend out to a radius of 425 ft, consistent with observations of cable and casing breaks in Well GB-1 at a distance of 480 ft and in Well GB-ER at 444 ft. A chimney height of 335 ft above the detonation point was also observed. At these distances, fractures may extend from the Pictured Cliffs up into the overlying Fruitland Sandstone and Kirtland Shale, and downward into the Lewis Shale. The shales are considered aquitards due to extremely low transmissivity, and both the Pictured Cliffs and Fruitland formations are gas-bearing and not considered to contain mobile water at the site (LRL, 1967a).

Potential exposure routes include ingestion, dermal contact, or inhalation of contaminated groundwater or natural gas. The potential exposure route by ingestion of Ojo Alamo groundwater can be eliminated based on the very poor water quality. Sulfate in the Ojo Alamo at Well EPNG 10-36 is over 5,000 milligrams per liter (mg/L) (DRI, 1996b), whereas the standard for domestic supply in New Mexico is 600 mg/L (NMAC, 1996a).

Table 3-1
Summary of Gasbuggy Quality Objectives for Surface and Shallow Subsurface Investigation

<table>
<tr><th>Step 1
State the Problem</th><td colspan="6">Potential surface/shallow subsurface contamination at the Gasbuggy Site may pose a threat to human health and the environment. The location of potential sources and the nature and extent of potential contamination is unknown. Therefore, it is unknown if potential contamination at the site poses a threat to human health and/or the environment.</td></tr>
<tr><th>Step 2
Identify the Decision</th><th>Step 3
Identify the Inputs to the Decision</th><th>Step 4
Define the Study Boundaries</th><th>Step 5
Develop a Decision Rule</th><th>Step 6
Specify Limits on Decision Errors</th><th>Step 7
Optimize the Design for Obtaining Data</th></tr>
<tr><td>Determine the radiological and chemical COPCs</td><td>Historical data and documentation and preliminary field investigation</td><td rowspan="8"><u>Areas of Operation:</u>
Surface Ground Zero Area
Well GB-D Area
Recording Trailer Park
Control Point
Helicopter Pad

<u>AOCs:</u>
Mud pits, landfills, operational areas, storage areas, storage areas, potential release sites, and septic tanks

<u>Migration from AOC:</u> soil, shallow groundwater</td><td rowspan="8">Area-specific

If no COPCs exceed PALs, then no action is required.

If COPCs exceed PALs, then a risk assessment will be conducted.

If risk assessment determines unacceptable levels, then a corrective action alternatives analysis will be conducted.</td><td rowspan="8">Decision errors are based on risk assessment.

If data is insufficient to make a decision, then additional data will be collected.</td><td rowspan="8">Develop work plan and technical approach.</td></tr>
<tr><td>Determine Preliminary Action Levels (PAL) for COPCs</td><td>State and Federal Regulations, technological limits, site-specific dose-based levels</td></tr>
<tr><td>Determine the locations of the sources of potential contamination</td><td>Historical data and documentation, geophysical techniques, and field observations</td></tr>
<tr><td>Determine if COPC concentrations exceed PALs</td><td>Results of field-screening and/or laboratory data, statistical analysis of data, background conditions</td></tr>
<tr><td>Determine if pathway to shallow groundwater exists</td><td>Depth of soil contamination, depth to shallow groundwater, soil properties, analytical results</td></tr>
<tr><td>Determine the nature and extent of potential contamination (soil and shallow groundwater)</td><td>Results of field-screening and/or laboratory data, soil properties, mobility of COPCs</td></tr>
<tr><td>Determine if COPC concentrations are within acceptable risk levels</td><td>Risk requirements, future land use scenarios, risk levels, dose calculations for tritium</td></tr>
<tr><td>Determine if a corrective action is necessary</td><td>Results of risk assessment, dose calculations for tritium</td></tr>
</table>

The identified source and release mechanisms for potential contaminant migration formulated the basis for the design of the characterization work plan. Currently, there is no technology to remediate underground nuclear test cavities; therefore, the approach is to minimize potential exposure by using existing data and analysis of sufficient quantity and quality to evaluate if existing subsurface intrusion restrictions need to be adjusted to be protective of human health and the environment.

Additional information on the subsurface model and how it relates to the subsurface work plan is presented in Section 5.0. The DQO process for the site surface/shallow subsurface is summarized in Table 3-2.

3.2 Contaminants of Potential Concern

The COPCs for the surface/shallow subsurface and deep subsurface investigations were determined based on an evaluation of site-specific historical documentation regarding the drilling fluids, drilling methods, site operations, previous sampling efforts performed at Gasbuggy, process knowledge from other underground nuclear test areas, and State of New Mexico regulatory guidance.

All laboratory data for chemical COPCs will be evaluated for data quality according to "Contract Laboratory Program National Functional Guidelines for Inorganic Data Review" (EPA, 1994b), or "Contract Laboratory Program National Functional Guidelines for Organic Data Review" (EPA, 1999b), as appropriate. In addition, five percent of this data will be subjected to independent verification using the same guidelines. All laboratory data for radiochemistry analysis will be validated according to internal procedures.

3.2.1 COPCs for the Surface and Near-Surface Investigation

The COPCs to be considered were determined based on an evaluation of site-specific historical documentation, previous sampling efforts performed at the Gasbuggy Site, and process knowledge from other underground nuclear test areas.

A review of historical documentation found no indication of releases of potentially hazardous chemical constituents at the Gasbuggy Site other than those contained in drilling mud. Based on knowledge of drilling methods and the results of previous characterizations of mud pits associated with underground nuclear detonation sites, the mud pits at the Gasbuggy Site may contain diesel.

Table 3-2
Summary of Gasbuggy Quality Objectives for Subsurface Investigation

Step 1 State the Problem	Significant radionuclide contamination remains in the Gasbuggy cavity and cannot be remediated by existing technology. It is not known if existing subsurface intrusion restrictions are sufficient to eliminate potential exposure pathways, or prevent contaminant transport into resources of value, under existing conditions or during future resource development, nor whether such transport would pose a risk to human health or the environment if it occurred.

Step 2 Identify the Decision	Step 3 Identify the Inputs to the Decision	Step 4 Define the Study Boundaries	Step 5 Develop a Decision Rule	Step 6 Specify Limits on Decision Errors	Step 7 Optimize the Design for Obtaining Data
Determine the radiological and chemical COPCs.	Historical data, process knowledge, known radiological decay rates	Modeling boundary to be based on scoping calculations.	If calculations predict possible contaminant transport beyond existing restrictions, either reduce uncertainty with additional data collection, or extend institutional controls if indicated by risk assessment.	Decision errors are based on model. If data is insufficient to make a decision, then additional data will be collected.	Develop work plan and technical approach.
Determine the PALs for COPCs.	State and federal regulations, site-specific dose-based levels				
Determine if the Ojo Alamo Aquifer is a transport pathway for COPCs.	Multiphase numerical modeling, investigations in Well EPNG 10-36, and future resource-use scenarios				
Determine the nature and extent of contamination in subsurface resources.	Historical data, knowledge of subsurface geology and hydrology, mobility of COPCs, multiphase numerical modeling				
Determine if future resource development could impact the extent of subsurface contamination.	Multiphase numerical modeling and future resource-use scenarios				
Determine if COPC concentrations at possible resource-use points are within acceptable limits or whether a human health dose assessment is warranted.	Multiphase numerical modeling, future resource-use scenarios, radionuclide concentration guidelines				
Determine if existing subsurface intrusion restrictions are adequate for site closure.	Modeling results, dose assessment results, and future resource-use scenarios				
Determine if a long-term monitoring program is technically warranted.	Modeling results, subsurface intrusion restrictions				

Other COPCs associated with the drilling mud include metals such as chromium and possibly lead. The *Project Gasbuggy Radiation Contamination Clearance Report* (EIC, 1979) indicates that the decontamination pit constructed in 1967 had never been used and that solvents were not used during the 1978 restoration. Information on the locations of on-site laboratories and COPCs used in those laboratories is inconclusive.

Based on site history and historical analytical data, radionuclides other than tritium can be eliminated from consideration as COPCs for the surface/shallow subsurface investigation (see Appendix A). Results of tritium analysis of soil samples collected during the preliminary field investigation in August and September of 2000 (Appendix C) were used to evaluate if there is a potential for human health risks associated with tritium at the Gasbuggy Site. Based on the evaluation (see Appendix D), it was determined that the levels of tritium that exist at the site today do not pose a current or future risk. Therefore, further characterization of the site for tritium contamination is not necessary.

The following is a comprehensive list of site characterization COPCs for future surface/shallow subsurface investigations (additional COPCs may be analyzed for waste characterization purposes):

- TPH, diesel and gasoline range
- VOCs
- SVOCs
- Total *Resource Conservation and Recovery Act* (RCRA) Metals

Based on discussions with the New Mexico Oil Conservation Division (NM OCD), COPCs listed in the New Mexico Water Quality Control Commission (NM WQCC) regulations in Title 20, *New Mexico Administrative Code* (NMAC) 6.2.3103, "Standards for Ground Water of 10,000 milligrams per liter Total Dissolved Solids Concentration or Less" (NMAC, 1996a), need to be considered to ensure that waste in the mud pits will be managed "in a manner to prevent contamination to surface or subsurface waters," as stated in 19 NMAC 15.C.105 (NMAC, 1996b).

The following additional parameters listed in 20 NMAC 6.2.3103 were analyzed for during the preliminary site investigation:

- Target Analyte List (TAL) metals plus boron, molybdenum, and uranium
- Major anions (i.e., bromide, chloride, cyanide, fluoride)
- Nitrates

- Sulfates
- Radium-226/-228

Although listed in 20 NMAC 6.2.3103, Polychlorinated Biphenyls (PCBs) were not analyzed for based on site knowledge and sampling results from other underground test areas that indicate there is no reason to believe there is PCB contamination at this site.

All site characterization samples collected during the preliminary field investigation were soil samples (groundwater was not encountered) and, therefore, cannot be directly compared to the NM WQCC water quality standards. The soil sample results will be used, as necessary, to formulate corrective action decisions and/or as part of a risk assessment, if necessary. Additional sampling for these parameters is not planned unless conditions encountered in the field dictate and/or shallow groundwater sampling is required (see Section 4.3). If groundwater samples are collected for these parameters, the PALs will be the levels indicated in 20 NMAC 6.2.3103 (NMAC, 1996a).

3.2.2 PALs for Surface and Shallow Subsurface Investigation

To determine if contamination exists, results of laboratory analysis for chemical COPCs in soil will be compared to preliminary action levels (PALs). For the purposes of this investigation, the PALs will be the industrial risk-based preliminary remediation goals (PRGs) provided in the *EPA Region IX Risk-Based Concentration Table* (EPA, 1999a). Laboratory results above PALs indicate the presence of COPCs at levels that may require a risk assessment to determine if corrective actions are required. Comparisons will also be made to representative background conditions established through statistical analysis of sample results. If representative inorganic site characterization values from AOCs are shown through statistical analysis to be not significantly different from representative background values, then a risk assessment may not be warranted. If representative inorganic background values exceed the EPA Region IX PRGs, risk due solely to background values may be estimated independently for comparison to the risk posed by the actual detected or representative COPC concentrations; however, the risk due solely to background constituent concentrations should not trigger corrective action (NMED, 2000a).

As specified in the New Mexico Environment Department (NMED), Hazardous Waste Bureau Position Paper's *"Use of Total Petroleum Hydrocarbon (TPH) Test Results for Site*

Characterization," in the absence of other contaminants above risk-based cleanup levels, results for TPH may be used to guide potential cleanup (NMED, 2000b).

The NM QAPP's (Appendix B) "Laboratory Chemical, Toxicity Characteristic Leaching Procedure (TCLP), and Radiochemistry Analytical Requirements for New Mexico Sites" table allows for both Method 5035 and Method 8260B for VOC analysis. During the preliminary field investigation at the Gasbuggy Site (Appendix C), Method 8260B was used. Due to the remoteness of the site, planned work schedules, and required hold times for Method 5035, it is likely that, if Method 5035 were used, a significant portion of data would be qualified as estimated. Since estimated data would not be usable for risk assessment purposes (Wycoff, 2000), Method 8260B will be used during future investigations.

3.2.3 COPCs for Subsurface Investigation

Radionuclides associated with underground nuclear explosions result from: (1) residual nuclear material that has not undergone a fission or thermonuclear reaction; (2) direct products of nuclear reactions (fission products and tritium); and (3) activation products induced by neutron capture in the immediate vicinity of the explosion (LLNL, 1976). A list of radionuclides that may be important for investigation of groundwater transport from underground tests is provided by LLNL (1995). The majority of radionuclides in the subsurface are nonvolatile or even refractory, therefore are unavailable for gas-phase transport. The only radionuclides detected in gas produced from the Gasbuggy cavity are Tritium, Carbon-14 (C-14), Argon-37 (Ar-37), Argon-39 (Ar-39), Krypton-85 (Kr-85), and Xenon-133 (Xe-133) (Holzer, 1970). Two of these have such short half-lives that they have essentially decayed away in the time since the test and are no longer of concern (Xe-133 and Ar-37). The significant COPCs for gas migration include:

- Tritium
- Kr-85
- C-14
- Ar-39

Tritium and Kr-85 are responsible for essentially all of the radioactivity observed in the gas. About 350 ± 20 curies of Kr-85 and about 4.5×10^4 curies of tritium are estimated to have been initially deposited in the chimney as a result of the Gasbuggy detonation (Holzer, 1970). As krypton is not retained to any significant extent by the body, tritium is the principal radionuclide of concern in the natural gas.

As will be discussed in Section 5.0, the pressure relationship between the Ojo Alamo and Pictured Cliffs precludes liquid-phase migration from the cavity up to the Ojo Alamo. Gas-phase transport is conceivable if there was a connection between the two formations shortly after the test, when the cavity was experiencing the high pressures of the detonation. The significant COPCs for groundwater migration are those that could have traveled to the Ojo Alamo in the gas phase, including some that subsequently decay to nonvolatile daughters. These include:

- Tritium
- Kr-85
- C-14
- Strontium-90 (Sr-90)
- Cesium-137 (Cs-137)

Annual monitoring of Well EPNG 10-36 by the EPA under the Long-Term Hydrological Monitoring Program (LTHMP) has detected tritium in the well above background in each year since 1984, except for 1987 (Boehlecke, 2001 and Dempsey, 2001). The levels of tritium detected in the well are less than 5 percent of the drinking water standard of 20,000 pCi/L (CFR 2000). Sampling by EPA has also detected Cs-137 at concentrations up to 16 pCi/L in Well EPNG 10-36 between 1990 and 1994, although no Cs-137 has been detected in well water since 1994 (Boehlecke, 2001 and Dempsey, 2001). These concentrations are less then 25 percent of the drinking water standard of 53.3 pCi/L (CFR, 2000 and INEL, 1988).

No chemical COPCs have been identified for the subsurface at Gasbuggy. The emplacement occurred through a 28-inch (in.) borehole drilled to 4,350 ft, with a 20-in. casing to the bottom of the borehole and cemented to land surface. A second, 7-in. casing was installed to the device depth, with the annular space and casing itself filled with zones of cement and zones of sand (DOE/NV, 1978). This was a simple stemming program to contain the nuclear test underground. This process did not involve the use of large amounts of metals, such as lead, typically associated with other underground nuclear tests.

4.0 Surface and Shallow Subsurface Work Plan

Additional field investigation will build on the data already acquired through historical research and the preliminary field investigation (Appendix C). The goal of further field investigation will be to fill existing data gaps in order to establish current site conditions and confirm or refute the CSM. Data collected will be used to identify and evaluate if further action is required to achieve permanent closure of the site that is protective of human health and the environment.

Additional investigation for the surface/shallow subsurface will consist of: (1) collecting additional surface/shallow subsurface soil samples to define the nature and extent of potential contamination in each AOC; (2) determining if there is or is not a path for COPCs to migrate to shallow groundwater; and (3) determine the nature and extent of potential contamination in the shallow groundwater, if applicable. Background conditions will be established by collecting soil samples and shallow groundwater samples, if applicable, at nonimpacted areas near the site. Figure 4-1 is a DQO decision flow chart that summarizes the characterization scope of work and technical approach for the additional field work proposed for the surface/shallow subsurface investigation.

The following sections define the technical approach and detail the activities to be completed for the additional field investigation. Unexpected site conditions may require modifications to the CSM, the DQOs, and/or field investigation activities.

4.1 Demarcate Areas of Concern

Historical aerial and oblique photographs, along with site engineering and "as-built" drawings, will be compared to the results of the geophysical surveys and the physical landmarks at the Gasbuggy Site to demarcate the AOCs. Locations for the AOCs will be found using landmarks and global positioning system (GPS) coordinates. The results of the preliminary field investigation including GPS coordinates will also aid in demarcating AOCs. Prior to beginning further soil investigation, the estimated extent of each AOC (e.g., mud pit, landfill, geophysical anomaly) will be located and staked.

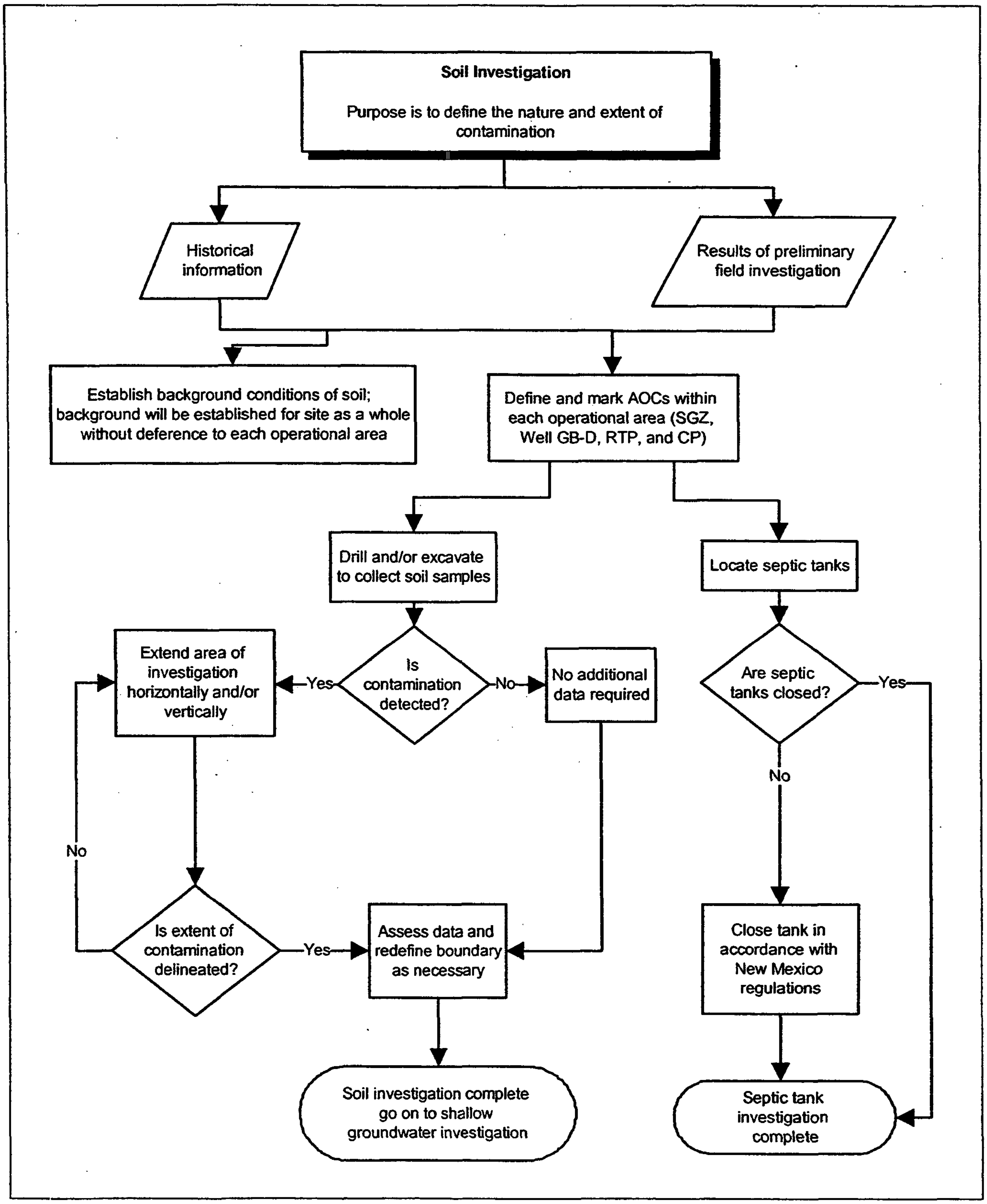


Figure 4-1
Surface and Shallow Subsurface DQO Decision Flow Chart
(Page 1 of 2)

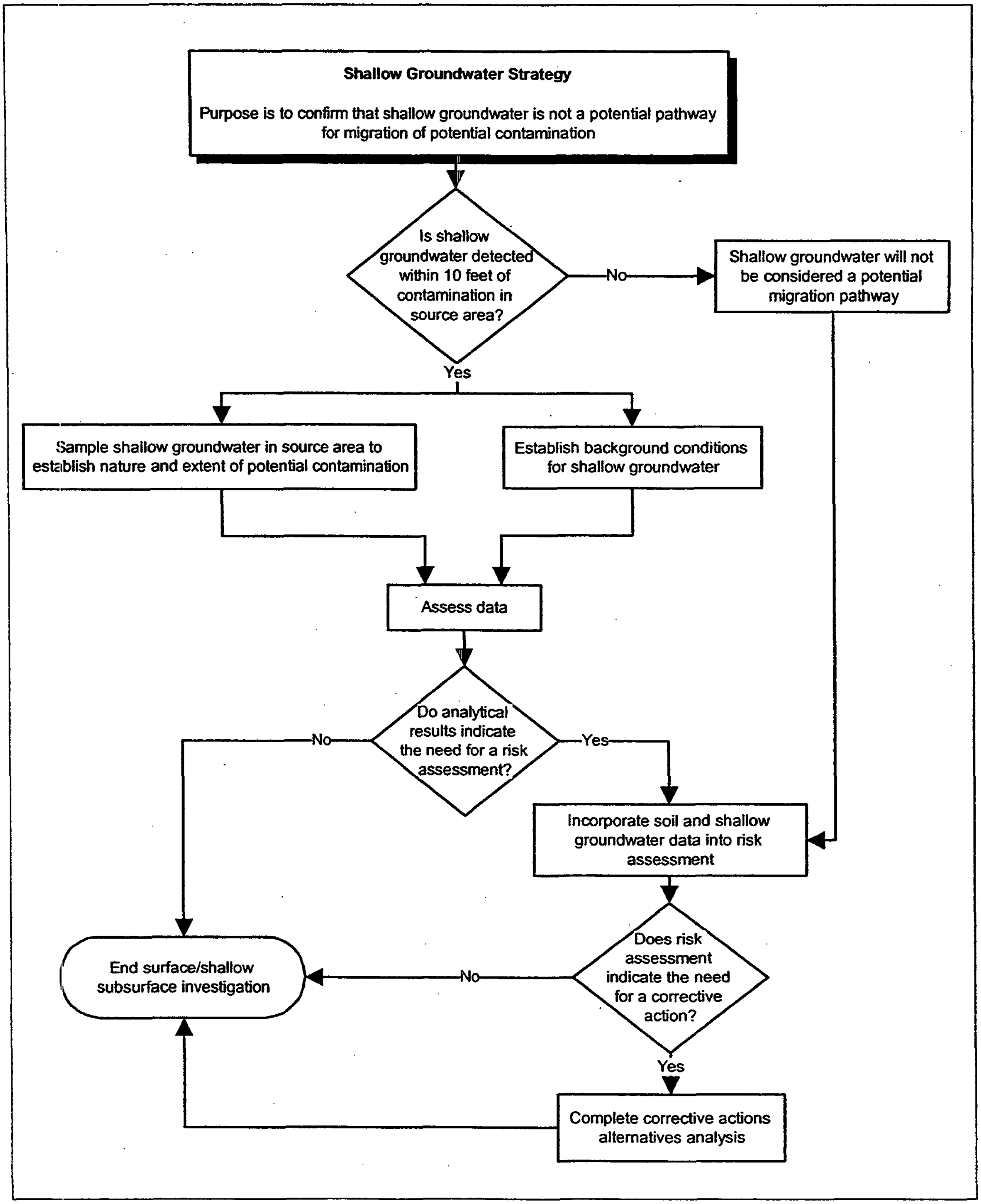


Figure 4-1
Surface and Shallow Subsurface DQO Decision Flow Chart
(Page 2 of 2)

4.2 Soil Sampling Investigation

Initial soil sampling will be conducted at the Well GB-D area, the RTP, and the CP operational areas. Follow-on soil sampling will be conducted at the SGZ area to fill data gaps that remain after the preliminary field investigation. No soil sampling is proposed for the HP operational area. Soil sampling will be conducted for the purpose of site characterization, quality control (QC), and waste characterization. Soil sampling will use a combination of biased sampling and systematic random sampling strategies. Biased samples will be collected in locations of known or suspected contamination. A systematic random sampling strategy will be utilized to characterize potential contamination in the mud pits.

Soil sampling will be conducted primarily by using drilling or direct-push technologies. Excavation may also be employed to collect soil samples at locations where geophysical surveys were unable to identify the exact location of a shallow subsurface feature.

4.2.1 Representative Inorganic Background Sample Collection

Background inorganic chemical concentrations for total RCRA metals will be established for the Gasbuggy Site. Systematic random sampling will be conducted in designated areas to collect samples for off-site laboratory analysis. The results will be used in comparing characterization samples and supporting risk assessments, if required.

Statistical methods have been employed in order to determine the appropriate number of samples to establish background concentrations for arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver. Equation 8 of Chapter 9 of SW-846 (EPA, 1996) gives the number of samples required to determine to within a specified percent error (e_r) the mean concentration of a parameter normally distributed in the study area, with a variability measured by a relative standard deviation (coefficient of variation [CV]), at a confidence level of 90 percent as:

$$n = (t_{0.90,n-1} * [CV/e_r])^2$$

where "t" is the one-tailed 90 percent Student's "t" value for the appropriate number of degrees of freedom (n-1).

The CV in the above equation refers to the variability of the specific parameter in the medium being sampled. It is usually unavailable until sufficient samples from the site have been analyzed. The variability of the proposed analytical method is usually substituted as a first approximation. However, in this case, data from five preliminary background soil samples taken at the Gasbuggy Site can be used to calculate the CV for the RCRA metals (Table 4-1). These samples were collected at depths ranging from 2 to 14 ft bgs in two boreholes located near the SGZ area but outside of the AOCs. Statistical analysis confirms these data are normally distributed.

Table 4-1
Statistical Analysis of RCRA Metal Results for Preliminary Background Soil Samples

Metal	Mean Background Concentration (mg/kg)	Standard Deviation (mg/kg)	Relative Standard Deviation (percent)
Arsenic	2.12	0.719	33.9
Barium	274.0	28.81	10.51
Cadmium	ND	NA	NA
Chromium	12.34	2.044	16.56
Lead	8.44	2.14	25.3
Mercury	ND	NA	NA
Selenium	ND	NA	NA
Silver	ND	NA	NA

mg/kg = Milligrams per kilogram
ND = Not detected
NA = Not applicable

By rearranging the above equation and substituting the number of samples analyzed (n=5), the one-sided Student's value for 4 degrees freedom at a 90 percent confidence level (1.533), and the relative standard deviations for each parameter, the percent error in the means of each analyte and the upper 90 percent confidence interval can be calculated as indicated in Table 4-2. Region IX PRGs (EPA, 1999c) are included for comparison.

A relative error of plus or minus 10 to 20 percent from the true mean at a confidence limit of 90 percent is considered acceptable for planned removal and remedial response studies (EPA, 1989).

Table 4-2
Calculation of Percent Error and 90 Percent Confidence Interval of RCRA Metal Results for Preliminary Background Soil Samples

Metal	Mean Background Concentration (mg/kg)	PRG (mg/kg)	Percent Error
Arsenic	2.12	2.7	23.3
Barium	274	10,000	7.2
Chromium	12.34	450	11.4
Lead	8.44	100	17.4

mg/kg = Milligrams per kilogram
PRG = Preliminary remediation goal for EPA Region IX (EPA, 1999c)

Thus, as shown in Table 4-2, the number of samples already analyzed serves to adequately establish the background levels of barium, chromium, and lead at the Gasbuggy Site.

To more accurately determine the background level of arsenic, it will be necessary to analyze at least ten samples (or five additional samples) to have the mean arsenic concentration calculated within the tolerable error of +/- 20 percent with 90 percent confidence. These samples will be submitted for off-site analysis for all eight RCRA metals.

The five samples will be taken from preselected 4-ft intervals in soil borings. The borings will be located in an area that is undisturbed and unaffected by site operations. The depth of sample collection will be from depths between 4 and 12 ft bgs. The exact depth will be randomly selected. If there is refusal at a shallower depth, then additional borings will be drilled to collect the required number of samples. The depth of 12 ft was based on the assumption that chemical contamination would not extend beyond this depth based on process knowledge, operational history, and results of the preliminary field investigation. If potential contamination is observed at deeper intervals through visual observations of soil cores and/or field screening, additional background samples may be collected for those depths. For the purposes of this investigation, the background values for inorganic parameters at all four operational areas designated for further investigations will be assumed to be the same.

4.2.2 Soil Sampling Techniques

The two techniques proposed for sample collection, soil boring and excavation, are described below. In addition, this section provides details on how specific locations within a soil boring or excavation will be chosen for sampling.

4.2.2.1 Soil Boring Techniques

Drilling methods such as direct-push, rotosonic, or other appropriate drilling technique will be used for the investigative drilling and soil characterization. The direct-push method penetrates the soil with minimal disturbance, using an advancing decontaminated hollow 4-ft core barrel. Acetate, cellulose, or polyvinyl chloride liner sleeves will be used to contain the cores at each boring. In the event that an additional volume of soil is needed for analysis, additional cores will be obtained from around the original boring at a radius of not greater than 1 ft. The rotosonic method penetrates soil with minimal disturbance using an advancing, decontaminated 10-ft core barrel. The resulting soil cores can be extruded into plastic bags in convenient handling lengths (approximately 5 ft) for sampling.

All drilling and sample collection tools that may come in contact with soil samples shall be decontaminated prior to each sampling event to minimize potential cross-contamination between sample locations. All samples collected for laboratory analysis will be fresh media rather than material used for field screening. Records will be kept of the soil description, field-screening measurements, and other relevant data. All required sampling information (e.g., date, time, sample interval) will be documented in accordance with the NM QAPP (Appendix B) and applicable contractor standard quality practices.

4.2.2.2 Soil Excavation Techniques

Soil excavation may be used to locate septic tanks, landfills, or other anomalies not identified by geophysical investigations. Excavation techniques will be appropriate for the anticipated depth and volume of the excavation. As such, techniques may include excavation with hand tools or heavy equipment (e.g., backhoe).

All excavation tools that may come in contact with soil samples shall be decontaminated prior to each sampling event to minimize potential cross-contamination between sample locations. Samples will be collected either directly from the bottom of the excavation or from material removed (e.g., sample may be collected from a backhoe bucket). All samples collected for laboratory analysis will be fresh media rather than material used for field screening. Records will be kept of the soil description, field-screening measurements, and other relevant data. All required sampling information (e.g., date, time, sample interval) will be documented in accordance with the NM QAPP (Appendix B) and applicable contractor standard quality practices.

Excavated material will be managed in soil piles near the excavation. The piles will be managed in a manner that is protected from run-on and run-off as the conditions require. Upon completion of investigation within each excavation, the soil will be returned to the excavation taking care to replace the soils to their approximate horizon of origin.

4.2.2.3 Field Screening

Soil samples will be collected for field screening at intervals appropriate for the method (e.g., 4-ft intervals for direct-push or 5-ft intervals for rotosonic), depth of investigation, and for the AOC being investigated. For example, TPH field screening would not be used for an AOC where TPH is not a COPC, nor would field screening be conducted every 4 ft if contamination is obvious due to staining and/or odor. When field screening is being used to guide the investigation and select sampling locations, it will be continued until two consecutive, "clean" field-screening samples are obtained or until 10 ft below the deepest detected contamination, whichever is deeper. If contamination is detected beyond 20 ft, or the limit of the technology is met prior to reaching 10 ft beyond detected contamination, drilling/excavation will stop and the situation will be evaluated to determine if the contamination is outside the planned scope of the investigation.

All soil cores and excavated material will be visually inspected and screened for VOCs using a photo-ionization detector (or similar). Samples may also be field screened using a method capable of identifying TPH, such as the Hanby test kit or other method. The results of field screening will be recorded on appropriate forms. Visual indications of contamination, elevated VOC readings, and/or elevated TPH screening, may be used to select samples for off-site analysis. The following field-screening results will be used to indicate if contamination is present:

- VOC readings of twice background (established daily) or 20 parts per million (ppm), whichever is higher
- TPH results of 100 ppm or greater

If contamination is detected by any of the above methods, the horizontal and vertical extent of the contamination will be defined by continuing soil borings and/or excavations until two consecutive nondetects are recorded and/or by completing step-out borings or excavations.

Site characterization field screening for radioactive constituents will not be conducted.

4.2.2.4 Sampling Criteria

Soil borings and/or excavation will be used for two primary purposes: (1) to collect soil samples from within an AOC to determine the nature and vertical extent of potential contamination, and (2) as step-out borings/excavations to determine the lateral extent of potential contamination. Unless otherwise indicated, samples will be collected as follows:

For borings/excavations that are within an AOC, a minimum of two samples will be selected for off-site laboratory analysis. One sample will be from the highest field-screening interval, and the second sample will be from the deepest vertical, nondetect interval or a minimum of 10 ft below the deepest contamination detected by field screening, whichever is deeper. If field screening and observation does not indicate contamination in a boring drilled in a suspect area, then a sample will be collected from the interval where contamination was expected based on field observations and process knowledge. For example, if soil below 4 ft bgs appears to be undisturbed and soil above 4 ft bgs appears to be fill or nonnative soil, the sample will be collected above the 4-ft level.

For step-out borings/excavations, if field screening does not detect any contamination, a sample from the equivalent depth interval (same depth as the contaminated boring) will be submitted for confirmation of the nondetect field-screening readings.

Discretionary sampling points may also be selected for laboratory analysis based on observation of:

- Moist or discolored zones
- Significant changes in soil grain size or debris in sample
- Changes in field-screening detection
- Odor

Geotechnical samples may be collected for evaluation of soil parameters to facilitate future corrective action strategies.

4.2.3 Soil Sampling Locations for Surface/Shallow Subsurface Characterization

Each soil sampling location will be named, described, and documented in accordance with the NM QAPP (Appendix B) and applicable contractor standard quality practices. In the field, decisions will be made to allow for changes to sampling locations and number of samples collected depending on field conditions. For example, if apparent contamination is more widespread than originally anticipated, it may be decided to expand the number of locations sampled. If bedrock or refusal is encountered at a very shallow depth, a subsurface soil sample may not be possible at that sampling location. If drilling, excavation, and/or sampling at a recommended location presents an undue health and safety risk to field personnel, the location will be changed. Changes, and the rationale behind each change, will be documented.

4.2.3.1 Surface Ground Zero Area

Known or suspect site features within the SGZ area discussed in Section 2.2.1 or found during the geophysical investigation (see Appendix C, Section C.6.0) are listed in Table 4-3. Geophysical and/or sampling results from the preliminary field investigation (Appendix C) were utilized, where applicable, to focus the COPCs and determine the proposed investigation method. These features will be investigated as summarized in Table 4-3 and described in the following sections. Historical and geophysical data have been compared to make a determination as to what geophysical anomalies represent (e.g., a known or unknown mud pit, landfill), and a unique name has been assigned.

Table 4-3
Investigation Strategy for Surface Ground Zero Area Known and Suspect AOCs
(Page 1 of 2)

Unique Identifier	Approximate Size (feet)	Summary of Proposed Investigation Strategy	Contaminants of Potential Concern
Well EPNG 10-36 Sump	50 X 25	Further investigation will include excavation and/or direct-push sampling to refine nature and extent of potential contamination.	TPH (DRO, GRO), VOCs, SVOCs, Total RCRA metals
Well GB-1 Mud Pit	100 X 50	Based on available historical documentation and the results of the geophysical investigation, these three mud pits can not be distinguished from each other. Therefore, for the purposes of further investigation, these three mud pits will be treated as one unit. Further investigation will include additional direct-push sampling to refine nature and extent of potential contamination.	TPH (DRO, GRO), VOCs, SVOCs, Total RCRA metals
Well GB-E Mud Pit B	NA		
Well GB-E Mud Pit C	NA		
Well GB-2 Mud Pit	150 X 125	Further investigation will include additional direct-push sampling to refine nature and extent of potential contamination.	TPH (DRO, GRO), VOCs, SVOCs, Total RCRA metals
Well GB-E Mud Pit A	150 X 175	Further investigation will include additional direct-push sampling to refine nature and extent of potential contamination.	TPH (DRO, GRO), VOCs, SVOCs, Total RCRA metals
Well GB-E Mud Pit D	75 X 50	Well GB-E Mud Pit D is located entirely within the lateral bounds of the Well GB-2 Mud Pit, but consists of a distinct mud layer. Further investigation will include additional direct-push sampling to refine nature and extent of potential contamination.	TPH (DRO, GRO), VOCs, SVOCs, Total RCRA metals
Well GB-E Mud Pit E	100 X 75	Further investigation will include additional direct-push sampling to refine nature and extent of potential contamination.	TPH (DRO, GRO), VOCs, SVOCs, Total RCRA metals
Landfill A	20 X 10	Further investigation will include excavation and/or direct-push sampling to refine nature and extent of potential contamination.	TPH (DRO, GRO), VOCs, SVOCs, Total RCRA metals
Landfill C	50 X 10		
Landfill D	30 X 10		
Landfill B	50 X 50	No further investigation is proposed.	No further sampling proposed.
Landfill E	50 X 20	No further investigation is proposed.	No further sampling proposed.

Table 4-3
Investigation Strategy for Surface Ground Zero Area Known and Suspect AOCs
(Page 2 of 2)

Unique Identifier	Approximate Size (feet)	Summary of Proposed Investigation Strategy	Contaminants of Potential Concern
Septic Tank A Septic Tank B	NA	Search for septic tank with exploratory excavation. If tank is located, verify it has been closed in place (filled). If tank has not been filled, sample any contents, and close in accordance with State of New Mexico regulations (NMAC, 1997).	Tritium and other COPCs as required for waste disposal (tank contents only)
Well EPNG 10-36 Drill Pad	50 X 50	No further investigation is proposed.	No further sampling proposed.
Well GB-1 Drill Pad	50 X 50	No further investigation is proposed.	No further sampling proposed.
Well GB-2 Drill Pad	50 X 50	No further investigation is proposed.	No further sampling proposed.
Well GB-E Drill Pad	100 X 100	No further investigation is proposed.	No further sampling proposed.
Well GB-3 Drill Pad	50 X 50	No further investigation is proposed.	No further sampling proposed.
Soil Pile	75 X 50	Excavate and sample based on field observations.	TPH (DRO, GRO), VOCs, SVOCs, Total RCRA metals
Gas-Flaring System	Unknown	Further investigation will include additional direct-push sampling to refine nature and extent of potential contamination.	TPH (DRO, GRO), VOCs, SVOCs, Total RCRA metals

DRO = Diesel-range organics
GRO = Gasoline-range organics
NA = Not applicable

EPNG 10-36 Sump

The geophysical survey conducted in August 2000 identified an anomaly with both a strong metallic and nonmetallic signature where this feature was predicted. It is unknown what may be producing the metallic response. No drilling mud was observed in a boring (GBP06) drilled in the center of the anomaly during the preliminary field investigation. No COPCs were detected above PALs in samples collected from the boring.

Excavation and/or soil boring is proposed to further investigate this anomaly. If excavation is used, a minimum of one trench will be excavated perpendicular to the long axis of the anomaly. If soil boring is used, a minimum of two additional soil borings will be drilled within the anomaly. Field screening and observation will be used to guide sample collection as described in Section 4.2.2.

Mud Pits

The objectives of further investigation of the mud pits are to characterize the concentration of diesel contamination within the drilling mud, characterize the vertical and horizontal extent of the diesel contamination, and provide additional negative evidence for contamination above PALs of COPCs other than diesel.

The following assumptions are made regarding the mud pits:

- Well GB-E Mud Pit D lies entirely within the bounds of the Well GB-2 Mud Pit. This is based on the findings of the preliminary field investigation, which indicated there are two distinct layers of potential contamination.
- One or more of the mud pits identified in Table 4-3 were used for the containment of drilling fluids for the reentry of wells EPNG 10-36, GB-2R, and GB-ER, and for the initial drilling of Well GB-3. Therefore, additional investigation for separate mud pits for these drilling events will not occur unless further evidence identified during the field investigation indicates it is necessary.
- As listed in Table 4-3, there are four distinct mud pits at the SGZ area (i.e., Well GB-2 Mud Pit, Well GB-E Mud Pit A, Well GB-E Mud Pit D and Well GB-E Mud Pit E) and one group of mud pits that will be investigated as one unit (i.e., Well GB-1 Mud Pit, Well GB-E Mud Pit B and Well GB-E Mud Pit C).

- The Well GB-2 Mud Pit and Well GB-E Mud Pit A are currently separated by a berm. This berm is assumed to represent the west and east boundaries, respectively, of these mud pits.

- The mud in each of the mud pits at the SGZ area and the one mud pit at the Well GB-D area are similar (i.e., the same ingredients were used).

- Based on the findings of the Preliminary Field Investigation (see Appendix C), TPH diesel is the only COPC identified above PALs in the mud pits. Gasoline and the lone VOC identified above PALs were found in the vicinity of the flare stack, and arsenic appears to be at background levels in the mud pits.

- Based on the findings of the Preliminary Field Investigation (see Appendix C), migration of diesel from the mud layer is not occurring.

Based on the diesel analytical data from the 2000 sampling event, to have the mean diesel concentration calculated within a tolerable error of +/- 20 percent with a 90 percent confidence, it will be necessary to analyze 64 samples for diesel. This includes the nine samples previously collected from the drilling mud. Therefore, 55 additional samples of drilling mud will be collected and analyzed for TPH diesel. These samples will be collected from the five identified mud pits or mud pit groups in the Surface Ground Zero Area (see Table 4-3) and the one mud pit at the Well GB-D area (see Table 4-4). The EPNG 10-36 sump will be treated independently because of its unique history (i.e., it cannot be assumed that the mud in the EPNG 10-36 sump is the same as the mud in the mud pits because it likely received drilling mud and/or other fluids prior to AEC use of the area [see Section 2.2.1]).

Results of the geophysical investigation, together with historical site knowledge, will be used to define the perimeters of each mud pit. Additional borehole locations will be randomly selected within these perimeters.

A borehole will be drilled at each of the preselected locations. A TPH diesel sample will be collected from any identified mud layer encountered. Mud layers encountered during the preliminary field investigation were generally less than 2 ft in thickness and transitional at both the top and bottom of the layer. The sample will be collected by homogenizing the interval identified as the mud layer.

To characterize the vertical extent of diesel contamination, samples will be collected below the drilling mud layer from a minimum of five borehole locations within each mud pit (boreholes already drilled during the preliminary field investigation are counted towards the total of five). Samples will be collected from an interval immediately below the mud layer and from a deeper interval. Field screening for diesel will be used to aid in the selection of sample collection depths. Field screening will be continued until two consecutive "clean" field-screening samples are obtained or until 10 ft below the deepest detected contamination, whichever is deeper, and a sample will be collected at this point (see Figure 4-2). If no mud layer is encountered and field screening does not indicate contamination, a sample will be collected at the depth where mud was expected to be encountered (based on where it was encountered in other boreholes within the mud pit) and at 10 ft below this level. See Figure 4-2 for an example of sampling locations.

To characterize the horizontal extent of diesel contamination, borings will also be advanced outside of the estimated lateral extent of contamination. If no mud is observed by visual inspection, and field screening does not indicate any contamination, it will be assumed the edge of the contamination has been defined. If mud is observed, it will be assumed the borehole was located within the AOC and a step-out location will be selected for another borehole. Samples for laboratory analysis may not be collected from step-out borings for mud pits.

In addition to the samples collected for diesel analysis, additional samples will be collected to provide added negative data on the presence of other COPCs listed for mud pits in Table 4-3. A minimum of five boreholes (boreholes already drilled during the preliminary field investigation are counted towards the total of five) will be advanced in each mud pit or group of mud pits to characterize for these additional COPCs. Boreholes selected for the diesel investigation will be used where appropriate. Samples will be collected from each identified mud layer and at a minimum of 10 ft below the lower most mud layer.

Landfills

The geophysical investigation did not identify any of the four landfills (Landfill A, B, C, or D) documented during the 1978 site remediation (EIC, 1979). Based on historical documentation, Landfill B contains only nonhazardous and nonradioactive construction debris and will not be investigated further. The historical diagram documenting the location of Landfills A, C, and D will be used to stake their predicted locations. Excavation is proposed to further investigate these landfills.

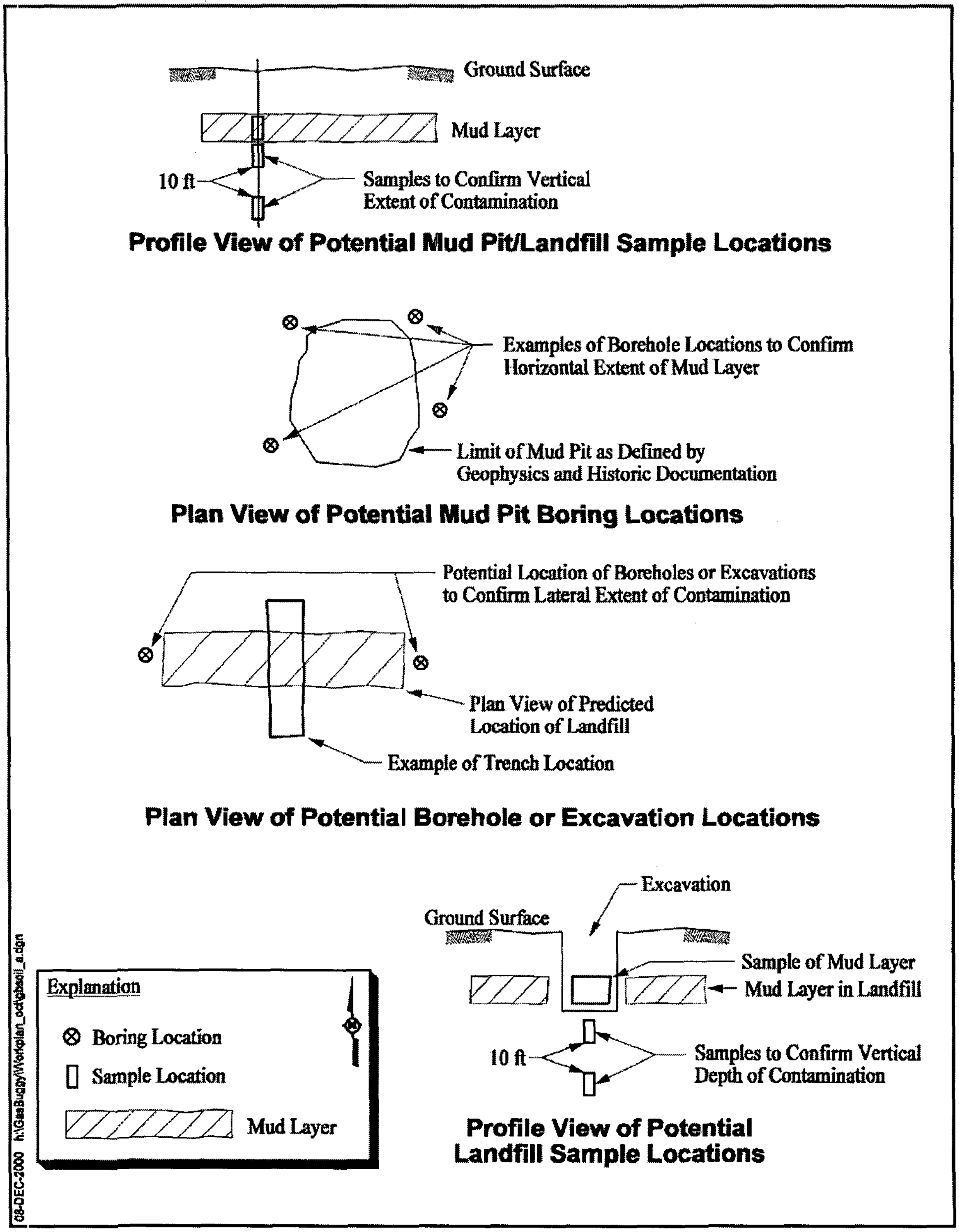


Figure 4-2
Example of Sampling Locations

Trenches will be excavated at the estimated center and perpendicular to the long axis of each landfill. Sampling will be conducted as described in Section 4.2.2. Because these landfills were used to dispose of drilling fluids previously held in tanks, it is assumed the contents of each of the landfills are homogenous. Therefore, one sample will be considered representative of the contents. The lateral extent of each landfill will be defined by visual observation and/or sampling in the same manner as described for mud pits. The vertical extent of potential contamination will also be defined in the same manner as described for mud pits. If no mud is found, then step-out trenches will be excavated 10 ft to either side of the original trench. This will continue until the landfill is identified or to a maximum of 50 ft laterally from predicted center line, whichever comes first. See Figure 4-2 for example of trench and sample locations.

Several anomalies were located where Landfill E was indicated in historical photographs. Based on the results of the preliminary field investigation (see Appendix C, Section C.6.0), it is assumed this landfill contains only metal and/or other construction debris and will not be investigated further.

Septic Tanks

The geophysical survey was unable to definitively locate the septic tanks identified in the historical documentation (see Figure 2-8). Excavation will be used to attempt to locate the septic tanks, where they are indicated by historical documentation. If excavation fails to locate the septic tanks, it will be assumed they were either never constructed, were closed in place in accordance with state of New Mexico regulations, or were removed, and investigation of the tank will be discontinued. If the location of a septic tank is identified, further investigation will be conducted as follows.

The septic tank lid, if one exists (the construction of the tanks is not known), will be excavated so that confirmation can be made that the tank was closed (e.g., filled with earth, sand, gravel, or concrete) in accordance with New Mexico regulations, Title 20 NMAC 7.3.410, "Abandoned Sewers and On-Site Liquid Waste Systems" (NMAC, 1997). If the tank was not filled and still contains any material that can be sampled, a sample will be collected and analyzed for tritium and the parameters necessary to dispose of any remaining waste. The waste will be removed and the tank closed in accordance with New Mexico regulations (NMAC, 1997).

Drill Pads

Based on the results of the preliminary field investigation, no additional investigation of the drill pads is planned (see Appendix C).

Soil Pile

During the preliminary field investigation, a soil pile was noted approximately 200 ft north of Well EPNG 10-36 at the northern boundary of the SGZ area. The origin of this pile is not known. Geophysical surveys indicated a scatter of small nonmetallic anomalies within this pile (possibly pieces of concrete). This pile is not visible in historical photos taken prior to filling of the Well GB-E mud pits (November-December, 1967), and may be a result of the grading conducted in the SGZ area prior to the detonation.

Investigation of the pile will be conducted by excavating a trench through the pile. Field screening and observation will be used to guide sample collection, as described in Section 4.2.2. If contamination is found, the extent will be defined in the same manner as that described for the mud pits. If no potential contamination is observed through field screening and visual observation, samples may not be required for laboratory analysis.

Flare Stack Area

Diesel, gasoline, and 1,2,4-trimethylbenzene were detected in samples collected during the preliminary field investigation at the historic location of the flare stack (see Appendix C). Additional direct-push sampling is proposed to further refine the nature and extent of potential contamination in this area. A minimum of three step-out boreholes will be drilled approximately 10 ft from the flare stack location. Field screening and observation will be used to guide sample collection as described in Section 4.2.2.

4.2.3.2 Well GB-D Area

Known or suspect site features discussed in Section 2.2.2, or found during the geophysical investigation (see Appendix C, Section C.3.4.2), and that require further investigation are listed in Table 4-4.

Table 4-4
Well GB-D Area Known and Suspect AOCs to be Further Investigated

Unique Identifier	Approximate Size (feet)	Summary of Proposed Investigation Strategy	Contaminants of Potential Concern
Well GB-D Mud Pit	80 X 40	Investigation will include direct-push sampling to define nature and extent of potential contamination.	TPH (DRO, GRO), VOCs, SVOCs, Total RCRA metals
Well GB-D Anomaly B[a]	100 X 75[b]	Investigation will include direct-push sampling to define nature and extent of potential contamination.	TPH (DRO, GRO), VOCs, SVOCs, Total RCRA metals
Well GB-D Drill Pad	50 X 50	Investigation will include direct-push sampling to define nature and extent of potential contamination.	TPH (DRO, GRO), VOCs, SVOCs, Total RCRA metals

[a]Anomalies identified by geophysical surveys are listed by the unique identifiers assigned to them in the report on the results of the geophysical survey (SAIC, 2000). Not all anomalies identified by geophysics require further investigation (see Appendix C).
[b]Anomaly extends beyond the western edge of surveyed area.

The Well GB-D Mud Pit will be investigated as part of the general mud pit investigation described for the SGZ area (see Section 4.2.3.1). As described, this investigation will include sampling at a minimum of five locations for all COPCs. Additional samples will be collected to characterize the diesel contamination within the drilling mud and define the vertical and horizontally extent of any diesel contamination.

The origin of the nonmetallic Well GB-D Anomaly B identified by geophysics is not known. The soil pile near this anomaly suggests a possible excavation and fill event; thus, the anomaly warrants further investigation. The estimated dimensions of the anomaly will be used to randomly select four locations within the anomaly, where soil borings will be located. Samples will be collected as described in Section 4.2.2. Evidence of soil disturbance and/or field-screening results will be used to locate sample collection points. If no contamination is indicated by field screening and there is no evidence of soil disturbance within the anomaly, then confirmation samples will be collected at a single randomly selected depth between 2 and 12 ft bgs within each boring. If potential contamination is observed or detected by field screening, step-out borings will be used to define the extent of the contamination.

Soil borings will also be completed at a minimum of three locations around Well GB-D to investigate potential releases on the pad. Field screening will be used to guide the investigation. The lateral extent of contamination will be defined with step-out borings, as necessary.

4.2.3.3 Recording Trailer Park

Suspect site features within the RTP found during the geophysical investigation (see Appendix C, Section C.3.4.3) and that require further investigation are listed in Table 4-5. There were no features documented in the historical information that required further investigation. Based on the results of the geophysical survey, Anomaly G appears to be a burial trench for metallic and possibly other construction debris. The estimated dimensions of the anomaly will be used to randomly select a minimum of two locations within the anomaly where soil borings will be located. Samples will be collected as described in Section 4.2.2. Evidence of soil disturbance and/or field-screening results will be used to locate sample collection points. If no contamination is indicated by field screening, and there is no evidence of soil disturbance within the anomaly, confirmation samples will be collected at a single, randomly selected depth between 2 and 12 ft bgs within each boring. If potential contamination is observed or detected by field screening, step-out borings will be used to define the extent of the contamination.

Table 4-5
Recording Trailer Park Known and Suspect AOCs to be Further Investigated

Unique Identifier	Approximate Size (feet)	Summary of Proposed Investigation Strategy	Contaminants of Potential Concern
RTP Anomaly G[a]	50 X 30	Investigation will include direct-push sampling to define nature and extent of potential contamination.	TPH (full scan), VOCs, SVOCs, Total RCRA metals

[a]Anomalies identified by geophysical surveys are listed by the unique identifiers assigned to them in the report on the results of the geophysical survey (SAIC, 2000). Not all anomalies identified by geophysics require further investigation (see Appendix C).

4.2.3.4 Control Point

Known or suspect site features within the CP discussed in Section 2.2.4, or found during the geophysical investigation (see Appendix C, Section C.3.4.4) and that require further investigation, are listed in Table 4-6. The septic tank indicated in historical site drawings (Figure 2-13) will be investigated in the same manner as that described for the septic tanks in the SGZ area

Table 4-6
Control Point Known and Suspect AOCs to be Further Investigated

Unique Identifier	Approximate Size (feet)	Summary of Proposed Investigation Strategy	Contaminants of Potential Concern
CP Anomaly C[a] (septic tank)	NA	Search for septic tank with exploratory excavation. If tank is located, verify it has been closed in place (filled). If tank has not been filled, sample any contents, and close according to New Mexico regulations (NMAC, 1997). Sample location(s) will be chosen based on site observations.	Tritium and other COPCs, as required, for waste disposal (septic tank contents only)
CP Anomaly E[a]	20 X 5	Investigation will include direct-push and/or excavation sampling to define nature and extent of potential contamination.	TPH (DRO, GRO), VOCs, SVOCs, Total RCRA metals

[a]Anomalies identified by geophysical surveys are listed by the unique identifiers assigned to them in the report on the results of the geophysical survey (SAIC, 2000). Not all anomalies identified by geophysics require further investigation (see Appendix C).

(Section 4.2.3.1). It is unknown what Anomaly E represents (see Appendix C, Section C.3.4.4). Based on the proximity of this anomaly to the location of a mobile radiological laboratory, as indicated in historical site photos, this anomaly will be further investigated. No other investigation or soil sampling is planned for this area.

4.2.3.5 Quality Control Samples

Quality control samples at the Gasbuggy Site will be collected, labeled, handled, and shipped to the laboratory in accordance with the NM QAPP located in Appendix B of this document and the contractor procedures.

4.2.3.6 Analysis

COPCs at the Gasbuggy Site, as mentioned in Section 3.2, are related primarily to constituents in the drilling mud and associated with drilling operations. Laboratory chemical, TCLP, and radiochemistry analytical requirements that may be used for the site characterization and waste characterization samples are specified in Appendix B.

4.3 Shallow Groundwater Investigation

Depth to shallow groundwater has not been established at the Gasbuggy Site. Therefore, investigation of shallow groundwater will be based on observations made during the field investigation.

Soil borings and/or excavations in which contamination is detected by direct observation or field-screening methods will be extended a minimum of 10 ft beyond the deepest contamination detected. If groundwater is located either in contact with contaminated soil or within 10 ft of contaminated soil (as determined in the field), then the shallow groundwater in the source area will be sampled and the background conditions for shallow groundwater will be established in accordance with Section 4.3.1.

4.3.1 Shallow Groundwater Well Installation and Monitoring

Shallow groundwater monitoring shall only be performed if it is determined that contamination from mud pits or other sources intercept the shallow groundwater table or contaminant migration may be occurring through the soil to the shallow groundwater table (see Figure 4-1, page 2 of 2). Based on the finding of the preliminary field investigation conducted in August and September of 2000, it appears unlikely that shallow groundwater sampling will be necessary. The deepest contamination above PALs was found at approximately 9 to11 ft bgs. The deepest borehole was pushed to 36 ft bgs, and no shallow groundwater was found.

If a shallow groundwater investigation is necessary, one background monitoring well will be installed in an area of the site that is hydraulically upgradient from any potential on-site contamination which may have resulted from past site activities. The location will be determined using all existing information from site investigations. The background well and other monitoring wells will be installed in accordance with the State of New Mexico monitoring well regulations. The depths for these wells are dependent upon the depth to shallow groundwater, but it is anticipated that total depth will be less than 100 ft bgs. The number and location of monitoring wells will be determined based on location of contamination, calculated flow gradient, and discussion with NMED. Soil boring logs and a well completion diagram for each well installed will be prepared. Water-level measurements will be taken when the well has been completed, developed, and has had a sufficient amount of time to equilibrate. All well locations and elevations will be surveyed at the completion of characterization activities.

4.4 Additional Requirements and Activities

The requirements and activities described in this section apply to both surface and subsurface investigations.

4.4.1 Health and Safety

All site preparations and work activities will be conducted in a manner that is protective of the safety and health of site workers, the public, and the environment. Site workers are encouraged to utilize the best available methods to perform job functions in supporting field activities. Standard work practices and procedures are designed to comply with all relevant and applicable federal, state, and local regulatory agencies.

Operations conducted at the Gasbuggy Site will be conducted in accordance with the primary Real Estate and Operations Permit holder's fully developed health and safety program. This program places the emphasis for the health, safety, and environmental protection on the company management team and the associates doing the work. The "safety first" philosophy is passed down from the management to the associates as the best method of doing business. The health and safety program and philosophy fully supports the U.S. Department of Energy, National Nuclear Security Administration Nevada Operations (NNSA/NV) Integrated Safety Management System, and is maintained through a system of inspections, audits, and reviews of field activities as they occur.

A site-specific health and safety plan (SSHASP) will be developed defining the scope of work to be conducted at Gasbuggy Site to identify the particular features, hazards, communication methods, responsibilities, and protective measures to be employed on site. Controls will be developed and implemented to minimize or eliminate identified hazards. The provisions of this plan are mandatory for all personnel assigned to the field project. Visitors are also required to abide by these procedures. The SSHASP is a living document and may be amended, as necessary, to deal with new hazards and changing conditions. Changes to the document may be verbal or written after obtaining the approval of the signatories to the original SSHASP. In addition, these changes may only be implemented after being discussed with the affected personnel on site.

4.4.2 Environmental Compliance and Waste Management

Contractor personnel will comply with applicable environmental compliance and waste management regulations and requirements in the conduct of site activities. A designated contractor shall be responsible for the on-site management and ultimate disposal of all waste generated as a result of the Gasbuggy Site characterization investigations. Waste will be managed on site in accordance with state and federal regulations. Soil waste from the mud pits may be managed and disposed of as excluded waste under the oil and natural gas industry-specific exclusion found in 40 CFR 261.4(b)(5) (CFR, 1999). Personnel must comply with waste management and environmental compliance policies and procedures established for the Gasbuggy Site.

Investigation-derived waste (IDW) will likely consist of the following waste streams: (1) used disposable sampling equipment and personal protective equipment; (2) soil; (3) rinsate water from decontamination of sampling equipment; and (4) waste generated as a result of field-screening activities (e.g., chemicals used in certain TPH field-screening kits). Investigation-derived waste will be managed on site in accordance with all applicable regulations for the type of waste (e.g., *Resource Conservation and Recovery Act* hazardous waste). To the extent possible, site characterization samples and knowledge of the waste stream will be used to characterize IDW generated during characterization activities. Additional analysis (e.g., toxicity characteristic leaching procedure) of site characterization samples and/or direct sampling and analysis of IDW will be conducted, as necessary, to aid in decision making regarding waste characterization and to meet waste acceptance criteria of potential disposal facilities.

4.4.3 National Environmental Policy Act Requirements

In accordance with the NNSA/NV's *National Environmental Policy Act* (NEPA) compliance program, a NEPA checklist shall be completed prior to commencement of site investigation activities at the Gasbuggy Site. This checklist compels NNSA/NV to evaluate this proposed project against a list of several potential environmental impacts which include, but are not limited to: air quality, chemical use, waste generation, noise levels, and land use. Completion of the checklist results in a determination of the appropriate level of NEPA documentation by the NNSA/NV NEPA Compliance Officer for this project.

4.4.4 Quality Assurance

All investigation activities will be completed in accordance with planning documents, standardized operating procedures, quality practices, and the procedures established in the NM QAPP. This plan describes the measures that will be taken to ensure the quality of field sample collection, storage, transport, analytical activities, and modeling associated with environmental data collection for the Gasbuggy Site investigation. This plan is located in Appendix B.

4.4.5 Community/Stakeholder Involvement

As part of the Gasbuggy Site investigation, NNSA/NV will interface with NMED to establish the scope for the site's activities. Additional stakeholder involvement will also be part of the scoped activity and may include public/town hall meetings, informational and technical briefings and presentations, and document reviews. Stakeholders identified throughout the scoped activity will be solicited to participate in designated activities as identified by NNSA/NV.

Cooperation with the USFS will be sought based on the locality of the site. Although the majority of the site (SGZ area) is located on lands officially withdrawn for AEC/DOE use, the smaller operational areas (e.g., RTP, CP) are not on withdrawn land. In addition, the site is surrounded by National Forest lands and access to the site is gained on Forest Service and/or Jicarilla Apache Reservation roads.

An effort will also be made to notify the Jicarilla Apache Tribal Council of planned activities at the Gasbuggy Site due to the proximity of the reservation to the site.

5.0 Subsurface Work Plan

There is no technology currently known to remediate underground nuclear cavities. The approach of the subsurface investigation is to use existing data to support a subsurface transport model (and dose assessment, if necessary) to evaluate if existing subsurface intrusion restrictions are sufficient for the protection of human health and the environment. Figure 5-1 is a DQO decision flow chart that summarizes the characterization scope of work and technical approach for the subsurface investigation. It is assumed that there are sufficient data available to complete the subsurface investigation, although additional data may be collected if a reduction in model uncertainty is needed.

From the three possible migration pathways (see Section 3.1.2), two potential exposure routes from the underground nuclear cavity have been identified: (1) gas-phase migration through the Pictured Cliffs Formation, and (2) groundwater migration through the Ojo Alamo aquifer.

Gas-phase migration through the Pictured Cliffs is the focus of the subsurface modeling effort. The potential migration pathway is transport of radionuclide-contaminated natural gas resulting from the development of the surrounding natural gas field. The region of interest will include the nuclear cavity and surrounding area, extending outward to a radius to be determined through the modeling effort. The subsurface modeling effort will be used to:

- Predict the nature and extent of contamination in the subsurface.
- Develop likely scenarios for future resource development and determine the impact of the scenarios on the extent of contamination.
- Evaluate the modeled extent of contamination relative to the subsurface intrusion (drilling) restrictions.

Groundwater migration through the Ojo Alamo aquifer is not a likely exposure route based on the physical constraints of the system (i.e., the pressure gradient opposes transport from the cavity to the Ojo Alamo). The results of a transport analysis performed by DRI (1996a and b) indicate that groundwater velocities in the Ojo Alamo are very low. In addition, the Ojo Alamo aquifer is not of

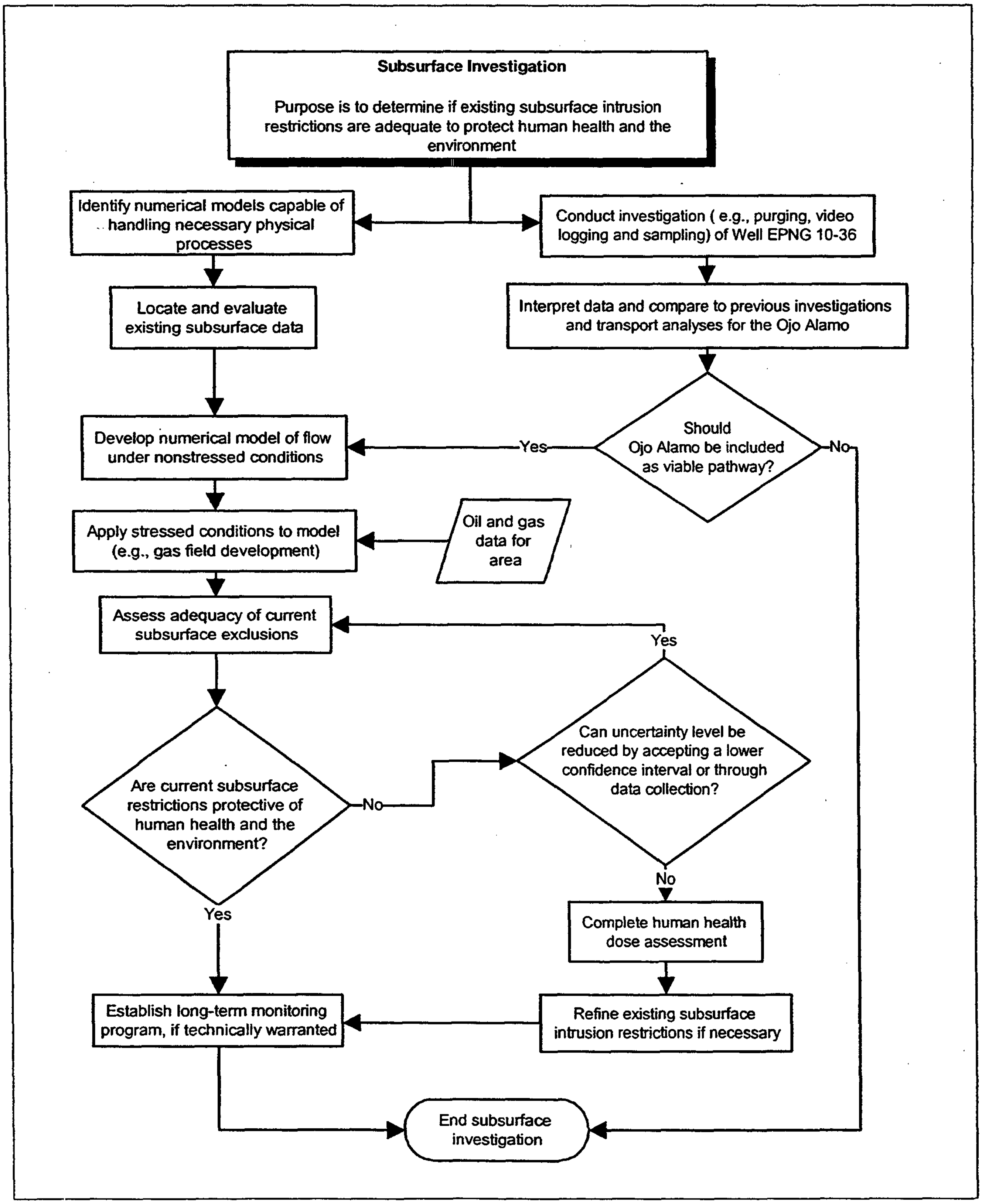


Figure 5-1
Subsurface DQO Decision Flow Chart

drinking water quality. Sulfate in the Ojo Alamo at Well EPNG 10-36 is over 5,000 mg/L (DRI, 1996b), whereas the standard for domestic supply in New Mexico is 600 mg/L (NMAC, 1996a). A groundwater exposure route is discussed below and additional field data collection is planned; however, this is not the primary objective of the subsurface investigation. The objectives of the anticipated groundwater data collection effort are:

- Video log the well to determine if the casing integrity has been compromised, thereby allowing water to enter the well at locations in addition to the perforations.
- Determine if contamination is entering Well EPNG 10-36 from the Ojo Alamo through the perforations at the bottom of the well, or through a breach in the integrity of the casing at another level.
- Collect hydraulic data for the site with a recovery analysis for the Ojo Alamo at Well EPNG 10-36.

In addition, data gained during the investigation may be used in making decisions regarding well abandonment and monitoring.

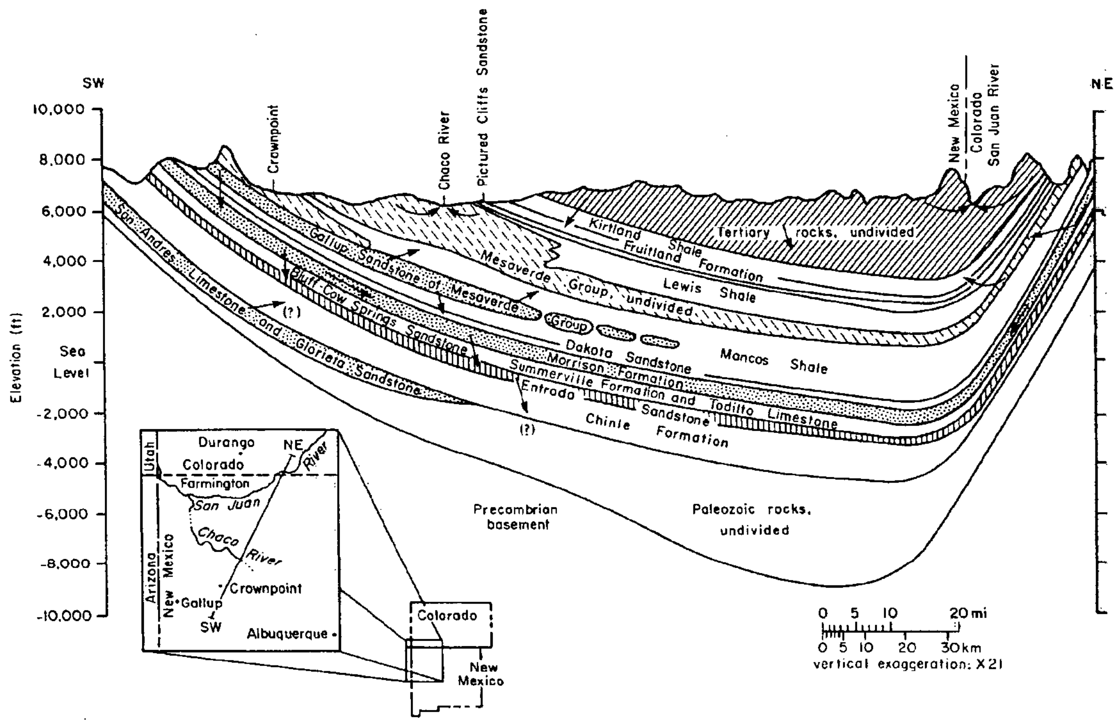
5.1 Conceptual Model of Subsurface Flow and Transport

The following sections include a more detailed conceptual model for the subsurface based on specifics of the site geology, hydrology, and the phenomenology of an underground nuclear test.

5.1.1 Geologic and Hydrogeologic Setting

The Gasbuggy Site is in the San Juan Basin, a large structural basin containing approximately 12,000 ft of sedimentary rocks (see Figure 5-2). The detonation occurred in the Lewis Shale Formation at a depth of 4,240 ft bgs. The test was designed to fracture the Pictured Cliffs, a gas reservoir directly overlying the Lewis Shale. The Pictured Cliffs Formation at the Gasbuggy Site is bounded by the 100-ft thick overlying Fruitland Formation comprised of sandstone, shale, and siltstone, and the underlying Lewis Formation of over 1,500 ft of shale (see Figure 5-3).

The Pictured Cliffs sandstone is one of the San Juan Basin's major gas reservoirs. It is a marine sandstone, grayish-white, fine- to medium-grained, angular to subrounded, and cemented with bentonitic clays (Peterson et al., 1965). In its productive areas, the permeability averages



Explanation

Direction of Groundwater Flow

Confining Beds

Major Aquifers

Note downward direction of flow from the overlying formations to the Pictured Cliffs.

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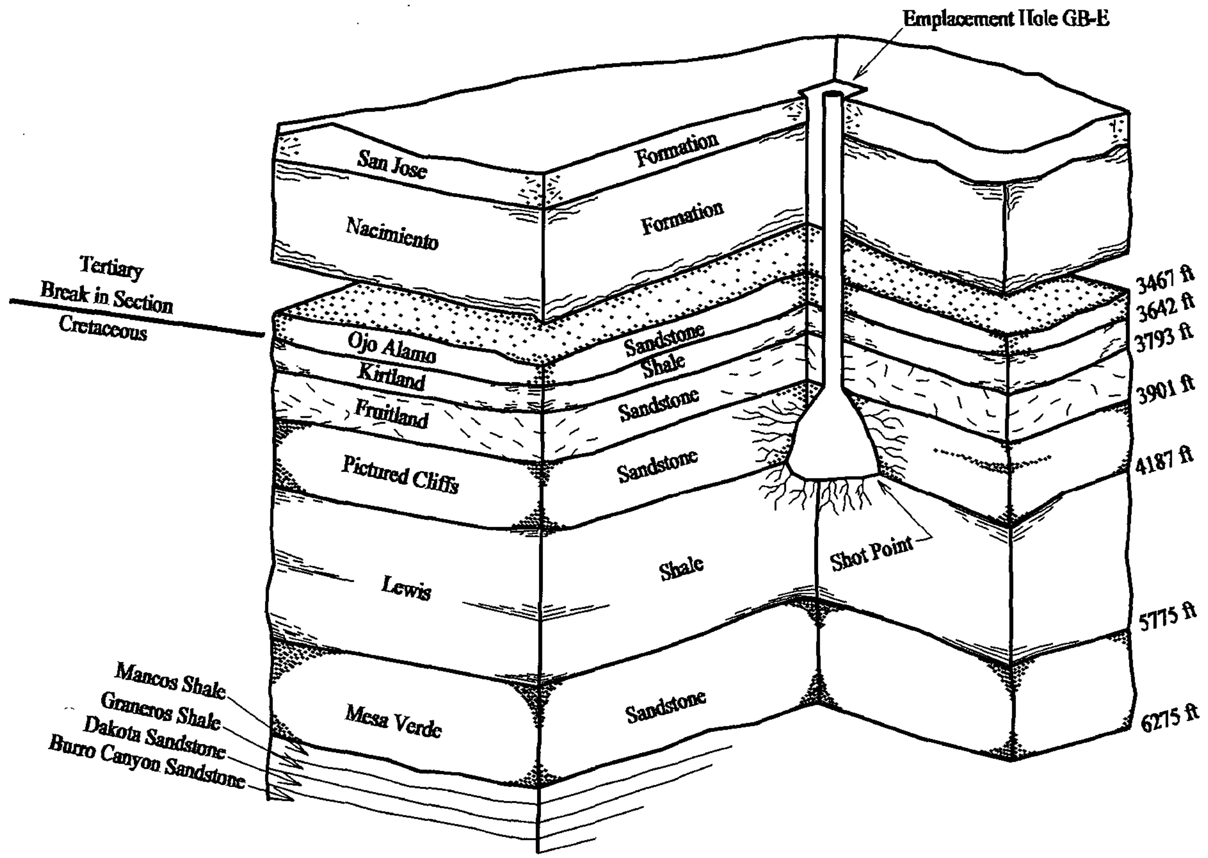
Source: New Mexico Bureau of Mines and Mineral Resources, 1983

Figure 5-2
Generalized Hydrogeologic Cross Section of the San Juan Basin



Source: DOE, 1986

Figure 5-3
Generalized Cross Section of Project Gasbuggy Emplacement Hole

2.96 millidarcies (md), with a porosity averaging 0.18 and an average water saturation of 44 percent. In the part of the San Juan Basin where the Gasbuggy test was conducted, the Pictured Cliffs is a low-productivity, sparsely developed reservoir with a thickness of about 300 ft. Prior to the test and based on data from the nearby region, the permeability of the Pictured Cliffs was estimated to be 0.14 md, porosity 0.11, gas saturation 0.41, formation pressure 1,260 pounds per square inch (psi), formation temperature of 117 degrees Fahrenheit (°F), and net pay thickness 190 ft (Ward et al., 1966). Data from two on-site exploration wells (i.e., wells GB-1 and GB-2) (see Figure 5-4), indicated an average permeability of 0.175 md, porosity of 0.12, gas saturation of 0.53, pressure of 1,012 psi, temperature of 130° F, and net thickness of 155 ft (Atkinson and Ward, 1967).

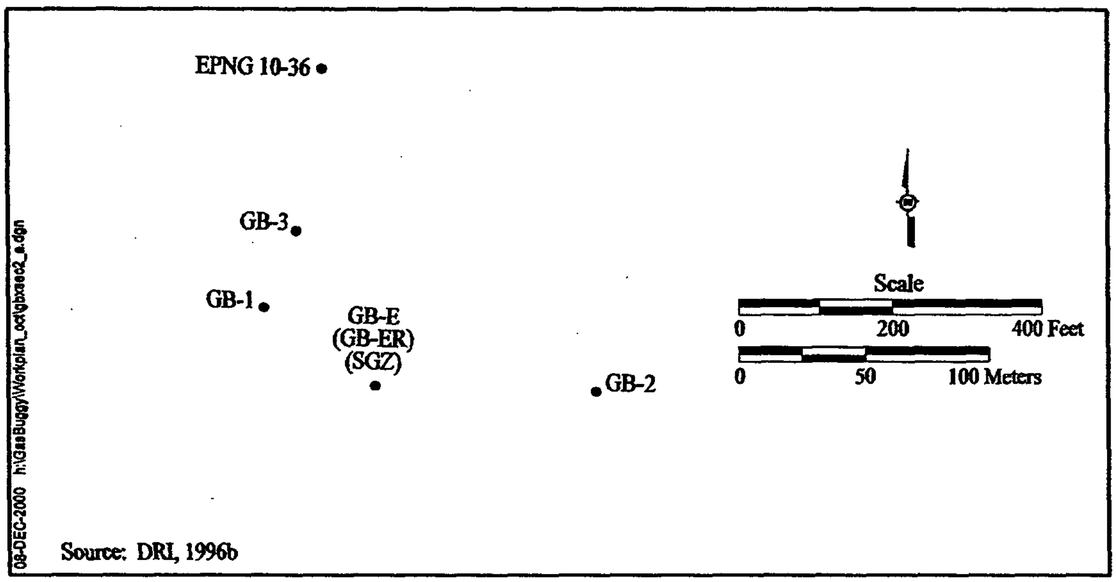


Figure 5-4
Location of Wells in the Immediate Vicinity of the Gasbuggy Test

The San Jose and Nacimiento formations produce water at the Gasbuggy Site, but are far above the zone of possible influence from the test. No significant natural connections are believed to exist between any of the water-bearing strata at the Gasbuggy Site (Sokol, 1970). The Ojo Alamo sandstone, the only aquifer of concern at the site, is separated from the Pictured Cliffs by the Fruitland sandstone and the Kirtland shale. The Ojo Alamo is a fine- to medium-grained, clayey Tertiary sandstone containing minor shale beds (Mercer, 1967). The bottom of the Ojo Alamo is approximately 600 ft above the working point of the test. The top of the Ojo Alamo is approximately 3,465 ft bgs, and the potentiometric surface is approximately 985 ft bgs. Although randomly oriented joints present throughout the San Juan Basin may conduct some groundwater flow, pore flow is believed to dominate in the Ojo Alamo. The primary recharge area for the aquifer is probably in the southeastern portion of the basin, with flow westward or northwestward toward the San Juan River (Sokol, 1970).

5.1.2 Description of the Gasbuggy Test and Its Effects

The 29-kt Gasbuggy detonation (DOE/NV, 2000) created a cavity of approximately 80 to 88 ft in radius, with a chimney of approximately 333 ft in height. The chimney was created by collapse and bulking of overlying material into the cavity, after the gases cooled and condensed (Holzer, 1970). Observations of cable and casing breaks in wells GB-1 and GB-ER indicated distances for fracturing of 480 ft and 444 ft. A strong influence of geologic weaknesses and discontinuities on fracture extent was evident, with the lower portion of the Pictured Cliffs more extensively fractured than the upper part, which was apparently protected by an intervening coal and shale layer (Holzer, 1970).

A compressional shock wave created by an underground nuclear explosion travels to land surface, causing a temporary rise in surface elevation. Surface spall can occur where the surface layers split away under the influence of tensile reflections from the surface and subsequent slap-down when the layers fall. This can result in fracturing of the near surface rock, confined to the upper tens to several hundreds of feet below land surface and unconnected to fractures from the cavity.

Permeability enhancement as a result of the nuclear test was below expectations. Testing revealed lower than expected production performance, which was attributed to the following factors: (1) overestimation of formation permeability prior to the test; (2) closing of newly created, unsupported fractures; and (3) sealing of the cavity walls by solidified melt glass (Stosur, 1977). Although permeability in the region within one cavity radius of the chimney may have increased by a factor of up to 100 over the pretest permeabilities, the fracture zone is relatively small compared to the surrounding, contributing reservoir, with production ultimately limited by that unaffected zone.

Although the stemming plan was designed to seal the emplacement well and prevent any leakage from the test, a small amount of radioactivity was detected at ground surface about eight hours after the detonation. The leakage apparently occurred in the explosive arming and firing cable with breaks in that cable possibly allowing radioactive gas to leak to porous portions of the stemmed emplacement hole (LRL, 1968a). After 1-1/2 hours, all cables were cut and sealed at the wellhead (LRL, 1968b). Analysis of a sample of the gas leaking up the cables determined the only radioactive materials present were inert noble gases (i.e., krypton and xenon) (AEC, 1971). Wet stemming material encountered on reentry indicated that water migrated upward under hydrostatic pressure from the Ojo Alamo (at 3,550 ft bgs) to at least 3,260 ft bgs and possibly up as far as 3,029 ft bgs. This water leak was attributed either to poor cement bonding in the stemming and/or explosion-caused grout failure (LRL, 1968a). Downward water migration into the chimney and cavity also occurred. Investigations into the unexpected amount of water encountered during gas production testing determined that the chemistry matched that of the Ojo Alamo groundwater (Power and Bowman, 1970). Hydraulic analysis and well history indicated leaks along the emplacement casing to be the pathway.

As in all underground nuclear tests, the majority of the radioactivity is contained in the melt glass in the bottom of the cavity. Krypton-85 and tritium account for essentially all of the radioactivity in the natural gas produced from the Gasbuggy chimney. About 350 ± 20 curies of Kr-85 and about 4.5×10^4 curies of tritium were deposited in the chimney by the explosion. The short-lived isotopes of Xe-133 and Ar-37 were also detected in gas samples from the chimney but have since decayed away. In addition, minor amounts of Ar-39 and C-14 were detected in the chimney gas. Significant quantities of radionuclides were removed from the chimney by gas flow testing. The tritium was found in the form of tritiated methane, some higher hydrocarbon fractions, tritiated hydrogen, as well as tritiated water. Only five percent of the total estimated tritium was found in the gas phase (Holzer, 1970). It is assumed that the remaining tritium is in water.

5.1.3 Conceptual Model for Contaminant Transport Through the Pictured Cliffs

Pores in the Pictured Cliffs are filled with both gas and water, almost half-and-half according to the site-specific data. Oil, if present, will be disregarded as an active phase. In models of two-phase flow through fractured rock, it is commonly assumed that the fracture spacing is larger than the pore spacing. This results in fractures containing only a mobile gas phase, while the porous medium contains both gas and liquid (water) phases (Wang and Narasimhan, 1985). This distribution of phases in the rock is derived from considerations of capillarity from the Laplace-Young equation

(Adams and Gast, 1997). Both phases are assumed to be continuous throughout the reservoir; they flow in response to pressure gradients of each phase.

Tritium produced by Gasbuggy exists in both the liquid and gas phase, and is capable of being exchanged between phases. In addition to pressure-driven flow, radionuclides are transported in both phases by diffusion and dispersion in the porous medium and fractures. The fracture permeability is higher than the permeability of the porous medium such that the most rapid transport mechanism is flow of tritiated gas through fractures. Two retardation mechanisms exist that may significantly reduce the distance and rate of transport: (1) diffusion of tritium gas from the fractures into the matrix, thereby reducing the concentration in the fractures and (2) radioactive decay. The degree to which these retardation mechanisms affect transport will be clear when the interplay among the flow rate through the fractures, matrix diffusion of tritium gas, and radioactive decay are modeled and understood. In addition to tritium, transport of Kr-85 and C-14 will be investigated, assuming the same transport mechanisms that occur for tritium.

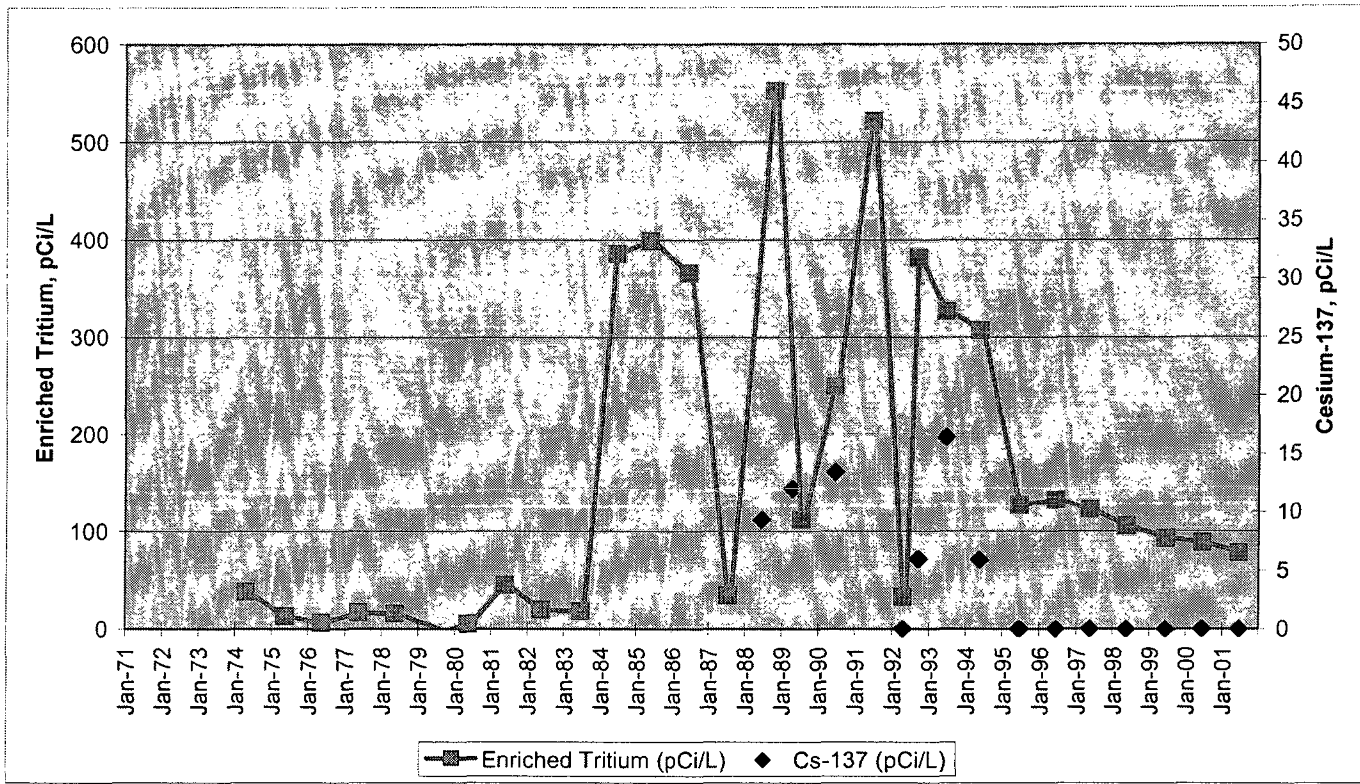
The Pictured Cliffs are bounded above and below by low permeability formations. The flow field may be in a transient state, depending on recent gas production history in the area. Initial simulations will focus on axisymmetric flow from a single well with a prescribed pressure; the outer boundary condition is no flow at a prescribed distance yet to be determined. It is expected that temperature gradients have minimal effect on flow and transport.

5.1.4 Conceptual Model for Contaminant Transport Through the Ojo Alamo

Pressures measured in the Pictured Cliffs Formation (measurements between 830 and 930 psi [LRL, 1967a], with an estimated maximum pressure of 1,050 psi [Holzer, 1970]) are lower than those in the Ojo Alamo (1,134 psi, based on depth to water of 945 ft [Holzer, 1970]). Thus, if a hydraulic connection exists between the two formations, water should flow downward from the Ojo Alamo to the Gasbuggy cavity. Given this situation, migration of radionuclides from the test cavity to the Ojo Alamo is limited to prompt injection of gaseous radionuclides under pressures created at the time of the explosion. The initial extreme pressures (close to 1 mega bar) are reduced to a few psi within minutes to hours, accompanied by cavity collapse (LLNL, 1999).

Evidence for a connection between the Ojo Alamo and the Gasbuggy cavity includes above-background tritium detected in water from the Ojo Alamo during reentry drilling (LRL, 1968a), continued water flow from the Ojo Alamo into the cavity that caused problems with gas-production testing (Power and Bowman, 1970), and pressure responses in the Ojo Alamo at Well EPNG 10-36 coinciding with decreases in chimney pressure during production testing (LRL, 1970). A connection was strongly indicated in the reentry well (Well GB-ER) as a water leak at a depth of approximately 3,550 ft was found in the first section of slots used by the cement staging tool (LRL, 1968a). It could not be determined whether a poor cement bond or motion caused by the test was the primary fault of the leaks. Posttest investigation of the Ojo Alamo at Well GB-3 further indicated that communication between the aquifer and the reservoir occurred at a single point, although it is impossible to rule out fracture connection (LRL, 1970). Monitoring of wells EPNG 10-36 and GB-3 during production testing found intermittent plugging of the point(s) of communication between the reservoir and aquifer, with complete plugging by late 1969 (Power and Bowman, 1970). The pressure relationship described above between the Ojo Alamo and Pictured Cliffs is borne out by the observation that the chimney contained an unexpected amount of groundwater, with the chemical composition linking its origin to the Ojo Alamo. This water inflow was an undesirable feature, as it reduced the gas production efficiency.

Monitoring of Well EPNG 10-36 by the EPA under the Long-Term Hydrologic Monitoring Program (LTHMP) did not detect radionuclides until low (compared to the drinking water standard of 20,000 pCi/l [CFR, 2000]), but above background, tritium concentrations began appearing in 1984 (see Figure 5-5). The tritium record is highly erratic. Logging and sampling at discrete depths in the well by DRI in 1994 and 1995 found essentially no tritium at the bottom of the well adjacent to the Ojo Alamo perforations. During the sampling, however, tritium concentrations of up to 138 pCi/L were found much higher in the well, associated with a water type uncharacteristic of the Ojo Alamo (DRI, 1996b). As the well is not perforated other than at the Ojo Alamo, the source of this water (and tritium) is unknown. Flowmeter measurements detected no vertical flow in the well that exceeded the detection limit of 0.03 liters per minute (DRI, 1996b). In 1995, EPA also sampled discretely. Results were similar to the DRI results, in that EPA data indicated very low tritium concentrations at the perforations and greater tritium concentrations at shallower depths in the wellbore (Boehlecke, 2001 and Dempsey, 2001).



Notes:
Data is from the Long-Term Hydrologic Monitoring Program operated by the EPA (Boehlecke, 2001 and Dempsey, 2001).
The samples collected in June 1988 and April 1989 were contaminated during sampling. The tritium results for these samples are not presented because the tritium aliquots were recollected in the same calender year. Due to limited Cs-137 data, the Cs-137 results for the June 1988 and April 1989 samples are presented.
The highest analytical result is presented when two or more duplicates were collected.
Multiple samples were collected at discrete intervals in June, 1995. The highest recorded value is presented here.
The *Safe Drinking Water Act* standard for tritium in drinking water is 20,000 pCi/L (CFR, 2000).
The *Safe Drinking Water Act* standard for Cs-137 in drinking water is 53.3 pCi/L (CFR, 2000 and INEL, 1988).

Figure 5-5
Tritium and Cesium-137 Concentrations for Well EPNG 10-36

The LTHMP sample collected from EPNG 10-36 on June 23, 1988, has a sample comment in the EPA records that it was "Accidently contaminated with Cs-137" (Boehlecke, 2001 and Dempsey, 2001). No elaboration is given as to the circumstances of this event, although it is possibly related to sampling of contaminated wells at the Gnome Site performed just prior to the Gasbuggy sampling. The results of a gamma scan led to a cesium analysis, which indicated 9.31 pCi/L Cs-137 at a 2 sigma confidence interval of 4.57 pCi/L. Although tritium contamination is not mentioned, this sample also contained the highest tritium concentration ever measured in the well, 750 pCi/L. Sampling in subsequent years found erratic concentrations of Cs-137; however, no Cs-137 has been detected in water samples collected from Well EPNG 10-36 since 1994. The sample collected in April of 1989 also bears a note of "Contaminated" on its results comment card. Additionally, a mud sample collected from Well EPNG 10-36 in 1995 (when the original production tubing was pulled from the well) was analyzed for Cs-137. Results indicated a concentration of 5.6 pCi/L (Boehlecke, 2001 and Dempsey, 2001).

A travel-time analysis, using hydraulic data from the site, concluded that contaminant migration velocities in the Ojo Alamo are likely to be too small to support transport for the distance from Well GB-ER to Well EPNG 10-36 over the 17 years observed, supporting the absence of contamination at the screened interval. A separate transport analysis determined that concentrations of tritium, Sr-90, and Cs-137 are unlikely to be detectable outside the area currently administered by DOE (DRI, 1996a), if contamination were present in the Ojo Alamo. Given the data and observations, the Ojo Alamo is not considered a viable contaminant transport pathway. However, uncertainty as to the source of the tritium detected higher in the wellbore of EPNG 10-36 remains. With the character of the water differing from that in the Ojo Alamo, and with no casing problems obvious on periodic casing integrity logs, one possibility is that this water and tritium were introduced to the well at some time in the past and have remained there since that time. If Cs-137 is indeed present in the mud at the bottom of the borehole, it may be due to prompt injection of a gaseous precursor along pathways open only during the high pressure immediately after the Gasbuggy test. A field effort is described in Section 5.2.2 of this Work Plan to address these remaining uncertainties regarding EPNG 10-36.

5.2 Data Quality Objectives of Subsurface Investigations

The following sections outline the DQOs for the two subsurface investigation tasks.

5.2.1 Subsurface Modeling DQOs

The objective of the subsurface modeling for Gasbuggy is to determine the potential for contaminant transport from the Gasbuggy cavity into resources of value, either under existing conditions or during future resource development. If such transport is indicated, it will be determined if the migration poses a potential risk to human health or the environment. This information will be used to identify an appropriate corrective action. Process knowledge, existing data, and analyses are sufficient to determine the absence of risk in the groundwater of the overlying Ojo Alamo sandstone, although evaluation of Well EPNG 10-36 is planned and described below.

The modeling process will:

- Calculate the potential nature and extent of contamination in the subsurface.
- Develop likely scenarios for future resource development and determine their impact on the extent of contamination.
- Evaluate the modeled contaminant extent relative to existing subsurface intrusion (drilling) restrictions.

The following six decision points are identified for the subsurface modeling, with corresponding associated actions:

- If appropriate existing numerical codes cannot be found, or adequate supporting data for the codes do not exist, then implement a different subsurface approach.
- If current gas production habits from nearby wells cannot be determined with confidence, then make reasonable gas production scenarios with concurrence from NMED.
- If contaminant migration to postulated production wells is predicted, then evaluate the uncertainty level for possible reduction through acceptance of a lower confidence level (e.g., consider going to 50 percent confidence rather than 75 percent confidence) or through additional data collection.

- If contaminant migration to postulated production wells is predicted and uncertainty cannot be effectively reduced, then perform a human health dose assessment for the potential contaminant migration to the projected production wells.

- If the human health dose assessment indicates unacceptable risk, then adjust the existing subsurface exclusion boundary.

- If the results of the contaminant migration model and/or the human health dose assessment indicate the need for a long-term monitoring program, then design a long-term monitoring program consistent with potential hazards.

5.2.2 Well EPNG 10-36 Data Collection DQOs

The objective of the data collection activity at Well EPNG 10-36 is to determine if contaminants are entering Well EPNG 10-36 from the Ojo Alamo or if contaminants measured in the well are remnant from some noncontinuing source. The key activity to achieve this objective is the purging of Well EPNG 10-36, which has not occurred prior to previous sampling; however, the removal of the inner tubing string in 1994 did cause the well to recover 100 ft. With the only perforations at the bottom (see Figure 5-6), the bottom of the well should have contained fresh formation water after the removal. The lack of purging causes uncertainties regarding previous findings, particularly when sampling at discrete depths has identified tritium high in the water column but not opposite the perforations in the Ojo Alamo. The information gained during this investigation will be used to identify the appropriate corrective action, which is likely to include plugging and abandoning the well.

The objectives of the field activity are:

- Video log the well to determine if the casing integrity has been compromised, thereby allowing water to enter the well at locations in addition to the perforations.

- Determine if contamination is entering the well from the Ojo Alamo through the perforations at the bottom of the well or through a breach in the integrity of the casing at another level.

- Collect hydraulic data for the site with a recovery analysis for the Ojo Alamo at Well EPNG 10-36.

The following three decision points are identified for the Well EPNG 10-36 work, with corresponding associated actions:

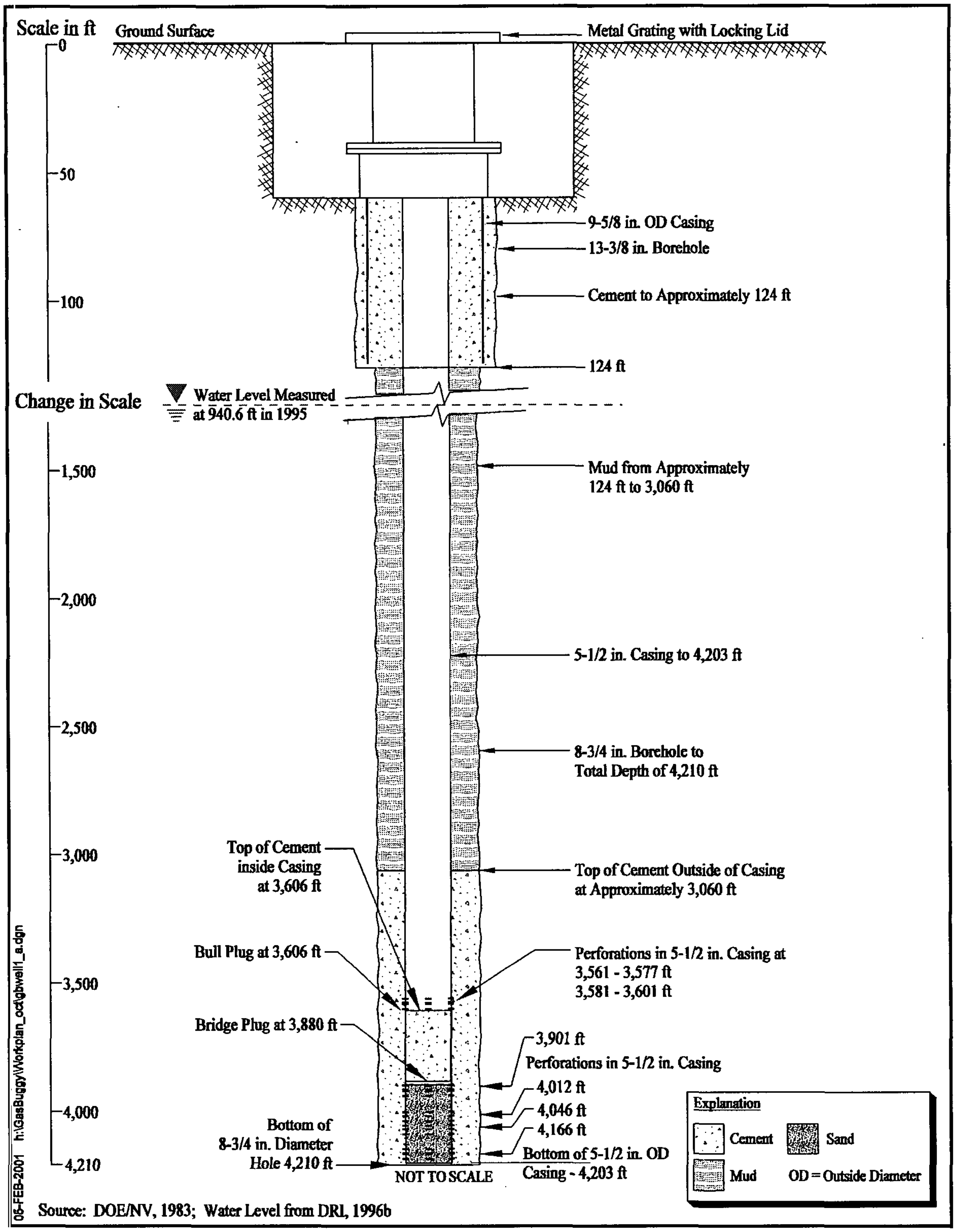


Figure 5-6
Status of Well EPNG 10-36 Prior to 1994 Field Activity

- If the casing integrity is poor, design a plugging and sealing program appropriate to BLM and State of New Mexico regulations.
- If tritium or Cs-137 at concentrations above background (as measured by EPA sampling prior to 1984) are found entering the well, expand the subsurface modeling activity to include liquid-phase transport from the cavity.
- If the hydraulic conductivity estimated based on testing in Well EPNG 10-36 differs dramatically from estimates in other site wells, expand the subsurface modeling work to include a reanalysis of the Ojo Alamo transport pathway as presented by DRI (1996a) using the new data.

5.3 Evaluation of Existing Subsurface Data

The first task is to transform the conceptual flow and transport model described in Section 5.1 into a quantitative model of flow and transport from the Gasbuggy cavity. Literature pertaining to the San Juan Basin will be thoroughly reviewed and both recent and historic data will be gathered from published sources, oil and gas companies, and regulatory agencies. These data are critical to the accurate development of the conceptual model and boundary conditions. The data will be evaluated to determine mean values and ranges for geologic and hydrologic parameters. These data are derived from reservoir production tests, well logging, and laboratory tests of cores. If data important to development of a successful model are unavailable, then data from analogous environments will be used. Data specific to the Gasbuggy cavity and chimney will also be important for defining the subsurface environment. As a joint government-industry test, much of the information about the Gasbuggy test is unclassified, facilitating the analysis. The last step in data collection will be to investigate the history of gas production near the Gasbuggy area and in the Blanco-Dakota gas field.

One likely data gap will be the limited knowledge of the distribution of fracture permeability in the subsurface. In addition, it is unlikely that there is much information regarding the pressure field around the well. Another possible data gap will be that the moisture retention curves of fractures are not accurately known. This will limit the accuracy of the pressure versus saturation relationship in fractures, and may result in limited understanding of the relative permeability of fractures under various saturations. Parker et al. (1987) has developed equations for relative permeability between gas and water for porous media, but the parameter values for successful simulation of two-phase flow through fractures will need to be estimated.

Some uncertainty will be introduced in the estimation of retardation due to fracture-matrix interaction (i.e., matrix diffusion). Although the diffusion coefficient for tritium is known, mass flux from a fracture into the matrix is highly dependent upon the tortuosity, which is unknown. Tortuosity can either be estimated from published values for similar rock types, or calculated from core samples using a diffusion cell apparatus and the solutions developed by Moridis (1999), if cores are available.

Regarding the investigation in Well EPNG 10-36, the hydraulic recovery data after purging will be compared to existing estimates of transmissivity to confirm the parameter value used in the previous transport analysis for the Ojo Alamo. Three field measurements of transmissivity have been made in the Ojo Alamo (e.g., in wells GB-1, GB-2, and GB-3 [drilled and tested after the Gasbuggy test]), with resulting values ranging from 0.4 gallons per day per foot (gpd/ft) to 2.3 gpd/ft (Mercer, 1969). Permeability was also measured on 57 cores collected from the Ojo Alamo in Well GB-1 (LRL, 1967a). These data have a large range with a geometric mean of 1.42 md.

5.4 Identification of Proper Numerical Model

Flow and transport in the complex subsurface environment of Gasbuggy are coupled processes that must be solved simultaneously to realistically understand the radionuclide distribution. Nearly all petroleum-oriented simulators solve for the flow field only. In contrast, most contaminant-oriented simulators do not solve for gas as an active phase. Few choices exist for the proper simulation of this subsurface environment.

The processes to be simulated include: transient two-dimensional multiphase, multicomponent flow in Cartesian or radial coordinates (possibly three-dimensional flow in Cartesian coordinates); active gas- and liquid-phase flow; radionuclide transport and decay; sources and sinks of mass; and phase changes of water. It is expected that temperature effects will be negligible; however, as work proceeds, it may be determined that a nonisothermal flow code is required. The code must be flexible enough to allow for changes to be written in specific pressure-saturation functions, allow implementation of a model for both fracture and matrix flow, allow for matrix diffusion, and allow for changes in the equations of state for gas and water, if necessary.

Two programs exist that will meet these criteria. The Transport of Unsaturated Groundwater Heat (TOUGH2) simulator (LBL, 1999) is a DOE-sponsored code that has been used extensively to study heat and mass flow in geothermal reservoirs, saturated/unsaturated zones, and oil and gas reservoirs. It has been used in studies of both nuclear waste isolation and environmental remediation (LBL, 1995b and 1998). Lawrence Berkeley National Laboratory (1995a) used the TOUGH simulator to study the impact of overpressuring on oil and gas migration in the Uinta Basin, Utah.

The second possible program is the Finite Element Heat and Mass (FEHM) simulator (LANL, 1996) developed at Los Alamos National Laboratory. The simulator models three-dimensional, time-dependent, multiphase, multicomponent, nonisothermal reactive flow through porous and fractured media. However, it appears that only an executable version is available, as opposed to the source code.

5.5 Modeling Process

The subsurface flow and transport model will focus around the Gasbuggy cavity at Well GB-ER. Initial simulations will focus on transient radial flow and radionuclide transport around the well. The lateral extent of the boundaries will not be determined until the existing data have been analyzed. The complexity of the domain will be increased by adding production wells and by varying reservoir properties as interpreted from the data. The last step will be to hypothesize pumping scenarios in nearby production gas wells and to apply these rates to the model. This will allow an estimate of radionuclide transport in future pumping scenarios to be developed. The domain will be extended until "far-field" flow and transport effects are diminished. Simulation results will be continually calibrated to pressure and flow data as the model is developed.

The modeling process can be summarized as follows:

1. Evaluate numerical models for the Gasbuggy subsurface application and select appropriate codes.

2. Locate subsurface data including data from historic sources, current oil and gas development sources, and regulatory agencies.

3. Interpret subsurface data to develop a conceptual model of flow and transport, and select boundary conditions.

4. Evaluate subsurface data to determine mean values and ranges for parameters.

5. Evaluate oil and gas production history in the region to develop a model of stressed conditions.
6. Develop and calibrate a steady-state gas- and liquid-phase flow model of the site.
7. Perform transport calculations under current, nonstressed conditions.
8. Develop a transient model of stressed (development) conditions.
9. Perform transport calculations under stressed conditions.
10. Evaluate results in the context of the subsurface exclusion boundary and with consideration of uncertainty.
11. Determine if long-term monitoring is technically warranted.

5.6 Well EPNG 10-36 Investigation Plan

The focus of the Well EPNG 10-36 investigation will be purging and sampling of the well. Experience with the water-level recovery after the production tubing was removed in 1994 indicates that the formation is not very productive and/or the well does not have good communication with the formation (DRI, 1996b). Under these conditions, it is impractical to purge the well using a submersible pump; therefore, purging by bailing is planned. The target will be to remove and recover approximately one well volume prior to sampling. The purged fluid will be managed and disposed of in accordance with Federal and State of New Mexico regulations.

Once purged, the slow recovery will leave the wellbore mostly empty long enough to allow video logging. Video logging will be used to supplement the previous casing integrity logs. Logging in an air-filled well will provide good clarity for the video image, with the added benefit that seepage into the well can also be noted. If poor integrity or leakage is noted, those horizons will be targeted for discrete sampling after well recovery.

Once the well has recovered to the static water level, discrete water samples will be collected at the perforations and any other zones suspected of providing inflow. Depths where tritium was previously detected will also be sampled. The analytical suite will include tritium; gross alpha; gross beta; Sr-90; gamma spectroscopy (includes Cs-137); major anions and cations; and stable isotopes of hydrogen, oxygen, and carbon. A C-14 and Carbon-13 (C-13) sample will also be collected at the perforations to provide an age for groundwater in the Ojo Alamo as a validation of the slow groundwater velocities previously interpreted.

The Well EPNG 10-36 field activities can be summarized as follows:

1. Measure the static water level in the well.
2. Purge the well bore. It is presumed that recovery will be very slow, so the well is purged nearly dry.
3. Video log the well, noting areas of casing weakness and seepage.
4. Monitor water-level recovery to derive hydraulic properties of the formation and determine when recovery is complete.
5. Perform hydrologic logging (e.g., temperature, electrical conductivity, flow logging).
6. Collect water samples. Sample intervals will include the perforations at the Ojo Alamo, horizons where tritium has been detected (i.e., tritium activities greater than 100 pCi/L in samples collected in 1995 at depths of approximately 950; 1,180; 1,410; 1,600; and 1,700 ft [DRI, 1996b]), and any suspect zones identified in the video and hydrologic logging.
7. Collect sample of mud from the bottom of the well, if possible.
8. Analyze water samples for tritium, gross alpha, gross beta, Sr-90, gamma spectroscopy (e.g., Cs-137), major anions and cations, and stable isotopes. One sample from the perforations will be analyzed for C-14 and C-13. Samples will also be analyzed for waste characterization parameters, as needed, to dispose of the purge water.
9. Analyze mud sample for tritium, gross alpha, gross beta, Sr-90, and gamma spectroscopy (e.g., Cs-137).
10. Interpret the data and compare to previous investigations and transport analyses for the Ojo Alamo.
11. Determine if the Ojo Alamo should be included as a viable transport pathway from the Gasbuggy cavity.

5.7 Evaluation of Results

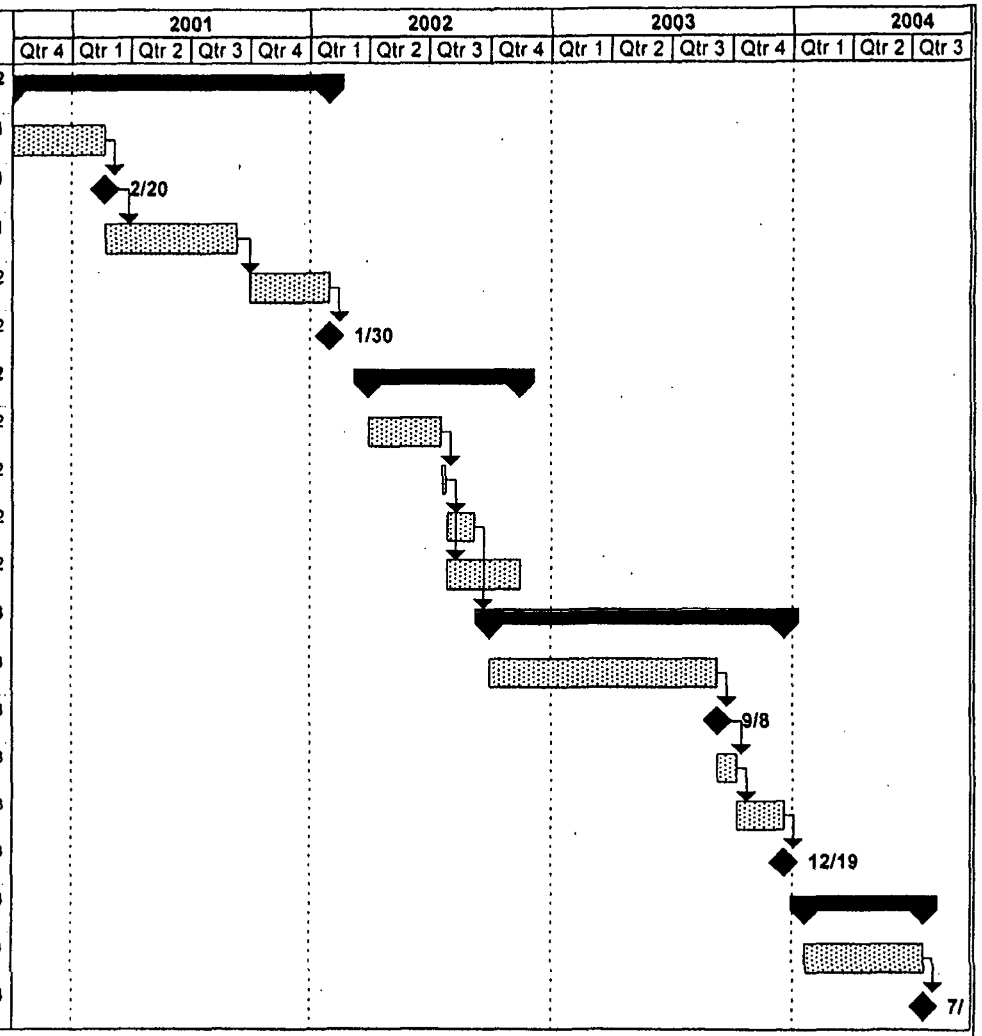
The results of the numerical simulations will be evaluated to determine the extent of radionuclide migration from the Gasbuggy test. An uncertainty analysis will be conducted so that minimum and maximum radionuclide transport distances and times can be estimated with a set degree of confidence. A human health dose assessment will be conducted if migration to a receptor is indicated. The current subsurface intrusion restrictions (drilling exclusion zone) will be reevaluated and possibly altered depending on the results from various stressed (pumping) and nonstressed reservoir conditions, and the results of the dose assessment, if performed.

The results of the Well EPNG 10-36 investigation will be evaluated to determine if the conclusion of minimal transport risk through the Ojo Alamo remains valid and to determine appropriate disposition of Well EPNG 10-36. If results indicate that the Ojo Alamo should be included as a viable transport pathway from the Gasbuggy cavity, groundwater transport will be added to the modeling investigation.

6.0 Schedule

A tentative project schedule has been developed and is presented in Figure 6-1 and Figure 6-2. This schedule provides information regarding the start times and durations for the tasks to be completed as part of the Gasbuggy Site investigation and modeling activities. This schedule also identifies dates for submission of progress reports and other reporting requirements for the Gasbuggy Site investigation project.

ID	Task Name	Duration	Start	Finish
1	**Site Characterization Work Plan**	**348d**	**Mon 10/2/00**	**Wed 1/30/02**
2	Prepare Work Plan	102d	Mon 10/2/00	Tue 2/20/01
3	Deliver to State (Rev. 0)	0d	Tue 2/20/01	Tue 2/20/01
4	State Review & Comments (Rev. 0)	144d	Wed 2/21/01	Mon 9/10/01
5	Respond to State Comments	88d	Mon 10/1/01	Wed 1/30/02
6	Deliver to State (Rev. 1)	0d	Wed 1/30/02	Wed 1/30/02
7	**Field Work**	**164d**	**Mon 4/1/02**	**Thu 11/14/02**
8	Prefield Activities	80d	Mon 4/1/02	Fri 7/19/02
9	Mobilization	5d	Mon 7/22/02	Fri 7/26/02
10	Field Investigation	30d	Mon 7/29/02	Fri 9/6/02
11	Laboratory Analysis	79d	Mon 7/29/02	Thu 11/14/02
12	**Site Characterization and CADD Report**	**319d**	**Tue 10/1/02**	**Fri 12/19/03**
13	Prepare Site Characterization and CADD Report	245d	Tue 10/1/02	Mon 9/8/03
14	Deliver to State (Rev. 0)	0d	Mon 9/8/03	Mon 9/8/03
15	State Review & Comments (Rev.0)	22d	Tue 9/9/03	Wed 10/8/03
16	Respond to State Comments	52d	Thu 10/9/03	Fri 12/19/03
17	Deliver to State (Rev. 1)	0d	Fri 12/19/03	Fri 12/19/03
18	Corrective Action Plan (CAP)	130d	Wed 1/21/04	Tue 7/20/04
19	Prepare CAP	130d	Wed 1/21/04	Tue 7/20/04
20	Deliver to State (Rev 0)	0d	Tue 7/20/04	Tue 7/20/04

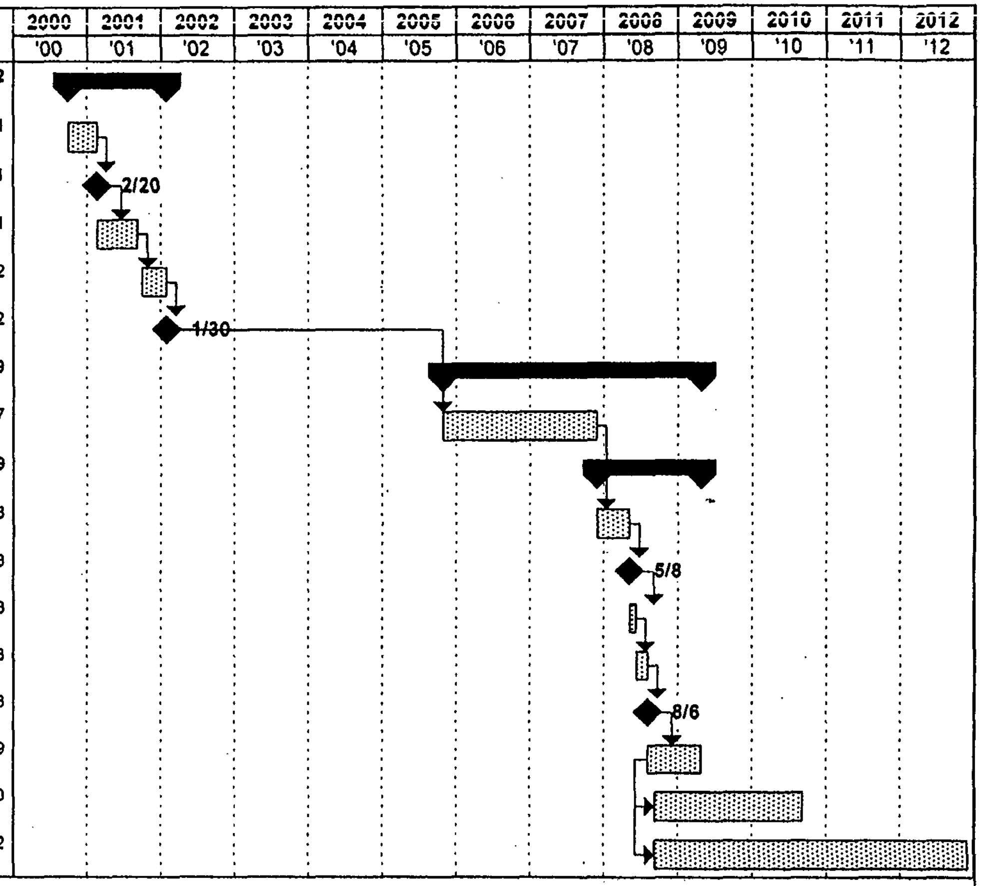


Project: Fig6-1_rev1.MPP
Date: Thu 1/24/02

Task; Progress; Milestone; Summary; Rolled Up Task; Rolled Up Milestone; Rolled Up Progress

Figure 6-1
Proposed Schedule for Surface Investigation at Gasbuggy Site

ID	Task Name	Duration	Start	Finish
1	**Site Characterization Work Plan**	348d	Mon 10/2/00	Wed 1/30/02
2	Prepare Work Plan	102d	Mon 10/2/00	Tue 2/20/01
3	Deliver to State (Rev. 0)	0d	Tue 2/20/01	Tue 2/20/01
4	State Review & Comments (Rev. 0)	144d	Wed 2/21/01	Mon 9/10/01
5	Respond to State Comments	88d	Mon 10/1/01	Wed 1/30/02
6	Deliver to State (Rev. 1)	0d	Wed 1/30/02	Wed 1/30/02
7	**Corrective Action Decision Document**	913d	Fri 10/28/05	Tue 4/28/09
8	Modeling Effort	543d	Fri 10/28/05	Tue 11/27/07
9	**Prepare Documents**	370d	Wed 11/28/07	Tue 4/28/09
10	Prepare CADD	117d	Wed 11/28/07	Thu 5/8/08
11	Deliver to State (Rev. 0)	0d	Thu 5/8/08	Thu 5/8/08
12	State Review and Comments (Rev. 0)	22d	Fri 5/9/08	Mon 6/9/08
13	Respond to Comments	42d	Tue 6/10/08	Wed 8/6/08
14	Deliver to State (Rev. 1)	0d	Wed 8/6/08	Wed 8/6/08
15	Model Validation	189d	Thu 8/7/08	Tue 4/28/09
16	Closure negotiations	520d	Mon 9/8/08	Fri 9/3/10
17	Closure Report	1107d	Mon 9/8/08	Tue 12/4/12



Project: Fig6-2_rev1.MPP
Date: Thu 1/24/02

Task | Summary | Rolled Up Progress
Progress | Rolled Up Task
Milestone | Rolled Up Milestone

Figure 6-2
Proposed Schedule for Subsurface Modeling of Gasbuggy Site

7.0 References

AEC, see U.S. Atomic Energy Commission.

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Appendix A

Gasbuggy Historical Radiological Monitoring and Sampling Results

A.1.0 Summary of Radiological Monitoring and Sampling for the Gasbuggy Site Surface

A review of the historical radiological environmental monitoring data for the Gasbuggy Site was performed to help determine if additional radiological characterization will be required. The information in this appendix does not include information on all monitoring and sampling efforts conducted in support of Project Gasbuggy, but those data that provide information which may be used to help determine current site surface and shallow subsurface conditions. For simplicity, shallow subsurface is defined as the area in which there is a potential for contamination associated with surface activities (e.g., gas flaring). A discussion of the historical data to be used in the subsurface (e.g., contamination from the cavity) investigation effort is included in Section 5.0 of the Work Plan. Therefore, it is not included in this appendix.

The review consisted of an evaluation of the historical data associated with radiological monitoring of the SGZ area during and after the detonation, natural gas discharges to the flare stack, wastes, air samples, gas samples, soil moisture sampling, vegetation sampling, thermoluminescent dosimeter measurements, remote area monitoring system, and aerial radiological surveys. It was concluded from this review of historical reports that:

- The level of radionuclide contamination in the soil that resulted from atmospheric releases from the flare stack were minimal.
- No radionuclides other than tritium and naturally occurring radioisotopes were found in soil samples collected during the 1978 Gasbuggy restoration effort (EIC, 1979).
- No soil moisture samples collected during the 1978 sampling event exceeded the site clearance criteria of 30,000 picocuries per milliliter (pCi/mL) of soil moisture (EIC, 1979).
- The highest concentration of tritium in soil moisture (1,303 pCi/mL) was at a location near the flare stack at a depth of 4 ft below ground surface (EIC, 1979).
- No radioactive material or low-level radioactive waste was buried on site during the 1978 restoration except for tritium contaminated water which was injected into the emplacement well and detonation cavity (EIC, 1979).
- The results from thermoluminescent dosimeter (TLD) radiation measurements were within the range that would be encountered from natural background radiation (AEC, 1973).

- Aerial surveys conducted during the detonation and after site restoration (1994) indicated that the range of exposure rates measured were within the range expected for natural background. No evidence of Cs-137 or any other man-made radionuclides were found (AEC, 1973 and EG&G/EM, 1995).

A.2.0 Monitoring and Sampling During Detonation and Posttest Drilling

Extensive monitoring and sampling was conducted during the detonation and subsequent posttest drilling. The information presented in this section includes information and data which supports the conclusion that no dynamic venting occurred during the detonation; therefore, the only radionuclides of concern at the Gasbuggy Site are the result of gas-flaring operations.

A.2.1 Detonation and Containment

Although the stemming plan was designed to seal the emplacement well and prevent any leakage from the test, a small amount of radioactivity was detected at ground surface about eight hours after the detonation. The leakage apparently occurred in the explosive arming and firing cable, with breaks in that cable possibly allowing radioactive gas to leak to porous portions of the stemmed emplacement hole (LRL, 1968a). After 1½ hours, all cables were cut and sealed at the wellhead. It is estimated that about one curie of gaseous radioactivity had escaped to the atmosphere (LRL, 1968b). Analysis of a sample of the gas leaking up the cables determined the only radioactive materials present were inert noble gases (i.e., krypton and xenon) (AEC, 1971).

A.2.2 Thermoluminescent Dosimeters

The U.S. Bureau of Radiological Health (Southwestern Radiological Health Laboratory) provided off-site radiological safety support to the Gasbuggy Project in June 1967. As a part of an interagency agreement with the AEC, a network of TLDs was established around the site out to approximately eight miles. Approximately 50 TLDs were located at approximately 1½-mile intervals along the existing roads and highways. The TLDs were posted on October 17, 1967, and exchanged on November 15, 1967, to measure background radiation prior to the experiment. They were exchanged again on December 8, 1967, two days before the detonation and removed on January 15, 1968, following the drill back into the test cavity. This set of TLDs were to measure radiation levels following the detonation and during drill-back activities (DHEW, 1970).

Readout of the predetonation TLDs (posted 11/15/1967 - 12/08/1967) showed dose rates ranging from 0.25 to 0.50 milliRoentgen (mR) per day. The post detonation TLD sets (posted 12/08/1967 -

1/15/1968) read from 0.29 to 0.55 mR per day (DHEW, 1970). The mean plus or minus one standard deviation for the pre- and postdetonation TLD sets were 0.37 ± 0.047 and 0.37 ± 0.055 mR per day, respectively. The results for the two sets of TLDs were within the range of naturally occurring background levels, and showed no statistically significant difference between pre- and postdetonation periods.

A.2.3 Remote Area Monitoring System

Remote area monitoring system (RAMS) detectors were installed in the emplacement well (Well GB-E), at the wellhead and on 250-ft and 450-ft arcs around the emplacement well during the detonation. The RAMS detectors positioned downhole and at the wellhead registered minimal readings due to radioactive gas migrating up the hole in the hours immediately after detonation. The maximum reading at the wellhead was 160 mR per hour, approximately 11 hours after detonation. None of the RAMs stations on the 250-ft and 450-ft arcs positioned around the wellhead indicated any radiation levels above background. No RAMS readings above background were observed during posttest operations, except in response to radioactive sources used during well logging (AEC, 1973).

A.2.4 Air Samples

Twenty-four hour air samples were collected daily from December 10, 1967, until after the drillback and gas sampling operations were completed, and the wellhead was shut in on January 17, 1968. Air samples indicated that "airborne radioactivity around SGZ never varied significantly from normal background levels" (AEC 1971).

A.2.5 Gas Sampling

As in all underground nuclear tests, the majority of the radioactivity is contained in the melt glass in the bottom of the cavity. Krypton-85 and tritium account for essentially all of the radioactivity in the natural gas produced from the Gasbuggy chimney. About 350 ± 20 curies of Kr-85 and about 4.5×10^4 curies of tritium were deposited in the chimney by the explosion. The short-lived isotopes of Xe-133 and Ar-37 were also detected in gas samples from the chimney but have since decayed away. In addition, minor amounts of Ar-39 and C-14 were detected in the chimney gas. Significant quantities of radionuclides were removed from the chimney by gas flow testing. The tritium was found in the form of tritiated methane, some higher hydrocarbon fractions, tritiated hydrogen, as well as tritiated water. Only five percent of the total estimated tritium was found in the gas phase (Holzer, 1970). It is assumed that the remaining tritium is in water.

Filter papers exposed to the gas flow during the high-rate production tests in early November 1970 indicated that no detectable activity of either ^{90}Sr or ^{137}Cs was observed (LRL, 1971).

A.2.6 Aerial Surveys

Aerial radiation measurements were performed by the U.S. Public Health Service's (PHS) South Western Radiological Health Laboratory on December 10, 1967, during the Gasbuggy detonation. A U.S. Air Force C-47 equipped for tracking radioactive plumes was flown at 11,000 ft. A PHS Turbo-Beech, Vegas 8, was used for low altitude monitoring (7,700-8,700 ft) of SGZ and was equipped for sampling and tracking any released activity. All readings made by both aircraft during the mission were at background levels (DHEW, 1970).

A.3.0 Effluent Monitoring During Gas Production Testing

Six major production tests were conducted after reentry drilling was completed in January 1968. Two took place in 1968, three in 1969, and the last one in 1973. Long-term production testing was completed in November 1973 and pressure monitoring activities were completed in late 1976 (DOE/NV, 1978). During production testing, water was carried up the tubing with the gas in the reentry well when the velocity of gas was sufficient to carry up water (AEC, 1971).

The limited tests in June and July 1968 produced 1,440 gallons of water. This water was placed in 36 55-gallon drums, "gelled," and sent to the NTS for disposal. The subsequent tests produced too much water to drum and dispose of in this fashion. Therefore, a steam/spray system was designed to vaporize the water into the flame at the top of the flare stack (AEC, 1971).

Tritium and Kr-85 were the primary radionuclides detected in the gas and liquid samples that were collected during production tests. A system to analyze low levels of krypton and tritium (STALLKAT) was utilized during all production test through November of 1969 (AEC, 1971).

During the 1973 gas production tests, the literature indicates that "The EPNG on-line monitoring trailer was used to maintain a continuous record of radioactivity produced and flared. A Liquid Scintillation Spectrometer was used to measure radioactivity concentrations in water sampled daily (AEC, 1973)."

Calculations for the total tritium released during the June and July 1968 tests was based on analysis of gas and moisture samples collected and analyzed by LRL. The tritium released during the tests was composed of three parts: tritium in the gas monitored by the STALLKAT system, tritium in wastewater from the steam-spray operations, and freeze-out samples collected after the bulk liquid separation. The data show 2,432 curies of tritium were released to the environment through November of 1969. The Kr-85 released during the June and July 1968 gas production tests was based on STALLKAT readings. The data show 364 curies of Kr-85 were released to the environment through November of 1969 (AEC, 1971).

The final set of gas production tests were conducted from May 15 - November 6, 1973. The details of how the release data was measured was not found. However, it was assumed that the methodology was similar to that mentioned for the tests conducted in 1968. Through November 6, 1973, 48.93 curies of tritium and 4.69 curies of Kr-85 were released to the environment (EPA, 1973). The two sets of production tests are listed in Table A.3-1.

Table A.3-1
Radioactive Release Measurements of Gaseous Effluents During Gasbuggy Production Testing

Gas Production Test	Kr-85 (curies)	Tritium (curies)
All production tests through December of 1969	364	2,432
1973 Production test	4.69	48.93
All production tests combined	369	2,481

Kr-85 = Krypton-85

Source: EIC, 1971 and EPA, 1973

These results indicate that the level of soil contamination that could have resulted from the flare stack releases would be minimal. This is based on: (1) the Kr-85 radionuclide is a noble gas which would not directly result in soil contamination; (2) the majority (approximately 75 percent) of what was released has decayed away in the 25-year period following the last release based on the half-lives for tritium and Kr-85, the two major nuclides; and (3) the tritium that may have condensed and infiltrated the soil would have dissipated due to evapotranspiration. The half-life for Kr-85 is 10.72 years, and the half-life for tritium is 12.3 years.

A.4.0 Restoration Activities

Site restoration activities were conducted over a six-week period in August-September 1978. Restoration activities included: (1) well plugging and abandonment; (2) decontamination, transport and disposal of equipment; (3) packaging, transport, and disposal of solid and liquid waste; (4) land surface restoration; and (5) final status sampling and analysis (DOE/NV, 1983). This section will concentrate on those activities affecting the amount of radioactivity at the site surface and shallow subsurface today.

A.4.1 Disposal of Radioactive Material

The facilities and structures at the Gasbuggy Site were dismantled and decontaminated (DOE/NV, 1983). Government-owned materials were shipped to the NTS. Equipment that was used by Eberline Instrument Corporation (EIC) (the AEC contractor for radiation safety) was surveyed and released for unrestricted use and EPNG-owned equipment was returned (DOE/NV, 1983).

Items that were impractical to decontaminate or could not be decontaminated were contained and shipped to the NTS for disposal (DOE/NV, 1983). Ten 55-gallon drums of materials, either known to be slightly radioactive or difficult to make a determination of radioactive content, were sealed, externally steam cleaned, and labeled for shipment as low-level radioactive waste. Nuclides other than tritium and naturally occurring isotopes were not found to be present. The total tritium content of all ten 55-gallon drums was less than 1 millicurie (mCi) (EIC, 1979).

Liquid waste materials consisted primarily of tritium-contaminated sludge and liquids from decontamination operations. Approximately 60 55-gallon drums (approximately 3,000 gallons) of tritium-contaminated water and sludge with an average concentration of 1,439 pCi/mL, and 7.3 55-gallon drums of tritium-contaminated water and sludge with an average concentration of 350 pCi/mL were pumped from the storage tank and the decontamination sump. The water did not contain other radioactive isotopes above detection limits except naturally occurring radioactive isotopes (see Table A.4-1). This material was injected into the GB-ER cavity before the reentry well was plugged (EIC, 1979).

Table A.4-1
Reported Results of Additional Analysis for Samples Collected During 1978 Restoration

Description of Sample	Gamma-Emitting Isotopes								Plutonium-238	Plutonium-239	Strontium-90
	Lead-212	Lead-214	Thallium-208	Bismuth-214	Bismuth-212	Actinium-228	Potassium-40	Cesium-137			
	Concentration of Isotopes in Liquid Samples (pCi/L)										
Sludge from decon sump and storage tank that was pumped down Well GB-ER	400 +/- 50	300 +/- 50	200 +/- 20	300 +/- 50	<400	100 +/- 20	2000 +/- 500	< 50	NA	NA	< 12.3
Water and sludge from separator	200 +/- 30	300 +/- 40	< 50	< 50	< 300	< 100	750 +/- 300	< 80	NA	NA	< 14.3
	Concentration of Isotopes in Solid Samples (pCi/g)										
Storage tank sludge	0.6 +/- 0.1	0.4 +/- 0.1	< 0.3	< 0.3	< 2.0	< 0.3	< 2.0	<0.2	0.0 +/- 0.02	0.0 +/- 0.02[a]	< 0.07
Soil sample from profile hole #1, 1-foot depth	0.7 +/- 0.2	0.7 +/- 0.2	< 0.4	0.6 +/- 0.2	< 1.0	< 0.3	41 +/- 6	< 0.2	NA	NA	< 0.03
Soil sample from profile hole #1, 5-foot depth	0.9 +/- 0.2	< 0.2	< 0.2	0.2 +/- 0.1	< 1.0	< 0.2	10 +/- 2	< 0.1	NA	NA	< 0.04
Soil sample from profile hole #24, 4-foot depth	3.0 +/- 1.0	2.0 +/- 1.0	1.2 +/- 0.4	0.4 +/- 0.2	< 2.0	< 0.3	41 +/- 10	< 0.2	NA	NA	< 0.12
Soil sample from forestry road #357 at windmill, distance from site is 4.4 miles, depth of sample - 1 foot	2.0 +/- 1.0	2.0 +/- 1.0	0.5 +/- 0.1	0.8 +/- 0.2	< 1.0	< 0.2	32 +/- 5	< 0.1	NA	NA	< 0.06
Soil sample from forestry road #357 at windmill, distance from site is 4.4 miles, depth of sample - 2 feet	0.7 +/- 0.2	0.4 +/- 0.2	< 0.3	0.6 +/- 0.2	< 2.0	< 0.3	20 +/- 4	< 0.2	NA	NA	<0.05

[a]Value reflects dry weight of sample

pCi/L = Picocuries per liter
+/- = Plus or minus
< = Less than

NA = Not analyzed
pCi/g = Picocuries per gram

Source: EIC, 1979

One hundred seventy-five 55-gallon drums (approximately 9,000 gallons) of low-level tritium-contaminated water was accumulated in a storage tank from the steam decontamination operations after GB-ER was plugged. This water was disposed of by vaporization to the atmosphere using a steam generator. Tritium levels in this water ranged from 14.7 pCi/mL to 43.7 pCi/mL, and a total of 1.31 mCi was estimated to have been released to the atmosphere over a period of 25 days in September 1978 (EIC, 1979).

A.4.2 On-Site Disposal of Materials

The historic decontamination area consisted of a concrete pad and asphalt/plastic sump liner. This pad, located in the northwest corner of the site, was broken up and buried in place by enlarging the original sump. Along with the decontamination pad, several other concrete pads from the site were broken up and buried at this location (DOE/NV, 1983). Swipe samples of the concrete pieces were analyzed for beta and tritium activity. The concentrations were less than (<) the LLD. Soil samples taken in the sump prior to backfilling were analyzed and the results were < LLD for tritium (2 pCi/mL). No radioactive material was disposed of in this burial (EIC, 1979).

Mud and "gel" loaded water used during the well plugging operations was buried on-site at three separate locations. Samples of this material were also taken prior to burial. The sample results were < LLD for tritium (EIC 1979).

A.4.3 Soil Sampling

Prior to environmental restoration activities (October 1973), EPNG personnel performed radiological soil sampling at the Gasbuggy Site. Data from this sampling event was not published and is not currently available. The EPNG data was used by EIC personnel to plan the 1978 environmental cleanup and sampling investigation. Three types of soil samples were collected by EIC personnel during restoration activities: (1) near-surface soil samples, (2) profile (shallow subsurface) soil samples and, (3) operational soil samples. All soil samples were analyzed for tritium in soil moisture. The LLD for tritium contained in the moisture of soil samples was 2 pCi/mL at three sigma error (EIC, 1979).

Surface soil sampling points were set on a 50-ft grid. Samples were collected at most of the grid nodes within the fence line (see Figure A.4-1) at a depth of 12 to14 in. bgs. The highest concentration detected, 965 pCi/mL tritium in soil moisture, was at location near the separators. All of the near surface soil sample results were less than the clearance criterion of 30,000 pCi/mL tritium in soil moisture established by DOE (EIC, 1979).

Profile soil samples were collected in order to obtain data on the vertical distribution of the tritium concentration with depth. The surface soil sample results guided selection of sampling points for the soil profiles. Originally, 21 profiles were performed to a depth of 6 ft. The results from these profile samples determined the selection of more locations and the need to go deeper at several of the first 21 locations. The profile samples were taken at the locations shown on Figure A.4-2 (EIC, 1979).

Thirty-one sets of profile sample results are reported in the *Project Gasbuggy Radiation Contamination Clearance Report* (see Table A.4-2). Elevated readings were observed at the flare stack and steamer shack locations. A sample collected at a depth of 4 ft bgs from profile #24, located near the Flare Stack, had the highest tritium result (1,303 pCi/mL). All of the profile soil sample results were less than the clearance criterion of 30,000 pCi/mL established by DOE for tritium in soil moisture (EIC, 1979).

Operational soil samples were collected by EIC personnel at 46 locations. Soil samples were taken in support of cleanup whenever a hole needed to be dug or soil disturbed. The sampling method was to remove man-made and vegetative material from the surface. Then a 100-square centimeter area of soil was taken down to a depth sufficient to provide enough moisture for a tritium distillation analysis. The location of these operational soil samples are shown on Figure A.4-3. Seventeen of 46 soil samples had tritium concentrations greater than the LLD. The results for these samples are listed in Table A.4-3 along with a description of their location. Elevated readings were located in the vicinity of the flare stack and steamer shack (EIC, 1979).

In addition, three soil samples collected on site and two off site were analyzed for Sr-90 and gamma-emitting isotopes along with several of the operation waste/water samples. This included the soil sample with the highest tritium concentration (EIC, 1979). The results of these analyses are presented in Table A.4-1.

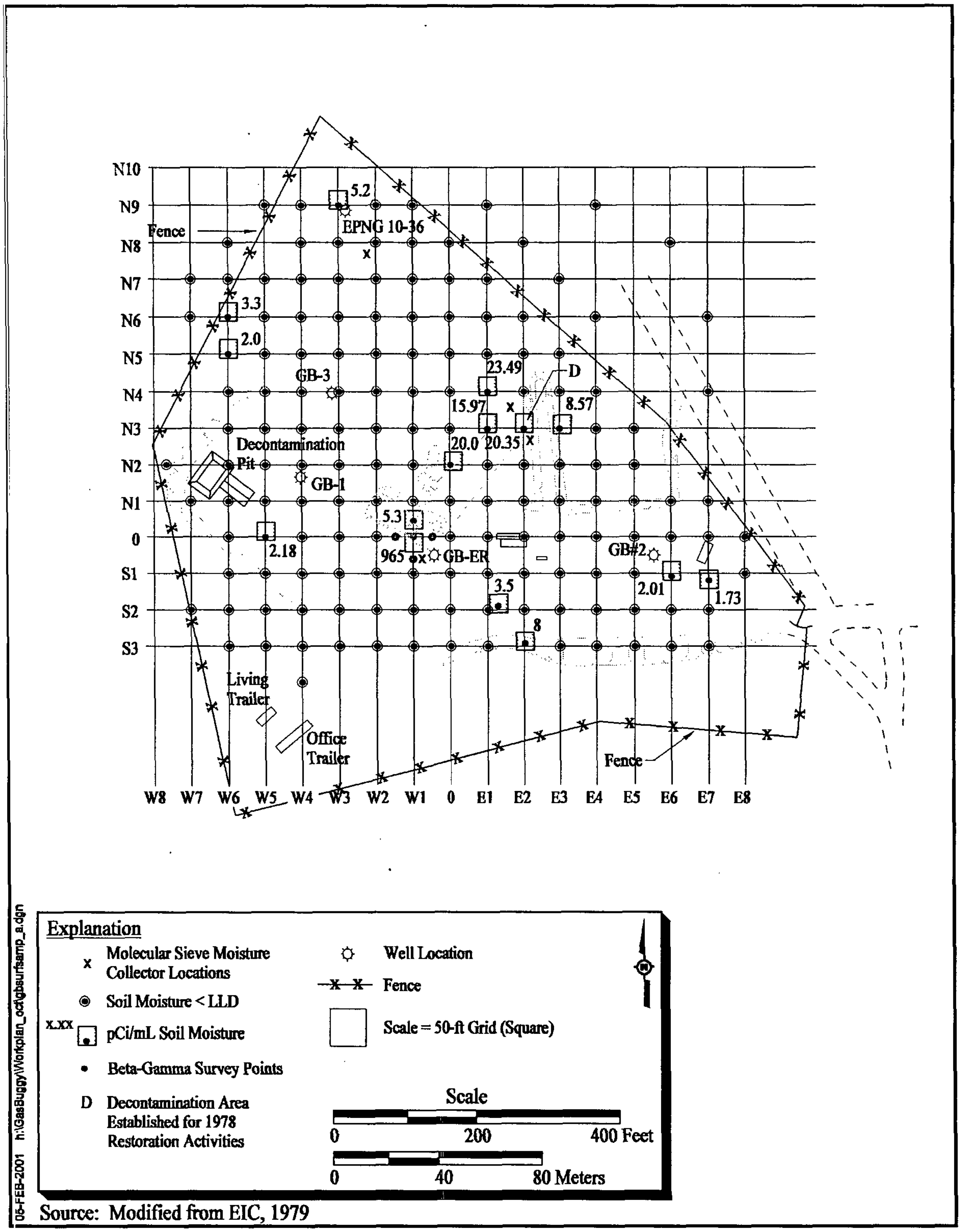

Figure A.4-1
Location of Surface Sampling Points

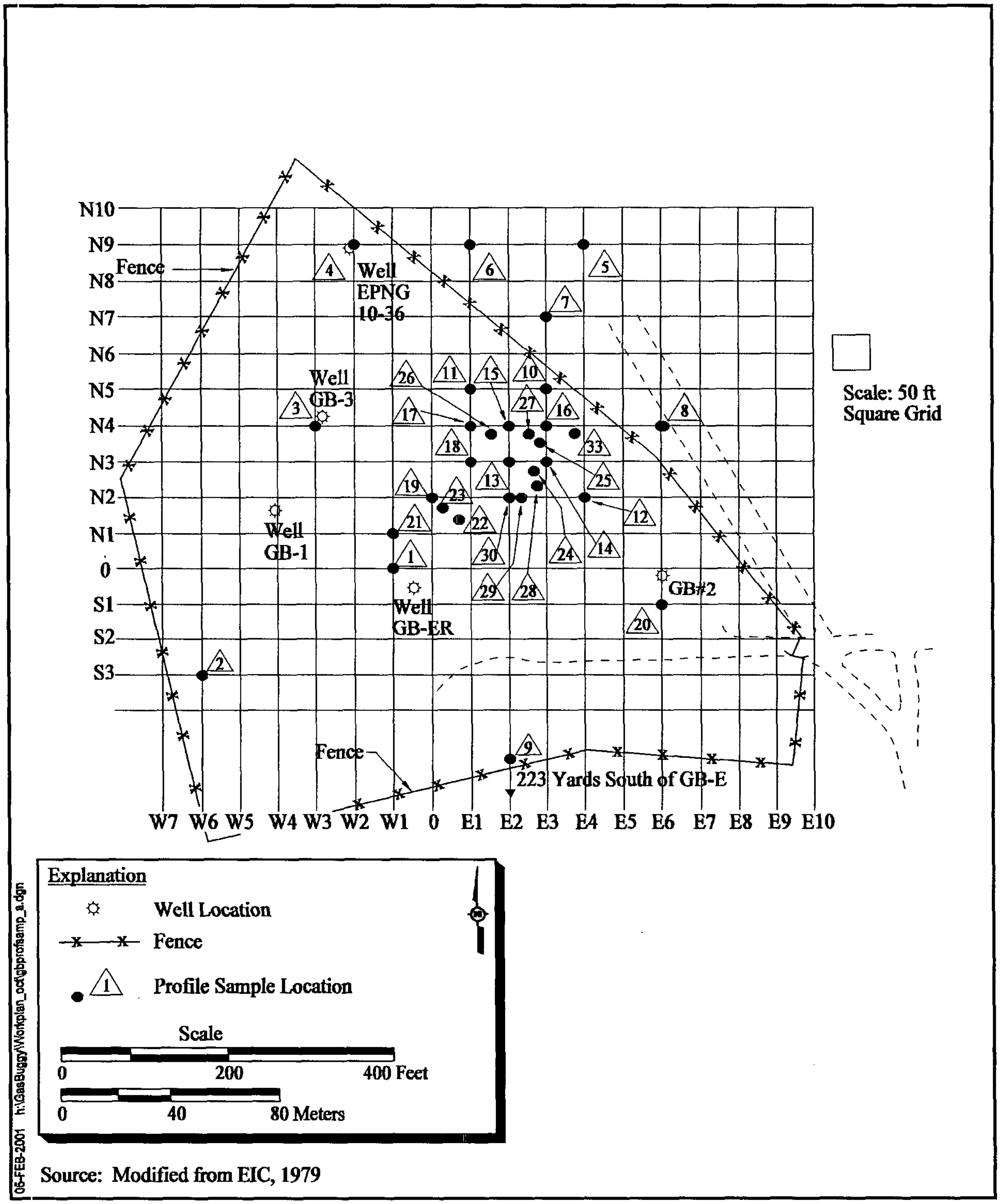

Figure A.4-2
Location of Profile Sample Sets

Table A.4-2
Results of Profile Sampling Sets
(Page 1 of 4)

Hole	Grid Location[a]	Depth (ft)	Tritium in Soil Moisture (pCi/mL)	Rerun of Hole[b]	Hole	Grid Location[a]	Depth (ft)	Tritium in Soil Moisture (pCi/mL)	Rerun of Hole[b]
1	W1 N0	1	154	74.5	5	E4 N9	1	< LLD	–
		2	180	69.3			2	2.3 (RC< LLD)	–
		3	234	60.7			3	1.9 (RC< LLD)	–
		4	232	126			4	< LLD	–
		5	249	164			5	< LLD	–
		6	558	121			6	< LLD	–
		7	–	112	6	E1 N9	1	< LLD	–
		8	–	63.9			2	< LLD	–
		9	–	40.4			3	< LLD	–
		10	–	24.7			4	< LLD	–
2	W6 S3	1	< LLD	–			5	< LLD	–
		2	< LLD	–			6	< LLD	–
		3	< LLD	–	7	E3 N7	1	< LLD	–
		4	< LLD	–			2	< LLD	–
		5	< LLD	–			3	< LLD	–
		6	< LLD	–			4	< LLD	–
3	W3 N4	1	< LLD	–			5	< LLD	–
		2	< LLD	–			6	< LLD	–
		3	< LLD	–	8	E6 N4	1	< LLD	–
		4	< LLD	–			2	< LLD	–
		5	< LLD	–			3	< LLD	–
		6	< LLD	–			4	< LLD	–
4	W2 N9	1	< LLD	–			5	< LLD	–
		2	< LLD	–			6	< LLD	–
		3	< LLD	–	9	223 yards S of GB-ER on E2	1	< LLD	–
		4	< LLD	–			2	< LLD	–
		5	< LLD	–			3	< LLD	–
		6	< LLD	–			4	< LLD	–
							5	< LLD	–
							6	< LLD	–

Table A.4-2
Results of Profile Sampling Sets
(Page 2 of 4)

Hole	Grid Location[a]	Depth (ft)	Tritium in Soil Moisture (pCi/mL)	Rerun of Hole[b]	Hole	Grid Location[a]	Depth (ft)	Tritium in Soil Moisture (pCi/mL)	Rerun of Hole[b]
10	E3 N5	1	< LLD	--	14	E3 N3	1	39.9	--
		2	< LLD	--			2	135	--
		3	< LLD	--			3	311	--
		4	< LLD	--			4	422	--
		5	< LLD	--			5	282	--
		6	< LLD	--			6	83	--
11	E1 N5	1	13.3	--	15	E2 N4	1	3.2	--
		2	< LLD	--			2	10.2	--
		3	2.0	--			3	23.1	--
		4	< LLD	--			4	39.1	--
		5	1.8	--			5	34.3	--
		6	1.6	--			6	18.8	--
12	E4 N2	1	< LLD	3.8	16	E3 N4	1	9.8	9.7
		2	< LLD	9.2			2	8.6	4.6
		3	< LLD	4.2			3	12.2	8.3
		4	< LLD	7.8			4	10.1	10.5
		5	2.6	33.1			5	16.2	12.0
		6	13.4	42.3			6	18.8	31.2
		7	--	44.9			9	71.5	53.4
		8	--	31.3			10	72.2	54.1
13	E2 N3	1	52.0	15.7			11	71.2	--
		2	31.7	38.1			12	73.3	--
		3	331	83.2	17	E1 N4	1	22.3	--
		4	131	34.6			2	74.3	--
		5	919	181			3	117.2	--
		6	980	--			4	79.4	--
		6	6.8	--			5	24.0	--
		7	< LLD	--			6	6.1	--
		8	< LLD	--					

Table A.4-2
Results of Profile Sampling Sets
(Page 3 of 4)

Hole	Grid Location[a]	Depth (ft)	Tritium in Soil Moisture (pCi/mL)	Rerun of Hole[b]	Hole	Grid Location[a]	Depth (ft)	Tritium in Soil Moisture (pCi/mL)	Rerun of Hole[b]
18	E1 N3	1	6.7	--	22	E1 N1 + 10N 18W	1	9.3	--
		2	20.4	--			2	7.4	--
		3	23.5	--			3	6.9	--
		4	30.7	--			4	7.3	--
		5	24.1	--			5	23.7	--
		6	14.3	--			6	99	--
19	0 N2	1	4.7	--			7	298	--
		2	7.1	--			8	218	--
		3	6.6	--	23	E1 N1 + 16N 33W	1	2.7	--
		4	5.2	--			2	6.8	--
		5	3.0	--			3	10.2	--
		6	< LLD	--			4	10.8	--
20	E6 S1	1	< LLD	--			5	34.9	--
		2	< LLD	--			6	49.9	--
		3	< LLD	--			7	69.9	--
		4	< LLD	--			8	59.6	--
		5	< LLD	--	24	E3 N2 + 45N 17W	1	49.3	--
		6	< LLD	--			2	135	--
21	W1 N1	1	< LLD	--			3	434	--
		2	< LLD	--			4	1303	--
		3	< LLD	--			5	578	--
		4	< LLD	--			6	385	--
		5	< LLD	--			7	186	--
		6	< LLD	--			8	86.9	--
					25	E3 N3 + 27N 14W	1	16.2	--
							2	6.6	--
							3	25.3	--
							4	61.5	--
							5	158	--

Table A.4-2
Results of Profile Sampling Sets
(Page 4 of 4)

Hole	Grid Location[a]	Depth (ft)	Tritium in Soil Moisture (pCi/mL)	Rerun of Hole[b]	Hole	Grid Location[a]	Depth (ft)	Tritium in Soil Moisture (pCi/mL)	Rerun of Hole[b]
26	E2 N3 + 19N 7W	1	3.2	–	29	E2 N2 + 21E	1	< LLD	–
		2	3.4	–			2	2.2	–
		3	6.4	–			3	< LLD	–
		4	15.5	–			4	< LLD	–
		5	35.1	–			5	< LLD	–
27	E2 N3 + 32N 9E	1	4.9	–			6	31.5	–
		2	13.0	–			7	< LLD	–
		3	10.6	–			8	< LLD	–
		4	31.5	–	30	E2 N2	1	< LLD	–
		5	52.5	–			2	< LLD	–
28	E3 N2 + 21N 11W	1	< LLD	–			3	< LLD	–
		2	< LLD	–			4	3.2	–
		3	< LLD	–			5	< LLD	–
		4	< LLD	–			6	< LLD	–
		5	< LLD	–			7	< LLD	–
		6	2.5	–			8	4.9	–
		7	< LLD	–	33[c]	E4 N3 + 38N 19W	1	< LLD	–
		8	< LLD	–			2	< LLD	–
							3	< LLD	–
							4	< LLD	–
							5	3.7	–
							6	6.9	–
							7	5.1	–
							8	3.2	–

[a]For location, see Figure A.4-2. Additional descriptions given after the coordinates refer to distance from coordinate in feet.
[b]Based on results, samples were recollected or additional samples were collected from Holes 1, 12, 13, and 16.
[c]The source document (EIC, 1979) does not give results for Sample Sets 31 and 32.

E = East
W = West
N = North
S = South

< LLD = Less than the lower limit of detectability (i.e., 2 pCi/mL)
RC = Recount (sample was reanalyzed)
– = No sample collected

Source: EIC, 1979

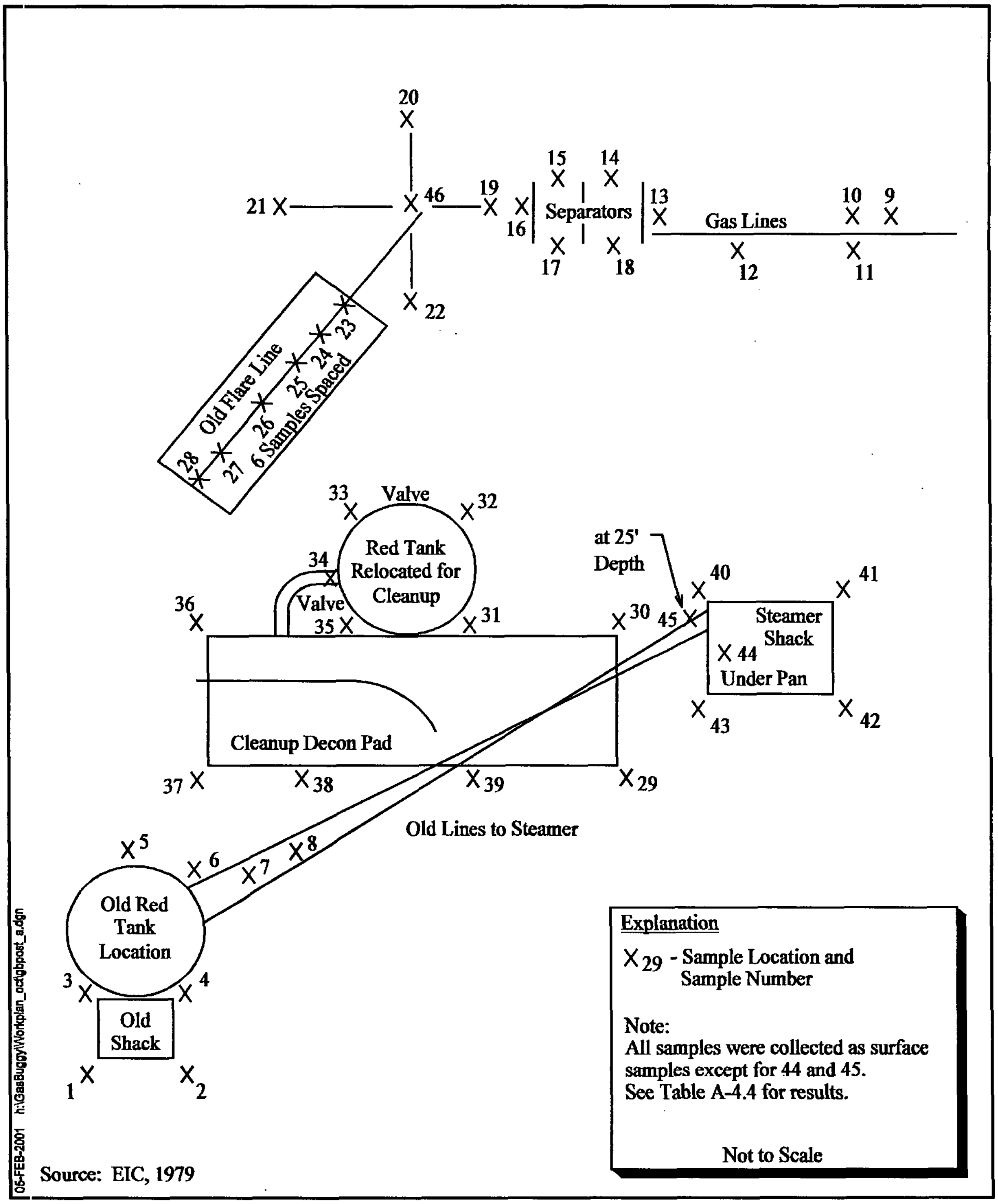

Figure A.4-3
Location of Post-Operational Soil Samples

Table A.4-3
Results for Post-Operational Soil Samples

Sample	Site Location	Tritium in Soil Moisture (pCi/mL)	Sample	Site Location	Tritium in Soil Moisture (pCi/mL)
1	Near storage tank and pump shack	< LLD	24	Along old flare line	< LLD
2	Near storage tank and pump shack	3.3	25	Along old flare line	< LLD
3	Near storage tank and pump shack	< LLD	26	Along old flare line	< LLD
4	Near storage tank and pump shack	< LLD	27	Along old flare line	< LLD
5	Near storage tank and pump shack	< LLD	28	Along old flare line	< LLD
6	Near storage tank and pump shack	< LLD	29	Around new operational location of storage tank and decon pan	< LLD
7	Along water line from storage tank	< LLD	30	Around new operational location of storage tank and decon pan	3.0
8	Along water line from storage tank	< LLD	31	Around new operational location of storage tank and decon pan	< LLD
9	Along gas lines	< LLD	32	Around new operational location of storage tank and decon pan	< LLD
10	Along gas lines	< LLD	33	Around new operational location of storage tank and decon pan	1.7
11	Along gas lines	< LLD	34	Around new operational location of storage tank and decon pan	10.5
12	Along gas lines	< LLD	35	Around new operational location of storage tank and decon pan	4.0
13	Where separators were	< LLD	36	Around new operational location of storage tank and decon pan	3.9
14	Where separators were	< LLD	37	Around new operational location of storage tank and decon pan	2.6
15	Where separators were	< LLD	38	Around new operational location of storage tank and decon pan	2.4
16	Where separators were	2.5	39	Around new operational location of storage tank and decon pan	1.8
17	Where separators were	< LLD	40	Around steamer shack	5.9
18	Where separators were	< LLD	41	Around steamer shack	6.6
19	6 feet north from GB-ER	< LLD	42	Around steamer shack	2.9
20	6 feet east from GB-ER	17.3	43	Around steamer shack	63.1
21	6 feet south from GB-ER	2.1	44	Under steamer sump	60.7
22	6 feet west from GB-ER	< LLD	45	2.5 feet under steamer sump	280
23	Along old flare line	< LLD	46	At GB-ER	7.8

< = Less than
LLD = Lower Limit of Detectability
pCi/mL = Picocuries per milliliter

Source: EIC, 1979

The results of this review suggest that, with the exception of tritium, the concentration of radionuclides measured in soil were not distinguishable from natural background levels. Tritium has a half-life of 12.72 years, and the concentrations would now be no more than approximately a quarter of the values measured in 1978. Lastly, no radionuclides other than tritium and naturally occurring radioisotopes were found in soil during the 1978 Gasbuggy restoration effort.

A.4.4 Vegetation Sampling

Vegetation samples were obtained from six locations on the Gasbuggy Site during the 1978 restoration. Results are presented in Table A.4-4. The tritium concentrations in the vegetation were consistent with the results of soil samples taken in the various areas. The highest concentration of tritium detected in the vegetation was at the flare stack area and measured 470 pCi/mL (EIC, 1979). This is well below the clearance criterion of 30,000 pCi/mL established by DOE for tritium in soil moisture (EIC, 1979).

Table A.4-4
Vegetation Sample Results

Location	Total Tritium[a] (pCi/mL water)
South side of road	2.8 +/- 0.5
North side of road	< 3.2 +/- 0.5
Storage tank area	10.4 +/- 0.3
Separator area	7.7 +/- 0.3
Flare stack area	470 +/- 2.6
Profile hole #16	7.2 +/- 0.6

[a]Free and organically bound water

pCi/mL - Picocuries per milliliter
+/- = Plus or minus
< = Less than

Source: EIC, 1979

A.4.5 Ground Radiation Surveys

After all site activity was complete, the area was surveyed for beta-gamma radiation. All readings were <0.05 millirad per hour for beta-gamma (EIC, 1979).

A.5.0 Post-Restoration Sampling and Monitoring

Two radiological monitoring efforts have been undertaken at the Gasbuggy Site since the 1978 restoration.

A.5.1 Ground Radiation Survey (1993)

In June of 1993, the EPA conducted a surface monitoring program. The goal of the program was to assess the extent of contamination and obtain data on the amounts and types of radionuclides at the site for use in future remediation activities. Gamma-ray spectra were obtained in the field with a high purity germanium detector. The total gamma-ray flux was measured with a portable pressurized ion chamber system for comparison with the *in situ* spectrometry results. Measurements were taken at eight survey locations at or near the site and a ninth location at Gobernador, New Mexico, approximately 10 miles northeast of the site. Results indicated radiation surveys conducted at on-site locations are similar to those taken off site (EPA, 1995).

A.5.2 Aerial Radiation Survey (1994)

An aerial radiological survey was conducted over the Project Gasbuggy Site on October 27, 1994. Parallel lines were flown at intervals of 300 ft over a 16-square mile area at a 150-ft altitude centered over the Gasbuggy Site. The purpose of the aerial survey was to detect and document any anomalous gamma radiation in the environment which may have been caused as a result of an underground nuclear detonation and from subsequent production tests. The exposure rates measured within the survey regions were generally uniform and typical of rates resulting from natural background radiation. No evidence of Cs-137 or any other man-made radionuclide was found (EG&G EM, 1995).

A.6.0 Conclusion

Extensive radiological monitoring was conducted during the detonation, gas production operations, site restoration activities, and subsequent to site restoration activities. Data indicate tritium is the only radionuclide of concern for the surface/shallow subsurface of the Gasbuggy Site. Sampling and analysis detected tritium in several soil and vegetation samples. No radionuclides other than tritium and naturally occurring radioisotopes were found in samples taken during the 1978 Gasbuggy restoration effort.

A.7.0 References

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Appendix B

New Mexico Quality Assurance Project Plan

(This quality assurance project plan is applicable to all
U.S. Department of Energy, National Nuclear Security Administration Nevada Operations Office
sites in the state of New Mexico.)

B.1.0 Introduction

This Quality Assurance Project Plan (QAPP) is a planning document used for the Offsites Project New Mexico Sites by the NNSA/NV Environmental Restoration Project (NV ERP). The NV ERP conducts environmental investigation and remediation activities at sites under the oversight of the NNSA/NV. It is the policy of the NV ERP to conduct all environmental restoration activities in a manner that produces data of a known quality. Safety is integrated into management and work practices at all levels so that missions are accomplished while protecting the public, the worker, and the environment.

The information provided in this QAPP describes policies, organization, responsibilities, and objectives of the New Mexico Sites and is intended to provide a consistent framework for the collection, evaluation, analysis, and use of data. This QAPP provides for the evaluation of risks associated with the activities to be performed and uses the graded approach to determine the required level of quality assurance. This document supplements, and is to be used in conjunction with, project planning documents which will contain QA/QC requirements appropriate for the site and activities being performed. Attachment 1 of this QAPP delineates the quality criteria that should be addressed in site-specific planning documents. In the event that project objectives or regulatory jurisdiction change, this document will be reevaluated for adequacy.

The requirements of this QAPP are consistent with those provided in DOE Order 414.1A, *Quality Assurance* (DOE, 1999). The NV ERP activities shall also be in compliance with DOE Order 440.1A, *Worker Protection Management for DOE Federal and Contractor Employees* (DOE, 1998), and DOE Order 450.4, *Safety Management System Policy* (DOE, 1996b). Work at hazardous waste sites shall be conducted in accordance with the applicable sections of 29 *Code of Federal Regulations* (CFR) 1910.120, *Hazardous Waste Operations and Emergency Response* (CFR, 1998b), and in accordance with *New Mexico Administrative Code* regulations for the disposal of hazardous waste.

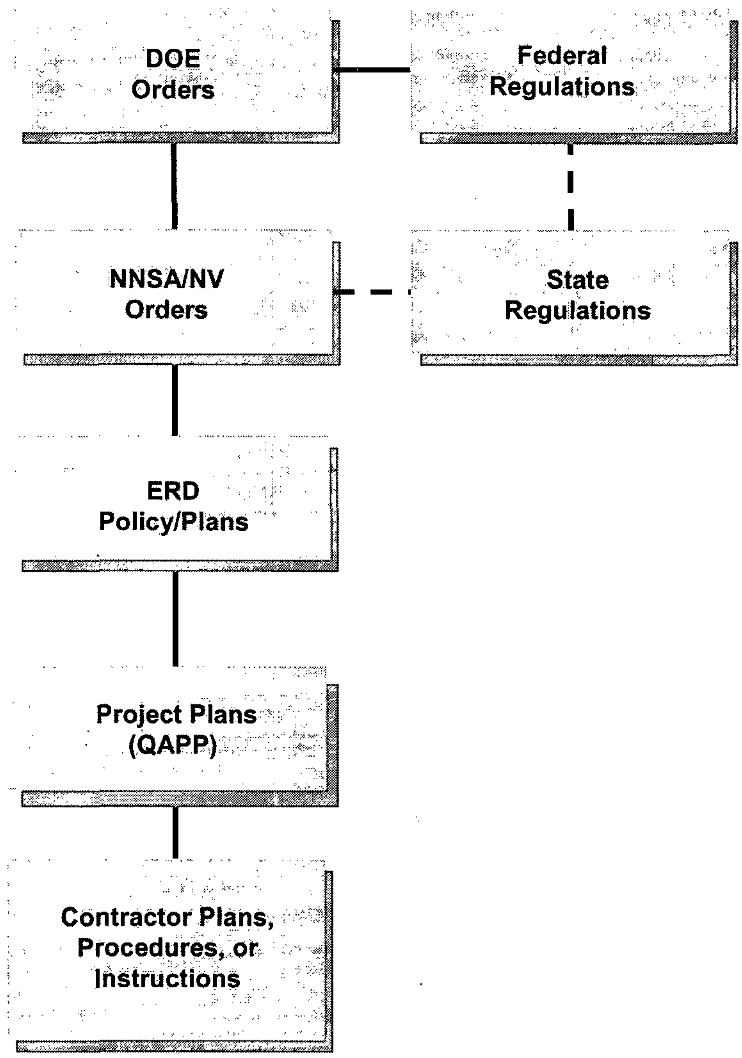
Work at the New Mexico Sites will be conducted in accordance with the applicable *New Mexico Administrative Code* regulations and New Mexico Statutes. Should radioactive waste be generated, it shall be handled and disposed of in accordance with 10 CFR Part 71, Subpart H, *Packaging and*

Transportation of Radioactive Materials - Quality Assurance (CFR, 1998a), and Nevada Test Site Waste Acceptance Criteria (NTSWAC) (DOE/NV, 2000). Sites that conduct activities or operations that involve radioactive and/or fissionable materials in such form and quantity that a nuclear hazard potentially exists shall also comply with the relevant parts of 10 CFR 830.120, *Quality Assurance Requirements* (CFR, 1996).

Figure B.1-1 delineates the hierarchy of documents for NV ERP activities.

QAPP Organization

The organization of this plan reflects the criteria of DOE Order 414.1A, *Quality Assurance* (DOE, 1999). The ten criteria therein covers three major areas: management, performance, and assessments. Management entails the planning and preparation required for the successful completion of the New Mexico Sites mission. Additionally, this section incorporates quality improvement processes to enable personnel to detect and prevent quality problems. The performance section establishes the requirements and procedures to be implemented to ensure that newly collected environmental data are valid, that uses of existing data are appropriate, and that methods of environmental modeling are reliable. Assessments provide a feedback loop to Offsites Project management whereby the feedback information can be used to evaluate and, if necessary, modify a system or process to ensure the quality of the product.



Key
DOE = U.S. Department of Energy
ERD = Environmental Restoration Division
NNSA/NV = U.S. Department of Energy, National Nuclear Security Administration Nevada Operations Office
QAPP = Quality Assurance Project Plan

Figure B.1-1
Hierarchy of Documents

B.2.0 Criteria 1 - Quality Program

The management systems for the New Mexico Sites encompass the planning and preparation necessary to ensure the successful completion of identified objectives. This QAPP has been prepared to provide the planning and control necessary for effective and efficient work processes. This document provides the overall QA Program requirements and the general quality practices to be applied to activities at the New Mexico Sites. Policy is established, roles and responsibilities are defined, lines of communication are identified, the needs and objectives of the Project are confirmed, and reviews are conducted to ensure (to the extent possible) that all necessary planning and preparation activities have taken place. Low-level radioactive and mixed waste managed under the NV ERP must also meet the requirements of the NTSWAC and the IT Corporation, Las Vegas (ITLV) waste certification program plan. The following sections describe the quality management systems to be employed for the effective management of the New Mexico Sites.

B.2.1 Quality Management Policy

It is the policy of the NV ERP to provide environmental management that incorporates applicable regulatory requirements. The Quality Management Program described in this document should be implemented for all New Mexico Sites environmental activities to ensure that work is performed in an efficient, controlled manner, and is appropriately documented. Project requirements should be applied on a graded approach, commensurate with the risk of failure of the items or processes and the potential harm those risks pose for human health and the environment. Activities shall conform with applicable federal, state, and local regulations, and contract requirements. Quality will be part of the normal course of work and incorporated from the earliest planning stages to completion of the work.

B.2.2 Project Organization

The NNSA/NV Environmental Restoration Division (ERD) is responsible for the administration of the NV ERP. The NV ERP is a major project under the DOE Office of Environmental Management, Southwestern Area Programs. Personnel from the ERD are assigned project management and technical support responsibilities. All NV ERP Project Managers are responsible for achieving quality within the specific projects they manage. The NNSA/NV ERD organization chart is provided in Figure B.2-1.

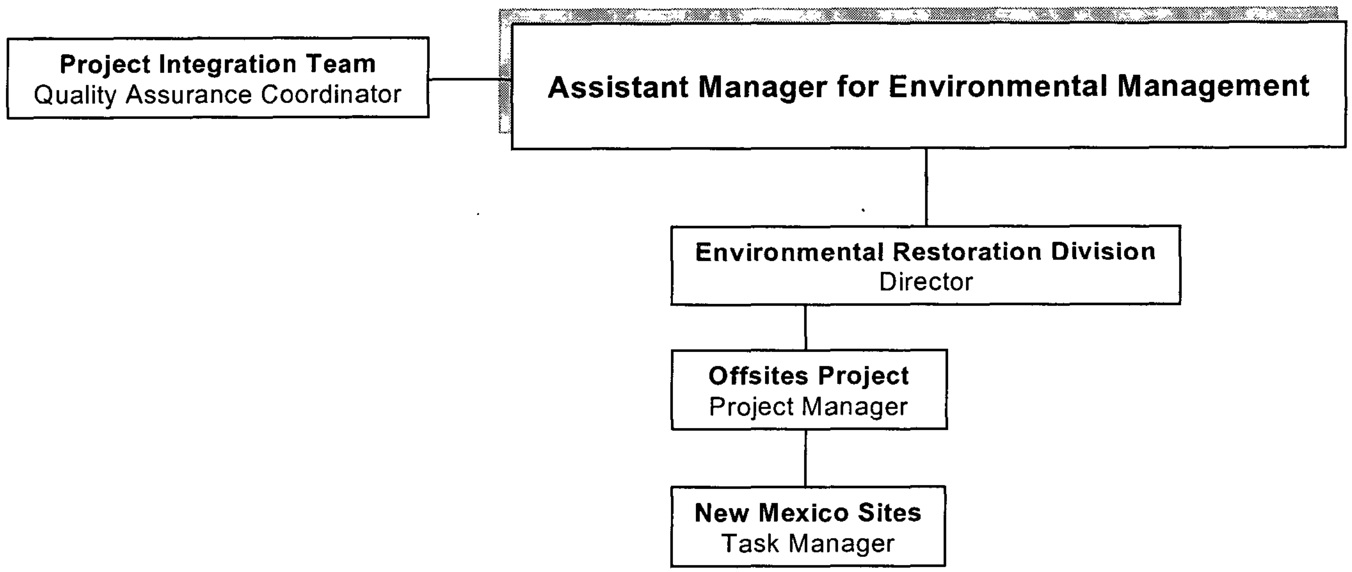


Figure B.2-1
NNSA/NV ERD Organizational Chart

Roles and responsibilities for NV ERP personnel and supporting contractors and organizations (referred to as Project participants) are described in the following sections.

B.2.3 NNSA/NV ERD Director

The NNSA/NV ERD Director has oversight and management responsibilities for all projects under the NV ERP and is responsible for the scope and implementation of the QA Program defined in this document. The Director is the senior management official responsible for ensuring that this QAPP is established, that quality requirements are implemented, and that opportunities for improvement are identified and incorporated.

B.2.3.1 NV ERP Project Manager

The NV ERP Project Manager reports directly to and is the prime point-of-contact with the NNSA/NV ERD Director. The NV ERP Project Manager has day-to-day management responsibilities for technical, financial, and scheduling aspects of his/her assigned project and shall monitor contractor performance of project activities. At a minimum, the NNSA/NV Project Manager is responsible for the following duties:

- Review, approve, and direct the implementation of NV ERP project-specific plans.
- Disseminate pertinent information from NNSA/NV to NV ERP participants.
- Review and approve changes to NV ERP project-specific documents.
- Monitor the activities of participating organizations and provide direction and guidance for improvement.
- Verify Project participants are adequately executing the responsibilities as delineated in this section.
- Notify and apprise the NNSA/NV ERD Director and NNSA/NV ERP Quality Assurance Coordinator (QAC) of significant conditions adverse to quality.
- Act as the point-of-contact for state regulator for all aspects of the project.

B.2.3.1.1 NV ERP Task Manager

The NV ERP Task Managers report directly to their respective NV ERP Project Managers. The Task Managers have day-to-day management responsibilities for technical and scheduling aspects of the assigned project task and shall monitor contractor performance of task activities. At a minimum, the Task Managers are responsible for the following duties:

- Ensure effective communication among contractors performing work for their assigned tasks.
- Participate in the organization and planning of activities.
- Perform periodic assessments (such as surveillances) of activities under their purview.
- Monitor the activities of participating organizations and provide direction and guidance for improvement.
- Notify the responsible NV ERP Project Manager and other involved personnel of significant conditions adverse to quality.

B.2.3.1.2 NV ERP Quality Assurance Coordinator

The NV ERP QAC has a direct line of communication with the NNSA/NV ERD Director and the NV ERP Project Managers. The NV ERP QAC will provide the overall direction of the QA function. At a minimum, the NV ERP QAC shall have the following duties:

- Identify and respond to QA/QC needs of the NV ERP and provide QA/QC guidance or assistance to individual Project Managers and Task Managers.
- Verify that systems are in place to evaluate data against analytical quality criteria.
- Verify that appropriate corrective actions are taken for nonconforming conditions.
- Notify the NNSA/NV ERD Director, the individual NV ERP Project Managers, and other involved personnel, of significant conditions adverse to quality or any adverse trends.

B.2.3.2 New Mexico Sites Project Participants

Project participants, such as supporting contractors and organizations, are responsible for developing the necessary procedures for their assigned scope of work and ensuring that work is performed in accordance with applicable federal, state, and local regulations, and approved NV ERP project plans and procedures consistent with individual contracts and agency agreements. To fulfill responsibilities specific to QA, participants shall, at a minimum, be responsible for the following:

- Report to the NV ERP Project Managers or NV ERP Task Managers concerning scope, schedules, costs, technical execution, and quality achievement of task order activities.
- Ensure the proper resources are provided for QA activities and that QA activities are integrated into project activities.
- Evaluate activities to ensure that planning document requirements are implemented.
- Implement applicable procedures and instructions that govern NV ERP activities.
- Verify that work is technically sound, of acceptable quality, and is consistent with project objectives.
- Ensure personnel are trained and qualified to achieve initial proficiency, maintain proficiency, and adapt to changes in technology, methods, or job responsibilities.
- Perform assessments, as applicable, to verify compliance with applicable requirements.
- Identify deficient areas and implement effective corrective action for quality problems.
- Notify the NV ERP Project Managers, the NV ERP Task Managers, and other involved personnel of significant conditions adverse to quality or any adverse trends.
- Verify that appropriate corrective actions are taken for nonconformances.

B.2.3.3 Analytical Laboratories

Analytical laboratories used to support the NV ERP are responsible for ensuring that samples are received, handled, stored, and analyzed according to the analytical laboratory's QA program and contract requirements. Analytical laboratories performing data analysis shall participate in Performance Evaluation Sample Programs appropriate for analyses performed and be subject to periodic audits. Subcontracted analytical services are subject to the same requirements. Verification of subcontractor conformance is the responsibility of the contracting organization.

B.2.4 Planning

The NV ERP and participant personnel responsible for oversight of data collection operations should verify that the data-collection system design is defined, controlled, verified, and documented. All planning shall incorporate the principles of Integrated Safety Management to mitigate hazards to workers, the public, and the environment. A graded approach to data quality requirements shall be used to meet the sampling objectives and data needs of a given site and the dynamic nature of the program. Work assignments should be clearly communicated with lines of communication established among all participants. Organizations assigned lead responsibilities shall coordinate project planning with decision makers and participating organizations.

B.2.4.1 Task Initiation

A project kickoff meeting should be conducted at the beginning of each task. This meeting should brief key personnel assigned to the task on the purpose of the task, the expected outcome, the schedule for the task, and personnel responsibilities for completion of the effort. The responsible manager should monitor the planning process to ensure communication of status, to assess progress, and to implement any corrective action needed to achieve timely completion.

B.2.4.2 Data Quality Objectives

When appropriate, planning and scoping for environmental data/information needs will include the use of the DQO process to determine the type, quantity, and quality of the data to be collected and the appropriate use of such data. Participants in the DQO process for each operation should include representatives of all data users and decision makers involved with that operation. The DQO process provides a systematic procedure for defining the criteria that a data collection design should satisfy. The appropriate NNSA/NV ERD personnel, NV ERP participants, and state regulators will jointly establish DQOs for each site, or group of similar sites, to allow the work to be planned in a manner that will ensure data will meet the needs of the end users. Representatives from these organizations should include data users and decision makers.

The most current version of EPA QA/G-4, *Guidance for the Data Quality Objectives Process* (EPA, 1994a), or an equivalent approach that incorporates the applicable elements of QA/G-4, should be used to develop DQOs. The DQO process should:

- Clarify the study objective.
- Define the most appropriate type of data to collect.
- Determine the most appropriate conditions from which to collect the data.
- Specify tolerable limits on decision errors which will be used as the basis for establishing the quantity and quality of data needed to support the decision.

Results of the DQO process shall be documented and project participants shall use the DQOs to develop a scientific and resource-effective data collection design.

B.2.5 Quality Indicators

Data quality indicator goals are qualitative and quantitative statements that specify the data requirements for the project. Sample analytical data goals are based on the intended use of the data, current field procedures, instrumentation, and available resources. Quality indicator goals are established during the site-specific DQO process to properly support the overall project or sampling task objectives. An evaluation of the quality indicators shall be performed during the assessment of data to determine if the goals set during the DQO process have been accomplished. Indicators of data quality as they relate to data collection and laboratory analysis include precision, accuracy, representativeness, completeness, and comparability.

B.2.5.1 Precision

Precision measures the reproducibility of data under a given set of conditions. Specifically, precision is a quantitative measurement of the variability of a population of measurements compared to their average value. Precision for inorganic analyses shall be assessed by collecting, preparing, and analyzing duplicate field samples and by creating, preparing, and analyzing laboratory duplicates from one or more field samples. Precision for organic analyses shall be assessed by collecting, preparing, and analyzing matrix spike (MS) and matrix spike duplicate (MSD) samples. Precision will be reported as relative percent difference (RPD). The RPD is calculated as the difference between the measured concentrations of Sample 1 and Sample 2, divided by the average of the two concentrations, and multiplied by 100. If the RPD exceeds predetermined limits for a given parameter, the data shall be evaluated for usability based on the purpose for the data and reasons for the increased RPD. This evaluation must be documented.

B.2.5.2 Accuracy

Analytical accuracy is defined as the nearness of a measurement to the true or accepted reference value. It is the composite of the random and systematic components of the measurement system and measures bias in a measurement system. Accuracy measurements for spike samples and laboratory control samples shall be calculated as percent recovery, which is calculated by dividing the measured sample concentration by the true concentration and multiplying the quotient by 100. The percent recovery shall be within the limits defined in site-specific plans. Values exceeding the acceptance criteria, established during the site-specific DQO process, must be evaluated for corrective actions.

Field accuracy is assessed by confirming that the documents of record track the sample from origin, through transfer of custody, to disposal. The goal of field accuracy is for all samples to be collected from the correct locations, at the correct time, placed in a correctly labeled container with the correct preservative, and sealed with custody tape to prevent tampering.

B.2.5.3 Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a sample population, a parameter variation at a sampling point, a process condition, or an environmental condition (EPA, 1998). Representativeness depends on the proper design and execution of a sampling program and it will be achieved through careful selection of sampling intervals and locations as well as analytical parameters and the correct collection methods.

The number of samples collected must be sufficient to demonstrate that the data represent the population of interest to the statistical certainty required by the DQOs. Collection, storage, handling, and transport of samples should be performed in a manner that preserves the *in situ* characteristics of the samples and maintains the representativeness of the sample to the site.

B.2.5.4 Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under correct, normal conditions (EPA, 1998). Completeness is affected by unexpected conditions that may occur during the data collection process. The number of samples prescribed for an activity must be sufficient to meet data requirements identified in the DQO process and must consider typical loss of data caused by handling, shipping, and analytical processes.

B.2.5.5 Comparability

Comparability is a measure of the confidence with which one dataset or method can be compared with another (EPA, 1998). Comparability is achieved by using standard techniques and procedures (e.g., standard operating procedures) to collect and analyze representative samples and by reporting analytical results in appropriate units. Comparability is limited by the other quality indicators because only when precision and accuracy are known can datasets be compared with confidence.

B.2.6 Reports to Management

Contractor management and NV ERP Project Managers shall be made aware of project activities and shall participate in the development, review, and operation of these activities. Management shall be informed of quality-related activities through the receipt, review, and/or approval of:

- Project-specific plans and procedures
- Assessment reports
- Corrective action requests, corrective actions, and schedules
- Nonconformance reports (NCR)

Individuals identifying nonconforming conditions or deficiencies are responsible for documenting and reporting said conditions. All nonconformances and findings related to quality shall be corrected as required, documented, and properly reported. In addition, periodic assessment of QA/QC activities and data quality parameters shall be evaluated and reported to the participating project field and laboratory management.

B.2.7 Readiness Reviews

Readiness reviews shall verify that all planning documents and processes are in place for the successful and efficient accomplishment of the mission. The readiness review includes verification that personnel are qualified and knowledgeable in the activities they are assigned to perform.

Readiness reviews shall be performed by participating organizations prior to the start of any major scheduled activity and prior to restarting work (following stop work orders) to verify and document that project planning and prerequisites have been satisfactorily completed. At a minimum, readiness reviews shall verify that the following issues have been addressed:

- The scope of work is compatible with project objectives.
- The planned work is appropriate to meet objectives.
- Work instructions have been reviewed for adequacy and appropriateness, formally approved, and issued to personnel who will be performing the work.
- Hazards have been identified, analyzed, categorized, and controls implemented.
- Proper resources (e.g., personnel, equipment, and materials) have been identified and are available.
- Assigned personnel have read the applicable work instructions and have been trained and qualified.
- Internal and external interfaces have been defined.
- Proper work authorizations and permits have been obtained.
- The calibration of all material and test equipment is current.
- A feedback mechanism has been established to facilitate process improvement.

B.3.0 Criteria 2 - Personnel Training and Qualifications

The NV ERP and project participant management shall ensure that personnel are qualified and knowledgeable in the activities they perform. Training should emphasize correct performance of assigned work and provide an understanding of quality requirements. Personnel qualification and training records shall be maintained as quality documents in accordance with DOE Order 414.1A, *Quality Assurance* (DOE, 1999).

B.3.1 Project Personnel

Personnel shall be trained and qualified to perform the tasks to which they are assigned. Objective evidence of qualifications may include academic credentials, personal resumes, registrations and/or certifications, licenses, and training records. The qualifications of personnel shall be evaluated against assigned responsibilities and any identified training needs must be addressed.

Training should be provided to achieve and maintain proficiency; adapt to changes in technology, methods, or job description; and allow for feedback and effectiveness of job performance. Training may take the form of orientation and/or indoctrination, formal classroom training, or on-the-job training. This training should include regulatory requirements, scopes of work, QA/QC requirements, and applicable work instructions.

Any required on-the-job training should be conducted and documented by personnel experienced in the task being performed in accordance with each organization's requirements. Any work performed by a trainee should be under the supervision of an experienced individual. Trainees should demonstrate capability prior to performing work independently.

B.3.2 Subcontractor Personnel

Subcontractor personnel shall be qualified and trained to perform the duties for which they were contracted. The contracting organization shall be responsible for verifying the qualifications of their subcontractors.

B.4.0 Criteria 3 - Quality Improvement

An objective of the New Mexico Sites activities is to produce quality products and to continuously seek methods to improve both processes and products. Processes shall be established with the objective of preventing problems and improving quality. Peer reviews of various work products should be built into the work processes to ensure the quality of the products prior to release. All personnel are encouraged to identify and suggest improvements in all areas of work performed for the New Mexico Sites.

Management shall seek to cultivate an atmosphere which fosters the belief that improvement is always possible, and accountability and excellence must be established at all levels. It is equally important to identify and implement process improvements and efficiencies. Successful techniques should be evaluated to determine the potential for performance improvements in other areas or projects. The following sections identify processes that, at a minimum, shall be implemented.

B.4.1 Internal Quality Control Checks

Quality control checks shall be performed for data collected in the field and data obtained through on-site and/or off-site analysis. Information shall be reviewed by someone other than the originator to ensure correct collection, transcription, and manipulation. Transcribed data shall be verified to ensure the correctness of the transcription. Data that has been manipulated shall be checked to ensure the manipulation process was performed as the originator intended.

Proprietary computer applications used for the evaluation of historical data maintained or transferred via electronic media shall have QC checks performed that are appropriate to the application being used. These checks must be documented and maintained in accessible files.

Field sampling and laboratory analytical activities shall incorporate QC procedures. All field and laboratory operations and systems shall be evaluated for their potential to impact the quality of generated data. System quality controls that meet the requirements of this QAPP shall be established and documented through the use of approved procedures, plans, or instructions.

The QC samples shall be incorporated into the analytical stream to assess the overall data quality produced by the program. The QC samples consist of field- and laboratory-generated samples which are used to evaluate sampling and analytical precision and accuracy as well as the levels of potential contamination introduced by the sampling and analytical effort. The following paragraphs describe the QC samples that will be generated.

B.4.1.1 Field Quality Control

The field data collection QC program is designed to provide confidence that data collected during field activities adequately represents the area of interest. For sampling activities, field QC samples provide a mechanism for assessing and documenting that the collection process meets the QA objectives of the project. The number and type of field QC samples required shall be determined during the planning process for each site. Field QC samples include, as applicable, trip blanks, equipment rinsate blanks, source blanks, field blanks, and field duplicates. Field QC samples shall be submitted to the laboratory in such a manner that the laboratory is not aware that the sample is for QC purposes. Collection and documentation of field QC samples shall be in accordance with approved procedures and site-specific plans. Other types of data collected, such as observational data and measurements, shall have the appropriate quality control checks applied to ensure the information collected is of a quality that meets the objectives of the activity.

B.4.1.1.1 Equipment Rinsate Blank Samples

An equipment rinsate blank is collected from the final rinse solution from the equipment decontamination process to determine the effectiveness of the decontamination process. The blanks shall be prepared by pouring deionized water through or over a sampling device after it has been decontaminated and prior to using the device for environmental sample collection. Care shall be taken to ensure that each part of the sample device which comes in contact with the sample is included in the rinse. If equipment rinsate blank analytical results indicate possible contamination of samples, environmental sample results shall be reviewed to determine whether qualifiers should be assigned to the data or whether the source should be resampled. Results of rinsate blank analyses shall be maintained with the corresponding sample analytical data in the laboratory records file and reported in the laboratory data package. One equipment rinsate blank sample shall be collected for each method of equipment decontamination employed. Equipment rinsate blanks shall be analyzed for the same analytical suite as the samples being collected.

B.4.1.1.2 Field Blank Samples

Field blanks are collected and analyzed by the laboratory to determine if contamination in the air during sample collection and packaging may have contaminated the samples. The field blanks are prepared by pouring deionized water or solid material that is certified to be without the contaminants of concern into clean sample containers in the field near the sampling locations, or by exposing a clean swipe to the same ambient conditions as those present during sampling. Field blanks should be collected as closely in time and space to the environmental sample as possible. If field blank analytical results indicate possible contamination of associated samples, environmental sample results shall be reviewed to determine whether qualifiers should be assigned to the data or whether the source should be resampled. One field blank is collected for each 20 samples collected. Field blanks shall be analyzed for the same analytical suite as the samples being collected.

B.4.1.1.3 Trip Blank Samples

A trip blank is a 40-milliliter volatile organic analysis (VOA) container of organic-free water that is shipped to the field along with the other VOA sample containers. The blank is not opened, but is otherwise maintained, handled, stored, packaged, and shipped as if it were collected in the field. The purpose of the trip blank is to determine if contaminants have entered the sample through diffusion across the Teflon™-faced, silicone rubber septum of the sample vial during the performance of laboratory, field, or shipping procedures. The trip blank is only analyzed for volatile organic constituents. Trip blanks shall be submitted for analysis at a frequency of one sample per shipping container that contains field VOA samples. If trip blank analytical results indicate possible contamination, environmental sample results shall be reviewed to determine whether qualifiers should be assigned to the data.

Following the analyses, if the trip blanks indicate possible contamination of the samples, the appropriate project personnel shall be notified. Results of trip blank analyses shall be maintained with the corresponding sample analytical data in the laboratory records file and reported in the laboratory data package.

B.4.1.1.4 Duplicate Samples

Field duplicates are QC samples that are collected as closely in time and space to the environmental sample as possible to assess sample variability and to measure sampling and analytical variability. Collection of the required number of duplicates shall be evenly distributed throughout the sampling activity. One duplicate shall be collected for each 20 samples collected. The field duplicates shall mirror the sampling and analytical profile of the original sample and be assigned a unique sample number. The duplicate sample number shall not indicate that it is a QC sample to minimize handling, analysis, and data evaluation bias. Parameters to be analyzed shall be the same as those analyzed for the corresponding environmental samples. Sample management and documentation procedures for duplicates shall be the same as those used for environmental samples. When the RPD results between the environmental sample and its duplicate are outside control limits, environmental results will be reviewed to determine whether qualifiers should be assigned to the data.

B.4.1.1.5 Source Blanks

A minimum of one source blank shall be collected from each source of water used for project activities to include decontamination. Source blanks shall be analyzed for the same parameters as the original samples. Source blanks shall be collected as close to the source as practical, but may be collected from on-site storage containers.

B.4.1.2 Analytical Laboratory Quality Control

All on-site and off-site analytical laboratories performing analyses for the New Mexico Sites shall conduct their activities in accordance with a written and approved QA plan. Laboratory quality control (LQC) samples shall be analyzed using the same analytical procedures used to analyze environmental samples. Each analytical laboratory shall generate QC samples during each analytical run to assess and document accuracy and precision associated with each analytical measurement in accordance with the laboratory QA plan. All data from concurrently analyzed LQC samples and other quality controls which are used to demonstrate analytical control shall be included in the laboratory's analytical report. The requirements for the types and number of LQC samples will depend on the analytical procedure or method and the laboratory's QA objective for each test.

Laboratory quality control samples include Laboratory Control Samples (LCS), method blanks, surrogate-spike, and MS/MSD samples.

B.4.1.2.1 Laboratory Control Samples

One LCS shall be prepared and analyzed with each batch of samples per matrix. The LCS shall be carried throughout the sample preparation and analysis procedures to assess laboratory accuracy and precision. The LCS shall be analyzed concurrently with each analytical batch for each analyte of interest and shall be prepared from standards independent of the calibration standard. Control limits for recovery shall be established, and recovery data shall be plotted on internal control charts. The LCS data outside these recovery limits shall be considered "out of control," and the laboratory shall initiate corrective action(s) that shall be performed in accordance with the laboratory's QA plan. Results of duplicate LCS analyses shall be reported as RPD and percent recovery and included with the associated analytical report. When LCS percent recovery is outside the control limits, environmental sample results will be reviewed to determine whether qualifiers should be assigned to the data.

B.4.1.2.2 Method Blank Samples

Method blanks shall be analyzed by the laboratory to check for instrument contamination and contamination and interference from reagents used in the analytical method. A method blank shall be concurrently prepared and analyzed for each analyte of interest for each analytical batch. Method blank data outside statistical control limits shall be considered "out of control," and corrective action(s) shall be performed in accordance with the laboratory's QA plan. Method blank data shall be reported in the same units as the corresponding environmental samples, and the results shall be included with each analytical report.

B.4.1.2.3 Surrogate-Spike Samples

Surrogate-spike sample analysis shall be performed for all samples analyzed by gas chromatography (GC), gas chromatography/mass spectrometry (GC/MS), and High Performance Liquid Chromatography (HPLC) to monitor laboratory performance and analytical procedures on a sample-by-sample basis. Surrogate standards are nontarget compounds added to GC, GC/MS, and HPLC standards, blanks, and samples prior to extraction or purging. Surrogate compounds are compounds that are not expected to be present in the associated environmental samples but behave similar to target compounds chromatographically. Surrogate compounds and concentrations added shall be those specified in the applicable analytical method. Recovery values for surrogate compounds shall be within the control limits specified by the laboratory and in accordance with assessment procedures in the laboratory's QA plan, or the analysis shall be repeated. Results of surrogate-spike sample analyses shall be reported as percent recovery. When surrogate percent recovery is outside the control limits, environmental sample results will be reviewed to determine whether qualifiers should be assigned to the data.

B.4.1.2.4 Matrix-Spike/Matrix-Spike Duplicate Samples

Project site-specific MS/MSD samples shall be analyzed by the laboratory to determine interferences of the sample matrix on the analytical methods and subsample variance of the laboratory data. A separate sample aliquot shall be spiked with the analytes of interest and analyzed with every 20 samples per matrix or, if fewer than 20 samples were collected, at least one of the samples shall be spiked. Results of the MS/MSD analyses shall be reported as percent recovery and RPD and included with the analytical report. Results that are outside the established recovery or reproducibility limits for the analytical method shall be considered "out of control," and the laboratory shall initiate corrective action(s) that shall be performed in accordance with the laboratory's QA plan. When the RPD results between the MS and MSD samples are outside control limits, environmental results will be reviewed to determine whether qualifiers should be assigned to the data. The MS/MSD samples shall not be collected for radiochemical analysis.

B.4.1.2.5 Laboratory Duplicate Samples

Two aliquots of the same sample per matrix shall be prepared and analyzed for inorganic analysis, and the duplicate results will be used to calculate the precision as defined by the RPD. If the precision value exceeds the control limit, the appropriate laboratory personnel will identify the root cause of the nonconformance and implement corrective actions. A laboratory duplicate analysis shall be performed with every 20 samples. When the RPD results between the environmental sample and its lab duplicate are outside control limits, environmental results will be reviewed to determine whether qualifiers should be assigned to the data.

B.4.1.3 On-Site Radiological Laboratory Quality Control

On-site radiological laboratory analysis may be performed for direct counting of soils by gamma spectral analysis. Any on-site laboratory analysis shall be performed in accordance with written, approved work instructions by trained personnel using properly calibrated equipment. Gamma spectroscopy requires physical preparation of the sample and direct counting. QC checks required shall verify the accuracy and precision of the counting system. A National Institute for Standards and Technology (NIST)-traceable mixed gamma standard shall be used.

B.4.1.3.1 Instrument Control Samples

An instrument control sample shall be analyzed with each batch of samples. The control sample shall be carried through the analysis procedures to assess laboratory accuracy and precision. Control limits for recovery shall be established, and recovery data shall be plotted on internal control charts.

B.4.1.3.2 Blank Samples

Blanks shall be analyzed to check for instrument and container contamination. A method blank shall be concurrently prepared and analyzed for each analytical batch. A minimum of one method blank shall be analyzed with each 20 samples.

B.4.1.3.3 Duplicate Samples

Duplicate results will be obtained and used to calculate precision. One in 20 samples shall be counted twice to provide precision data.

B.4.2 Data Precision, Accuracy, and Completeness

Quality control sample results are used to evaluate laboratory and field precision and accuracy. Precision shall be determined by comparing the concentrations of the various constituents between duplicate analyses. Accuracy shall be determined by comparing analytical results with the known (true) value of a reference standard (i.e., a laboratory control sample). The analytical accuracy for the spiked samples must be within the accepted accuracy of the method of analysis for the analyte of interest. Sample results falling outside of acceptable ranges for precision and accuracy shall be brought to the attention of laboratory management for evaluation and corrective action(s), as needed.

Completeness shall be determined by comparing the amount of valid data obtained from a measurement system to the amount that was expected to be obtained. Data precision, accuracy, and completeness requirements shall be dependant on the end use of the data and determined during the DQO process for each site.

Laboratory results shall be checked upon receipt. If there appears to be an error in the analysis, the laboratory shall be contacted immediately, and corrective action(s) must be taken. If investigation reveals that processes were not in control, corrective action(s) shall be taken, and the resulting data evaluated to determine any impacts.

B.4.3 Corrective Action

This section establishes the methods and responsibilities for identifying, reporting, controlling, and resolving conditions of nonconformance and conditions adverse to quality for activities performed in support of the New Mexico Sites work.

B.4.3.1 Nonconformance

A nonconformance is a deficiency in characteristic, documentation, or procedure that renders the quality of an item or activity as unacceptable, or indeterminate. The NV ERP policy encourages all personnel to identify and document nonconforming items and processes. It is also NV ERP policy to identify nonconformances in a manner that focuses on solutions and discourages fault-finding to encourage the open identification and resolution of problems. Individuals identifying nonconforming conditions or items are responsible for documenting and reporting the nonconformance. Responsible personnel should be notified at the time the nonconformance is identified so that, when possible, corrective measures may be taken immediately.

All NCRs shall be handled in accordance with each organization's internal processes. An NCR shall specify:

- Originator
- Date of the nonconformance
- NCR number (unique)
- Responsible organization
- Requirement(s)

- Nature of the nonconformance
- Disposition
- Technical justification for disposition

When an NCR affects cost, schedule, scope, or is a health and safety issue, the applicable NV ERP Project Manager and the NV ERP QAC and Health and Safety Representatives must be notified.

B.4.3.2 Cause Analysis

A root cause is the most basic element that, if corrected, will prevent recurrence of the same (or similar) problem. Cause analysis should be used where the understanding of the basic underlying cause is important to the prevention of similar or related problems. The cause analysis should be used to gain an understanding of the deficiency, its causes, and the necessary corrective actions to prevent recurrence. The level of effort expended should be based on the possible negative consequences of a repeat occurrence of a problem. The term "root cause" is used generally and does not require the use of highly sophisticated methods such as is used for accidents.

B.4.3.3 Trend Analysis

Trend analyses should be performed on nonconforming conditions, deficiencies, root causes, and the results of improvement initiatives to identify any possible trends. Adverse trends shall be brought to the attention of the appropriate management. Positive trends, such as improved performance or cost savings resulting from enhancements or the application of new technology, should be shared to facilitate improvement in other areas or projects. As appropriate, information obtained from trend analyses should be included in a Lessons Learned system.

B.4.3.4 Lessons Learned

A Lessons Learned system has been established at NNSA/NV as a focal point for reporting and retrieving important information concerning experiences gained through previous activities. Improvement can be fostered through incorporation of applicable Lessons Learned into work processes and project planning activities, including work plan development, budget development, and strategic planning. The Lessons Learned program should be used interactively with other management tools such as critiques, assessments, readiness reviews, and evaluations of field activities.

B.5.0 Criteria 4 - Documents and Records

The New Mexico Sites shall have planning documents, as deemed necessary, for the work to be performed. Contractors may determine that additional procedures are necessary to further define the responsibilities and activities of specific scopes of work. Figure B.1-1 is a flowchart of the guidance documents.

B.5.1 Documents and Records

Systems and controls shall be implemented by project participants for identifying, preparing, reviewing, approving, revising, collecting, indexing, filing, storing, maintaining, retrieving, distributing, and disposing of pertinent quality documentation and records.

B.5.1.1 Document Review and Control

Plans and reports shall be reviewed for quality requirements, technical adequacy, completeness, and accuracy prior to their approval and issuance. The NV ERP documents shall be reviewed in accordance with the NNSA/NV procedure AMEM-02-002, *Document Review and Coordination* (DOE/NV, 1999).

A system or process for identifying documents that require control and controlling those documents shall be implemented to ensure that the latest revision of a document is used. The New Mexico Sites management is responsible for ensuring that personnel who perform work are in possession of the most current version of the documents applicable to the activities being conducted.

Revisions to controlled documents shall be approved by the same level of authority or organization as the original. Documents no longer in use should have their status clearly indicated, and record copies should be maintained in accordance with DOE Order 200.1, *Information Management Program* (DOE, 1996a).

B.5.1.2 Change Control

Changes or modifications to approved procedures or plans may be necessary to adjust an activity to actual field conditions or to revise programmatic methods of implementing project requirements.

New Mexico Sites participants shall ensure that changes are properly identified, documented, approved, and controlled in accordance with the individual procedures of each participant organization. Verbal authorization of changes are permitted but must be documented and followed up with a written change notice in a timely manner. Changes shall be approved commensurate with the original document prior to implementation of the change. Changes to the SSHASP shall be in accordance with the participants applicable procedures. The NNSA/NV Project Manager shall be notified of changes that impact the technical scope, cost, or schedule of the project.

B.5.1.3 Records Maintenance

Sufficient records of New Mexico Sites activities shall be prepared, reviewed, and maintained. Project records shall be maintained in accordance with DOE Order 200.1 (DOE, 1996a), *Information Management Program*. Contractors and other agency participants shall have a system in place for the storage and retrieval of quality records that is consistent with environmental regulations and DOE Order 200.1 (DOE, 1996a).

B.6.0 Criteria 5 - Work Processes

The performance of activities shall be based upon the objectives of the project. Details of specific, environmental, data-collection activities will be discussed in the applicable site-specific planning documents. Appropriate technical methods or a scientific rationale shall be employed. Activities shall be performed in accordance with approved procedures and site-specific plans that comply with the applicable requirements of DOE Orders, procedures, and project planning documents. Upon request, contractors and participating organizations shall supply the NNSA/NV with copies of applicable procedures. Deviations from the applicable approved project plans and procedures shall be approved and documented.

B.6.1 Evaluation and Use of Existing and New Data

Existing and new data shall be evaluated against current requirements for their intended use. This analysis consists of editing, screening, checking, auditing, verification, and review. Methods shall be in place for the control and transfer of data, control of interpretive work products, and the control of data within a database. The process should provide guidance for gathering, manipulating, and distributing data. The quality of existing data shall be determined, based on the traceability of data and the level of QA/QC applied to the data during initial collection, prior to inclusion into a central database. Reports or interpretative works shall indicate the quality of the data being used. Prior to use, newly acquired analytical data will be evaluated against predetermined objectives and criteria.

B.6.2 Computer Hardware and Software

Computer hardware/software configurations are defined as the combination of computer program software version, operating software version, and model of computer hardware. Computer software and hardware/software configurations used in the acquisition, modeling or storage of environmental data shall be installed, tested, used, maintained, controlled, and documented to meet the requirements of the user and/or data management criteria. Compatibility between software and hardware systems must be achieved for long-term retrievability. To the extent possible, contractor's and project participant's hardware and software should be compatible with that of the NV ERP.

B.6.2.1 Computer Systems

Computer hardware/software configurations for the storage and manipulation of environmental data should be tested by knowledgeable individuals prior to actual use and the results documented and maintained. Changes to hardware/software configurations should be assessed to determine the impact of the change on the technical and quality objectives of the environmental program. If any of the components are changed or modified and a new configuration results, or if program requirements change so that the capability of the hardware/software configurations to meet the new requirements is uncertain, then the configuration should be retested and redocumented.

Computer hardware/software configurations integral to measurement and testing equipment (M&TE) that are calibrated for specific uses do not require further testing unless the software uses change or the configuration is modified.

The physical media on which software is stored shall be controlled and protected so that software and data are physically retrievable and protected from loss or compromise by catastrophic events. Back-up copies shall be maintained so that a single event will not cause a significant loss of software or data.

B.6.2.2 Software Design/Development

Project participants involved in the development or use of major-use software for modeling or technical computations will develop and implement processes for the development, modification, verification/validation, and control of computer software codes. Code criteria should be clearly defined prior to development or purchase and should be consistent with applicable national standards. Software will be qualified for use, based on its ability to provide acceptable results for its intended application. The configuration of software should be controlled and documented so traceability is maintained through the developmental history. Documentation of the development or modification of software codes must include the appropriate peer reviews and verification/validation.

B.6.2.2.1 Code Evaluation

Newly developed computer codes or modifications to existing software shall be reviewed and the reviews documented by individuals who are knowledgeable in the area of code development. Reviewers should consider the following aspects:

- Assumptions are reasonable and valid
- Correctness of the mathematical model
- Conformance of methods to accepted and published concepts (recognizing that alternative methods and interpretations other than those of the evaluators may be acceptable)
- Consistency of results with known data
- Reasonable and prudent use of data and analysis tools
- Appropriateness for intended purpose

B.6.2.2.2 Code Verification/Validation

Software should be qualified for use based on its ability to provide acceptable results for the intended application. Software verification and validation activities will include provisions for providing confidence that the software adequately and correctly performs all intended functions. The extent of verification/validation required shall depend on the complexity, risk, and uniqueness of the code. Computer software code modifications shall be verified and validated according to the same requirements as the original code. Verification of changes may be limited to the scope of the modification, if the rest of the code is not affected. Acquired technical software used without modification must have operational checks performed through test cases to verify that the software is functioning as intended.

Computer applications, project participants, used for the evaluation of historical data maintained or transferred via electronic media shall have QC checks performed as appropriate to the application being used. These checks must be documented and maintained in project files.

B.6.2.2.3 Software Documentation

All developed or procured computer codes shall be uniquely identified. Computer software code documentation shall be maintained with associated calculations and reference material. Documentation will consist of software design and reference material, verification/validation records, operational test records, and user-oriented information.

B.6.2.3 Peer Review of Software and Code Applications

The peer review is an assessment of the assumptions, calculations, extrapolations, alternate interpretations, methodology, acceptance criteria, and conclusions pertaining to interpretive work products generated through use of computer software. Peer reviews shall be performed and documented to ensure that interpretive work products are technically adequate, properly documented, and satisfy established technical and quality requirements. Peer reviewers shall possess the appropriate subject matter/technical expertise and not have participated in preparing the original work. All review comments and the attendant comment responses shall be recorded on review sheets and maintained in the project files. The acceptable level of accuracy of each interpretive work product should be established by project management.

B.6.3 Field Investigation

Field activities generally involve the collection of data for the purpose of decision making. Field data acquisition shall be accomplished through the use of approved plans, procedures and/or instructions, by qualified personnel using appropriate tools and calibrated equipment. Additionally, all work shall be performed safely within the controls established to prevent/mitigate hazards. Details of specific environmental data collection activities shall be delineated in the associated project plans and instructions. Data acquisition methods for which a procedure does not exist (those that are unique, experimental, or under development) shall be detailed in the project-specific plans or instructions.

B.6.3.1 Sample Custody

Chain of custody for each field sample collected must be documented to provide the traceability of possession from the time the samples are collected until disposal. A sample is considered to be in custody if it meets any of the following criteria:

- Is in a person's actual possession
- Is in a person's unobstructed view after being in the person's physical possession
- Is in a secured area to prevent tampering after having been in the person's physical possession
- Is in a designated secured area, restricted to authorized personnel only

Sampling events shall be monitored to ensure that custody procedures and records are being properly implemented. Without exception, sample custody shall be continuously maintained for all samples collected.

B.6.3.1.1 Chain of Custody Form

Each individual who possesses a sample is responsible for sample custody until the sample is relinquished to another individual or a secure storage area via the chain of custody form. Field teams shall initiate chain-of-custody forms for samples collected during field activities in accordance with written and approved procedures and/or instruction. Whenever samples are transferred to a new sample custodian, the new custodian shall sign his or her name, the company name, and note the time and date that the transfer occurred. There shall be no gaps on the record of custody. The chain of custody form shall accompany the samples during handling and shipment, and it shall chronicle the history of custody.

B.6.3.1.2 Custody Seals

To ensure that tampering is easily detectable, each sample container shall be individually sealed with a custody seal. The seal shall be placed over or around the lid of the sample container so that the container cannot be opened without breaking the seal. Each custody seal shall be initialed and dated by the sample custodian.

B.6.3.1.3 Sample Labels and Identification

Sample labels shall contain the unique sample numbers and other sampling information. This information must be entered using indelible ink and the label securely affixed to the container. All information and data for a sample are keyed to each sample's unique number. The sample label shall contain the following required information:

- Project name
- Unique sample number
- Sampling date and time (military)
- Sample location and depth interval (if applicable)
- Sample medium
- Requested analyses
- Name of the individual collecting the sample
- Preservation or conditioning of the sample

Each sample number shall be indicated on both the container and field data/sample collection forms. For samples requiring multiple containers, the same sample identification numbers shall be required on each container. Labels that are not plastic coated and have the potential to smear or deteriorate shall be covered with clear tape.

B.6.3.1.4 Sample Handling, Preservation, Packaging, and Shipping

Proper sample handling is achieved by selecting the appropriate sample containers, preservation procedures, and holding times for specific analyses. Where applicable, sample containers shall be certified clean per EPA protocol and shall remain sealed until ready for use. Certificates of container cleanliness shall be maintained in the project files. A table of parameters and analytical methods is provided in Attachment 2.

Upon completion of sampling, labeling, and custody sealing, each sample shall be placed in a separate, sealable plastic bag; transferred to an appropriate shipping container cooled with ice 4°C (± 2°C), if required; and protected from breakage by using shock-absorbent packing material. Approved procedures must comply with Title 49 CFR, Parts 170 to 180 (CFR, 1999) for the packaging, labeling/placarding, and shipping of samples.

B.6.3.1.5 Decontamination

To prevent cross-contamination of samples, equipment coming in contact with samples shall be decontaminated prior to use, between sampling locations, and before leaving the site. Certification of cleanliness shall be obtained for disposable or precleaned sampling equipment, if they are not decontaminated by the sampling organization. Decontamination activities shall be performed and documented in accordance with the participating organization's approved written procedures.

Equipment rinsate blanks shall be submitted to the analytical laboratory to assess the effectiveness of the decontamination process. If the rinsate blank results indicate possible contamination, corrective actions shall be implemented to preclude recurrence. Sample results obtained using the suspect sampling equipment shall be reviewed to determine whether analytical qualifiers should be assigned to the data.

B.6.3.1.6 Investigation-Derived Waste

Investigation-derived waste (IDW) shall be containerized pending the results of waste characterization. To ensure compliance with DOE requirements and federal and state regulations, IDW shall be characterized and disposed of in accordance with approved plans.

B.6.3.1.7 Field Documentation

Field documentation should be of sufficient detail to facilitate the reconstruction of field activities. Field personnel shall document activities on a logbook or on the appropriate form as required by each contractor doing work for the New Mexico Sites. Documentation should be made in indelible ink and include all information applicable to the activity being performed.

Field-generated records shall be independently reviewed to verify they are complete and accurate. This review should be noted on the reviewed document with an initial and date. Records shall be preserved and maintained in accordance with Section B.5.1.3.

B.6.3.1.8 Photographic Documentation

With the approval of the NNSA/NV Project Manager, photographs may be taken during the corrective action investigation and/or corrective action activities. Photographs shall be documented on a photographic log in accordance with contractor procedures. The photographs and negatives shall be processed and stored in accordance with NNSA/NV security procedures and National Archives and Records Administration regulations.

B.6.3.2 Identification and Control of Items

The New Mexico Sites participants shall establish and document sufficient controls to ensure that quality-affecting items, such as equipment, components, and material can be readily identified. These controls shall be established to prevent incorrect use, to retain integrity of materials, and to preserve the desired operating characteristics of equipment. Controls shall be applied that are based on the risk to the project if control of the item is lost. Appropriate controls shall be applied prior to and subsequent to use. Specific requirements for preservation and packaging shall be identified in project documents.

Hazardous materials shall be properly controlled and transported in accordance with Title 49 CFR Part 171-180, *Transportation - Hazardous Materials Shipping Regulations* (CFR, 1999).

B.6.3.3 Calibration and Preventive Maintenance

The M&TE used at the New Mexico Sites shall be uniquely identified and controlled. A system of calibration and preventive maintenance shall be employed by project participants to ensure the proper operation of M&TE. Reference standards of the correct type, range, and acceptable uncertainty shall be used for collecting data consistent with the project objectives.

B.6.3.3.1 Calibration

Approved procedures or the manufacturer's recommendations shall be used to calibrate M&TE prior to use and at prescribed intervals thereafter. The frequency of calibrations (periodic or factory) shall be based on the manufacturer's recommendations, national standards of practice, equipment type and characteristics, and past experience. Operational, or in-house, calibrations and/or source-response checks shall be performed on the appropriate M&TE prior to the start of work and at prescribed intervals to verify the equipment's continued accuracy and operational function.

Equipment for which the periodic calibration period has expired, equipment that fails calibration, or equipment that becomes inoperable shall be tagged "out-of-service" and, when possible, segregated to prevent inadvertent use. Results of activities performed using equipment that is out of calibration shall be evaluated for adverse affects and the appropriate personnel notified.

Physical and chemical standards shall have certifications traceable to National Institute of Standards and Technology, EPA, or other nationally recognized agencies. Supporting documentation on all reference standards and equipment shall be maintained.

B.6.3.3.2 Preventive Maintenance

Preventive maintenance shall be performed to maintain performance and reliability, prevent equipment from failing during use, and to identify sources for repair replacement. Preventive maintenance programs shall include all sensitive equipment.

Field equipment preventive maintenance programs will provide the following as applicable:

- A listing of the equipment included in the program
- The frequency of maintenance considering manufacturer's recommendations and/or previous experience with the equipment
- A list of spare parts to be maintained
- Activities to be performed in the event of equipment failure (i.e., spare parts maintained, backup instrumentation, or sources to repair or replace instrumentation)

B.6.3.4 Laboratory Operation

Laboratories performing analytical work for the New Mexico Sites must operate in accordance with an acceptable written QA program. Plans and procedures relevant to the New Mexico Sites work must be made available upon request. Deviations from approved procedures shall be documented.

All New Mexico Sites participants who subcontract analytical services must ensure quality of services through established procurement practices and oversight activities. Laboratories must participate in an Interlaboratory Performance Evaluation program appropriate to sample types and analyses. The laboratory must provide the results of these performance evaluation studies along with the laboratory's response to any deficiencies which were identified upon request.

B.6.3.4.1 Preanalysis Storage

Samples received at the analytical laboratory that have been entered into the sample tracking system shall be placed into a storage refrigerator or secure storage area until analyzed. The methods of storage are generally intended to:

- Retard biological action
- Retard hydrolysis of chemical compounds and complexes
- Reduce volatility of constituents
- Reduce adsorption effects
- Reduce light exposure

Preservation methods are generally limited to pH control, preservative addition, and refrigeration. Preanalysis sample storage procedures shall be documented and described in laboratory-specific procedures.

B.6.3.4.2 Post-Analysis Storage

The possibility of reanalysis requires that proper environmental control for post-analysis samples be provided. These controls shall be described in laboratory-specific procedures. The samples shall be properly disposed of by the laboratory unless other arrangements have been made to return them to the site. The laboratory must contact the participants designated personnel prior to disposal of samples.

B.6.4 Analytical Data Usability

Analytical data received for input into a project shall be assessed for acceptability against the requirements stipulated in the applicable project document. Personnel should verify that analytical data reports have been reviewed by appropriate individuals other than those generating the analytical data or the report, and that all forms of the report (printed or electronic) carry a notice of any limitations on the use of the data.

B.6.4.1 Data Management

Analytical data shall be controlled and managed to guarantee data integrity throughout acquisition and development. Systems must be established for directing analytical data results into a controlled data management system. Requirements shall be established for identification, collection, selection, control, and transfer of analytical data both within and external to the NV ERP data management system. Analytical data that are submitted shall be qualified and traceable to original data records and procedures established for processing, storage, and control of data. Analytical data users are responsible for determining if the data are sufficient for their intended use.

Each participating organization responsible for generating environmental data for the New Mexico Sites shall have a management plan for handling data that describes the flow of data from its generation through its final use and storage. The Data Management Plan shall include or reference the specific procedures to be used for data verification and validation to ensure that all data used to support decisions made for the New Mexico Sites are of known and documented quality. Procedures shall be used to optimize the detection and correction of errors and prevent data loss during data reduction, reporting, and data entry into databases.

B.6.4.2 Evaluation and Use of Data

Participating organizations shall have a system in place for the control and transfer of data and interpretive work products to the NV ERP Common Data Repository, and provide guidance for gathering, manipulating, and distributing data. The quality of existing data shall be determined, based on the traceability of data and the level of QA/QC applied to the data during initial collection and current requirements for their intended use. This analysis consists of editing, screening, checking, auditing, verification, and review. Reports, models, or interpretative works shall indicate the quality of the data being used. Prior to use, newly acquired analytical data will be evaluated against predetermined objectives and criteria. Computer applications used for the evaluation of data maintained or transferred via electronic media shall have quality control checks performed as appropriate to the application being used.

B.6.4.3 Data Reduction, Verification, and Validation

Computations performed on raw data are considered data reductions. Numerical reduction of field and analytical data shall be formally checked in accordance with approved procedures, and this checking must be performed prior to the presentation of results. If unchecked results are to be presented, transmittals or subsequent calculations based on these results must be marked "preliminary" until the results are checked and determined to be correct.

Verification is the process of checking and reviewing the data reduction process. Data verification is a systematic review of data by qualified individuals to check data reduction and ensure that data meet specified guidelines.

Validation of analytical data is a comprehensive verification which includes complete review of raw data. The site-specific DQO process shall establish what percentage of analytical data packages shall be validated. Qualifiers may be attached to the data to indicate the results of the verification process. These qualifiers may restrict or limit certain uses of the data.

B.6.4.3.1 Data Completeness Review

A completeness review should be conducted to ensure that field and laboratory data and documentation are present and complete. During this review, problems should be identified and documented. Information from this review should accompany the data. The review should include the verification that:

- Overall deliverable objectives are met.
- Laboratory documentation is complete and accurate.
- Significant problems are identified in laboratory documentation.
- Chain of custody documents are complete and contain required information.
- Analytical practices are consistent with chain of custody requirements.
- Analytical information presented is correct and complete.
- Analytical practices are within technical guidelines.
- All field forms are present and complete.

B.6.4.3.2 Data Review and Summary

Selected QC checks and procedures shall be evaluated for compliance or noncompliance with DQO standards. Deficiencies in the data package shall be communicated to the laboratory, and additions or corrections to the data package shall be controlled. Data review shall be conducted by personnel with training in, and a technical understanding of, laboratory methods and data quality. Data review shall include, but not be limited to, the examination of the following:

- Analytical requirements have been met.
- Critical items meet the project requirements.
- Analytical method QC compliance evaluated and applied to results/qualifiers.
- Sample data quality indicator goals are evaluated.
- Surrogate data quality indicators are evaluated.
- Laboratory QC sample data quality indicators are evaluated.
- Calibration information evaluated and applied to results/qualifiers.
- Internal standard evaluated and applied to results/qualifiers.
- Serial dilution effects evaluated.
- Holding time criteria has been met.
- Laboratory data qualifiers are correct and explained or a key is included.
- Compound analyte concentration is accurate.
- Sample collection and storage requirements are met.

B.6.4.3.3 Data Validation

Data validation encompasses a complete validation of the analytical results according to EPA functional guidelines or an equivalent industry-standard protocol. Data validation and review of Contract Laboratory Program (CLP) and CLP-like data packages shall be performed in accordance with the *USEPA Contract Laboratory Program, National Functional Guidelines for Inorganic Data Review* (EPA, 1994b) and *Contract Laboratory Program, National Function Guidelines for Organic Data Review* (EPA, 1999) or a national standard. This review is designed to be conducted by personnel with training in, and a technical understanding of, laboratory methods and data quality, and with the extensive experience required of professionally trained data validators. Calculations of results from raw data will be verified, and data validation qualifiers will be assigned. The results of this review and a summary of parameter detections shall be forwarded to the appropriate project manager.

Data validation shall include a check of the calculation of all QC sample results and a third party confirmation of a minimum of five percent, based on direction from the NNSA/NV Radioactive Waste Acceptance Program, of the sample result calculations from characterization samples or samples intended to demonstrate that the contaminant(s) of concern have been isolated, stabilized, and/or removed. Data validation shall also include a check of all the functional guideline parameters included in lower-level reviews.

The percentage of data packages to be validated for the New Mexico Sites shall be dependent on the end use of the data and established during the site-specific DQO process. Sample results selected for validation shall be determined by use of a random number generator or may be selected by project management in cases where special criteria exist. The NNSA/NV New Mexico Sites Task Manager shall maintain the option of having additional validation performed.

B.6.4.4 Laboratory Data Reporting

Analytical data reports must contain, at a minimum, the following information:

- Cover page with the reviewer's signature, data qualifiers, and a description of any technical difficulties encountered during the analyses
- Date the sample was received
- Date the sample was prepared
- Date the sample was analyzed
- Sample identification number
- Laboratory sample identification number
- Analytical method reference number
- Analytical results
- Tabulated QC sample results
- Instrument tuning and calibration results
- Final copy of the chain of custody form, with appropriate signatures
- Hard copy raw data of calibration, QC samples, and the analyses of field samples

Data packages shall be required for all analytical results unless sample results are excluded from data validation by NNSA/NV project management. Validated data shall be reviewed to determine whether they meet the DQOs of the investigation. The data shall be reviewed to ensure that the required number of samples were collected, critical samples were collected and analyzed, and the results passed data-validation criteria. The data shall also be reviewed to determine whether detection limits were met. Data-reporting techniques shall be in accordance with the project data-reporting requirements; data-reporting procedures should be consistent with those found in the *User's Guide to the Contract Laboratory Program* (EPA, 2000).

B.6.4.4.1 Data Reporting

Data shall be reported in accordance with standardized formats. Electronic data transfers shall be delivered, along with the hard copy, on 3.5-inch diskettes or other methods agreed upon with the NV ERP Common Data Repository custodial organization. The laboratory data will not be loaded into the common data repositories for general use until it has been verified/validated.

B.7.0 Criteria 6 - Design

Any quality-affecting items or processes designed in support of the New Mexico Sites shall be in accordance with a documented design control process and based on sound engineering and scientific principles using the appropriate standards. The acceptability and adequacy of the design product shall be verified or validated by a qualified individual(s) other than those who performed the original design. Verification and validation shall be completed prior to approval and implementation of the design. Design records shall include the design steps and sources of input that support the final output. The final design output shall be approved in accordance with the participants' internal procedures. Changes or modifications to the final design shall be subject to the same control measures and approvals as applied to the original design.

B.8.0 Criteria 7 - Procurement

Procurement of items and services for the New Mexico Sites shall be consistent with standard commercial purchase order terms and conditions, and performed in cooperation with the NNSA/NV Contracts Management Division. Project participants must have processes in place that meet the requirements of their contracts or agreements and applicable federal requirements.

B.8.1 Procurement Control

Items and services of a technical nature procured in support of the New Mexico Sites shall be of a quality that meets the requirements of the project. Project participants shall establish controls to ensure that, as a minimum, procured items and services meet specifications delineated in the procurement documents. Each participating organization shall have systems in place to track items and confirm the delivery of procured items and services as specified. Project participants shall have a program in place, invoking the appropriate quality requirements of the contractor's QA program and specifying any project requirements for the procurement of items and services.

Subcontractors procured for New Mexico Sites activities must be evaluated for prior experience, ability to perform specific tasks, and cost. The capabilities of subcontractor personnel shall be assessed by the procuring contractor to verify qualifications and determine the type and amount of training and supervision needed for environmental restoration activities.

B.8.1.1 Procurement Documents

Procurement documents for the New Mexico Sites shall define the scope of work for the item or service being procured and provide specifications, acceptance criteria, shipping and handling requirements, health and safety requirements, and any documentation required, as applicable. Technical specifications shall either be directly included in the procurement documents or included by reference to specific drawings, specifications, procedures, regulations, or codes that describe the items or services to be furnished. Procurement documents shall be reviewed for accuracy and completeness by qualified personnel prior to initial issue. Changes to a procurement document require the same level of review and approval as the original document.

B.8.1.2 Measurement and Testing Equipment

Procurement documents shall also require that all purchased and rented M&TE be calibrated to existing national standards prior to acceptance and that calibration documentation is provided. Calibration certification and instrument manufacturer's manuals should be available in project files for M&TE. Schedules for recalibration shall be established and implemented for M&TE requiring periodic calibration.

B.8.1.3 Verification of Quality Conformance

If applicable, procurement documents for New Mexico Sites-related items or services shall require access to the subcontractor's or vendor's facilities, including their subtier facilities, work areas, and records for assessments to verify acceptability. Upon delivery, procured items or services shall be inspected for conformance to procurement specifications and requirements prior to using items or placing them in service. Project personnel have the authority to stop work if significant quality problems are identified. Procured items should be evaluated for suspect/counterfeit parts. If there are indications that suppliers knowingly supplied substandard items or services, the DOE Office of Inspector General shall be notified.

B.9.0 Criteria 8 - Inspection and Acceptance Testing

Inspections and acceptance testing shall be accomplished for specific items in accordance with approved inspection documents and test procedures that reflect acceptance and performance criteria. Individuals performing inspections and acceptance testing shall be independent of those who performed the work. Quality-affecting materials used during characterization, corrective action, or sampling activities shall be inspected upon receipt for adequacy. The M&TE used in the performance of inspections or acceptance tests shall be calibrated and properly maintained. Any item or work determined to be defective shall be controlled to avoid inadvertent use.

B.10.0 Criteria 9 - Management Assessment

Planned and periodic assessments shall be conducted and shall involve the participation of project management. The primary emphasis of management assessments is to evaluate the implementation of the integrated QA program and identify problems that hinder the achievement of objectives. Contractor management should conduct periodic assessments that focus on such issues as the:

- Adequacy of implementation of the integrated QA program, with particular emphasis on quality improvement
- Existence of any management biases or organizational barriers that impede the improvement process
- Adequacy of the appraised organization's structure, staffing, and physical facilities
- Existence of effective training programs

The results of the assessment shall be documented in a final report and issued to the appropriate personnel. Management has the primary responsibility to ensure the timely follow-up of corrective actions, including an evaluation of the effectiveness of management's actions. Results of the management assessment should be entered into a tracking system for the purposes of identifying trends and lessons learned.

B.11.0 Criteria 10 - Independent Assessments

Independent management and technical assessments shall be performed to verify compliance with applicable quality requirements, DOE policies, and procedures. Assessments shall be conducted to measure item and service quality, the adequacy of work performance, and to promote improvement. The scheduling of the assessments and resource allocation for independent assessments should be based on the status, risk, and complexity of work being assessed.

The group performing the independent assessment shall be composed of individuals that are not directly involved in the work being assessed. Each group performing independent assessments shall have sufficient authority and freedom to carry out the activities necessary to effectively conduct the assessment. Assessments should focus on improving the quality of the processes that lead to the end product.

Results of each assessment should be tracked and resolved by responsible management with follow up of deficient areas. Assessment responses should include: corrective action, identification of the root cause, actions to prevent recurrence, and actions for improvement.

B.12.0 References

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U.S. Environmental Protection Agency. 2000. *User's Guide to the Contract Laboratory Program,* EPA 540-R-99-004. Washington, DC.

B.13.0 Glossary

Acceptance Criteria

Specific characteristics of an item, process, or service defined in codes, standards, or other requirement documents. (DOE/NV, 1993)

Accuracy

A measure of the closeness of an individual measurement or the average of a number of measurements to the true value. Accuracy includes a combination of random error (precision) and systematic error (bias) components that are due to sampling and analytical operations; the EPA recommends using the terms "*precision*" and *bias*," rather than "*accuracy,*" to convey the information usually associated with accuracy. (EPA, 1998)

Activity

An all-inclusive term describing a specific set of operations or related tasks to be performed, either serially or in parallel (e.g., research and development, field sampling, analytical operations, equipment fabrication), that in total result in a product or service. (ASQC, 1994)

Assessment

The evaluation process used to measure the performance or effectiveness of a system and its elements. Assessment is an all-inclusive term used to denote any of the following: audit, performance evaluation, management systems review, peer review, inspection, or surveillance. (ASQC, 1994)

Audit (Quality)

A systematic and independent examination to determine whether quality activities and related results comply with planned arrangements and whether these arrangements are implemented effectively and are suitable to achieve objectives. (ASQC, 1994)

Bias

The systematic or persistent distortion of a measurement process which causes errors in one direction (i.e., the expected sample measurement is different from the sample's true value). (ASQC, 1994)

Calibration

Comparison of a measurement standard, instrument, or item with a standard or instrument of higher accuracy to detect and quantify inaccuracies and to report or eliminate those inaccuracies by adjustments. (ASQC, 1994)

Certification

The act of determining, verifying, and attesting in writing to the qualifications of personnel, processes, procedures, or items in accordance with acceptance criteria. (DOE/NV, 1993)

Characteristic

Any property or attribute of a datum, item, process, or service that is distinct, describable, and/or measurable. (ASQC, 1994)

Comparability

A measure of the confidence with which one data set can be compared to another. (ASQC, 1994)

Completeness

A measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under correct, normal conditions. (ASQC, 1994)

Condition Adverse to Quality

An all-inclusive term used in reference to any of the following: failures, malfunctions, deficiencies, defective items or nonconformance. (DOE/NV, 1993)

Corrective Action

An action taken to eliminate the causes of an existing nonconformance, deficiency, or other undesirable situation in order to prevent recurrence. (ASQC, 1994)

Criteria

Rules or tests against which the quality of performance can be measured. They are most effective when expressed quantitatively. Fundamental criteria are contained in policies and objectives, as well as codes, standards, regulations, and recognized professional practices that DOE and DOE contractors are required to observe. (DOE/NV, 1993)

Data Quality Objectives (DQOs)

Qualitative and quantitative statements derived from the DQO process that clarify study technical and quality objectives, define the appropriate types of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions. (ASQC, 1994)

Data Quality Objectives Process

A systematic strategic planning tool based on the scientific method that identifies and defines the type, quality, and quantity of data needed to satisfy a specific use. The key elements of the process include:

- Concisely defining the problem
- Identifying the decision to be made
- Identifying the key inputs to the decision
- Defining the boundaries of the study
- Developing the decision rule
- Specifying tolerable limits on potential decision errors
- Selecting the most resource efficient data collection design

Data quality objectives are the qualitative and quantitative outputs from the DQO process. The DQO process was developed originally by the EPA, but has been adapted for use by other organizations to meet their specific planning requirements. (ASQC, 1994)

Data Usability

The process of ensuring or determining whether the quality of the data produced meets the intended use of the data. (ASQC, 1994)

Deficiency

An unauthorized deviation from acceptable procedures or practices, or a defect in an item. (ASQC, 1994)

Design

Specifications, drawings, design criteria, and performance requirements. Also the result of deliberate planning, analysis, mathematical manipulations, and design processes. (ASQC, 1994)

Document

Any written or pictorial information describing, defining, specifying, reporting, or certifying activities, requirements, procedures, or results. (ASQC, 1994)

Environmental Data

Any measurements or information that describe environmental processes or conditions, or the performance of environmental technology. (ASQC, 1994)

Environmental Data Operations

Work performed to obtain, use, or report information pertaining to environmental processes and conditions. (ASQC, 1994)

Graded Approach

The process of basing the level of application of managerial controls applied to an item or work according to the intended use of the results and the degree of confidence needed in the quality of the results. (See data quality objectives process.) (ASQC, 1994)

Independent Assessment

An assessment performed by a qualified individual, group, or organization that is not a part of the organization directly performing and accountable for the work being assessed. (ASQC, 1994)

Inspection

An activity such as measuring, examining, testing, or gauging one or more characteristics of an entity and comparing the results with specified requirements in order to establish whether conformance is achieved for each characteristic. (ASQC, 1994)

Item

An all-inclusive term used in place of any of the following: appurtenance, facility, sample, assembly, component, equipment, material, module, part, product, structure, subassembly, subsystem, system, unit, documented concepts, or data. (ASQC, 1994)

Management Assessment

The determination of the appropriateness, thoroughness, and effectiveness of management processes. (DOE/NV, 1993)

Measurement and Testing Equipment (M&TE)

Tools, gauges, instruments, sampling devices or systems used to calibrate, measure, test, or inspect in order to control or acquire data to verify conformance to specified requirements. (ASQC, 1994)

Method

A body of procedures and techniques for performing an activity (e.g., sampling, chemical analysis, quantification) systematically presented in the order in which they are to be executed. (ASQC, 1994)

Nonconformance

A deficiency in characteristic, documentation, or procedure that renders the quality of an item or activity unacceptable or indeterminate; nonfulfillment of a specified requirement. (ASQC, 1994)

Precision

A measure of mutual agreement among individual measurements of the same property, usually under prescribed similar conditions, expressed generally in terms of the standard deviations. (ASQC, 1994)

Procedure

A specified way to perform an activity. (ASQC, 1994)

Process

Any activity or group of activities that takes an input, adds value to it, and provides an output to a customer. The logical organization or people, materials, energy, equipment, and procedures into work activities designed to produce a specified end result (work product). (DOE/NV, 1993)

Quality

The totality of features and characteristics of a product or service that bear on its ability to meet the stated or implied needs and expectations of the user. (ASQC, 1994)

Quality Assurance (QA)
An integrated system of management activities involving planning, implementation assessment, reporting, and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected by the customer. (ASQC, 1994)

Quality Assurance Program
The overall program (management system) established to assign responsibilities and authorities, define policies and requirements for the performance and assessment of work. (DOE, 1999)

Quality Control (QC)
The overall system of technical activities that measures the attributes and performance of a process, item, or service against defined standards to verify that they meet the stated requirements established by the customer; operational techniques and activities that are used to fulfill requirements for quality. (ASQC, 1994)

Quality Improvement
A management program for improving the quality of operations. Such management programs generally entail a formal mechanism for encouraging work recommendations with timely management evaluation and feedback or implementation. (ASQC, 1994)

Quality Indicators
Measurable attributes of the attainment of the necessary quality for a particular environmental decision. Indicators of quality include precision, bias, completeness, representativeness, reproducibility, comparability, and statistical confidence. (ASQC, 1994)

Quality System
A structured and documented management system describing the policies, objectives, principles, organizational authority, responsibilities, accountability, and implementation plan of an organization for ensuring quality in its work processes, products (items), and services. The quality system provides the framework for planning, implementing, and assessing work performed by the organization and for carrying out required QA and QC. (ASQC, 1994)

Readiness Review

A systematic, documented review of the readiness for startup or continued use of a facility, process, or activity. Readiness reviews are typically conducted before proceeding beyond project milestones and prior to institution of a major phase of work. (ASQC, 1994)

Record

A completed document that furnishes evidence relating to items or activities. (DOE/NV, 1993)

Remediation

The process of reducing the concentration of a contaminant (or contaminants) in air, water, or soil media to a level that poses an acceptable risk to human health. (ASQC, 1994)

Representativeness

A measure of the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. (ASQC, 1994)

Risk

A quantitative or qualitative expression of possible loss which considers both the probability that an event occurrence will cause harm or loss and the consequences of that event. (DOE/NV, 1993)

Root Cause

The most basic reason for conditions adverse to quality that, if corrected, will prevent occurrence or recurrence. (DOE/NV, 1993)

Self Assessment

Assessments of work conducted by individuals, groups, or organizations directly responsible for overseeing and/or performing the work. (ASQC, 1994)

Service

The result generated by activities at the interface between the supplier and the customer, and by supplier internal activities to meet customer needs. Such activities in environmental programs include design, inspection, laboratory and/or field analysis, repair, and installation. (ASQC, 1994)

Specification

A document stating requirements and which refers to or includes drawings or other relevant documents. Specifications should indicate the means and the criteria for determining conformance. (ASQC, 1994)

Standard Operating Procedure

A written document that details the method for an operation, analysis, or action with thoroughly prescribed techniques and steps, and that is officially approved as the method for performing certain routine or repetitive tasks. (ASQC, 1994)

Surveillance (Quality)

Continual or frequent monitoring and verification of the status of an entity and the analysis of records to ensure that specified requirements are being fulfilled. (ASQC, 1994)

Technical Review

A documented critical review of work that has been performed within the state of the art. The review is accomplished by one or more qualified reviewers who are independent of those who performed the work, but are collectively equivalent in technical expertise to those who performed the original work. The review is an in-depth analysis and evaluation of documents, activities, material, data, or items that require technical verification or validation for applicability, correctness, adequacy, completeness, and assurance that established requirements are satisfied. (ASQC, 1994)

Traceability

The ability to trace the history, application, or location of an entity by means of recorded identifications. In a calibration sense, traceability relates measuring equipment to national or international standard, primary standards, basic physical constants or properties, or reference materials. In a data collection sense, it relates calculations and data generated throughout the project back to the requirements for quality for the project. (ASQC, 1994)

Training

The process of providing for and making available to an employee(s) and placing or enrolling an employee(s) in a planned, prepared, and coordinated program, course, curriculum, subject, system, or routine of instruction or education, in fiscal, administrative, management, individual development, or other fields which improve individual and organizational performance and assist in achieving the agency's mission and performance goals. (DOE/NV, 1993).

Validation

Confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use are fulfilled. In design and development, validation concerns the process of examining a product or result to determine conformance to user needs. (ASQC, 1994)

Verification

Confirmation by examination and provision of objective evidence that specified requirements have been fulfilled. In design and development, verification concerns the process of examining a result of a given activity to determine conformance to the stated requirements for that activity. (ASQC, 1994)

Attachment 1

Quality Criteria for Site-Specific Documents

Site-Specific Quality Assurance Project Plans Requirements

Site-specific planning documents must contain QA/QC requirements appropriate for the site and activities being performed. This attachment delineates the quality criteria that should be included in either the site-specific planning document or addressed in an appendix to the appropriate document:

- Quality Objectives and Criteria for Measurement Data: Describe the project quality objectives and performance criteria.

- Special Training Requirements/Certification: Identify and describe any specialized training or certification requirements and discuss how such training will be provided and how the necessary skills will be assured and documented.

- Required Documentation and Records: Define the information that must be included in the data report package and the reporting format. Identify documents (e.g., interim progress reports, final reports) that will be produced. Specify the final disposition of records including retention period.

- Sampling Process Design: Describe any experimental design or data collection design for the project and classify all measurements as critical or non-critical.

- Sampling Methods Requirements: Describe specific performance requirements for the method. Address what to do when a failure in the sampling occurs, who is responsible for the corrective action, and how the effectiveness of the corrective action shall be determined and documented.

- Laboratory Requirements: Identify volume requirements, preservative requirements, and holding times.

- Analytical Methods Requirements: Identify the analytical methods, waste disposal requirements (if any), and specific performance requirements for the method.

- Quality Control Requirements: Identify required measurement QC check for both the field and laboratory. State the frequency of analysis for each type of QC check.

- Instrument/Equipment Testing, Inspection, and Maintenance Requirements: Describe how inspections and acceptance testing of environmental sampling and measurement systems and their components will be performed and documented.

- Reports to Management: Identify the frequency and distribution of reports issued to inform management of the status of the project.

- Reconciliation with Data Quality Objectives: Describe how the results obtained from the project or task will be reconciled with the requirements defined by the data user or decision maker.

Attachment 2

Laboratory Chemical, Toxicity Characteristic Leaching Procedure, and Radiochemistry Analytical Requirements for New Mexico Sites

Laboratory Chemical, Toxicity Characteristic Leaching Procedure, and Radiochemistry Analytical Requirements for New Mexico Sites

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Parameter or Analyte	Medium or Matrix	Analytical Method	Container Requirement	Preservative	Minimum Reporting Limit	Relative Percent Difference (RPD)[a]	Percent Recovery (%R)[b]
ORGANICS							
Total Volatile Organic Compounds (VOCs)	Water	8260B[c] 5030B[c]	40-mL G w/ Teflon®-lined septum	pH<2 w/HCL & Cool to 4°C	5 µg/L[d]	Lab-specific[e]	Lab-specific[e]
	Soil		2-oz. G widemouth w/ Teflon®-lined lid	Cool to 4°C	5 µg/kg[d]		
Toxicity Characteristic Leaching Procedure (TCLP) VOCs							
Benzene	Aqueous and Soil	1311/8260B[c]	Aqueous 40 mL G w/ Teflon®-lined septum Soil 2-oz. G widemouth w/ Teflon®-lined lid	Cool to 4°C	Lab-specific[e]	Lab-specific[e]	Lab-specific[e]
Carbon Tetrachloride					Lab-specific[e]		
Chlorobenzene					Lab-specific[e]		
Chloroform					Lab-specific[e]		
1,2-Dichloroethane					Lab-specific[e]		
1,1-Dichloroethene					Lab-specific[e]		
Methyl Ethyl Ketone					Lab-specific[e]		
Tetrachloroethene					Lab-specific[e]		
Trichloroethene					Lab-specific[e]		
Vinyl Chloride					Lab-specific[e]		
Total Semivolatile Organic Compounds (SVOCs)	Water	8270C[c]	1-L AG w/ Teflon®-lined lid	Cool to 4°C	Analyte-specific estimated quantitation limits[d]	Lab-specific[e]	Lab-specific[e]
	Soil		4-oz. G w/ Teflon®-lined lid				
TCLP SVOCs							
o-Cresol	Aqueous and Soil	1311/8270C[c]	Aqueous 1-L AG w/ Teflon®-lined lid Soil 8-oz. G w/ Teflon®-lined lids	Cool to 4°C	0.10 mg/L[d]	Lab-specific[e]	Lab-specific[e]
m-Cresol					0.10 mg/L[d]		
p-Cresol					0.10 mg/L[d]		
Cresol (total)					0.30 mg/L[d]		
1,4-Dichloro-benzene					0.10 mg/L[d]		
2,4-Dinitrotoluene					0.10 mg/L[d]		
Hexachloro-benzene					0.10 mg/L[d]		
Hexachloro-butadiene					0.10 mg/L[d]		

Laboratory Chemical, Toxicity Characteristic Leaching Procedure, and Radiochemistry Analytical Requirements for New Mexico Sites
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Parameter or Analyte	Medium or Matrix	Analytical Method	Container Requirement	Preservative	Minimum Reporting Limit	Relative Percent Difference (RPD)[a]	Percent Recovery (%R)[b]
Hexachloro-ethane	Aqueous and Soil	1311/8270C[c]	Aqueous 1-L AG w/ Teflon®-lined lid; Soil 8-oz. G w/ Teflon®-lined lids	Cool to 4°C	0.10 mg/L[d]	Lab-specific[e]	Lab-specific[e]
Nitrobenzene					0.10 mg/L[d]		
Pentachloro-phenol					0.50 mg/L[d]		
Pyridine					0.10 mg/L[d]		
2,4,5-Trichloro-phenol					0.10 mg/L[d]		
2,4,6-Trichloro-phenol					0.10 mg/L[d]		
Total Pesticides	Water	8081A[c]	1-L AG w/ Teflon®-lined lid	Cool to 4°C	Analyte-specific (CRQL)[f]	Lab-specific[e]	Lab-specific[e]
	Soil		4-oz. G w/ Teflon®-lined lid				
TCLP Pesticides							
Chlordane	Aqueous and Soil	1311/8081A[c]	Aqueous 1-L AG w/ Teflon®-lined lid; Soil 4-oz. G w/ Teflon®-lined lid	Cool to 4°C	0.0005 mg/L[f]	Lab-specific[e]	Lab-specific
Endrin					0.001 mg/L[f]		
Heptachlor					0.0005 mg/L[f]		
Heptachlor Epoxide					0.0005 mg/L[f]		
gamma-BHC (Lindane)					0.0005 mg/L[f]		
Methoxychlor					0.005 mg/L[f]		
Toxaphene					0.05 mg/L[f]		
Polychlorinated Biphenyls (PCBs)	Water	8082[c]	1-L AG w/ Teflon®-lined lid	Cool to 4°C	Analyte-specific contract-required quantitation limits (CRQL)[f]	Lab-specific[e]	Lab-specific[e]
	Soil		4-oz. G w/ Teflon®-lined lid				
Total Herbicides	Water	8151A[c]	1-L AG w/ Teflon®-lined lid	Cool to 4°C	1.3 µg/L[c]	Lab-specific[e]	Lab-specific[e]
	Soil		4-oz. G w/ Teflon®-lined lid		66 µg/kg[c]		
TCLP Herbicides							
2,4-D	Aqueous and Soil	1311/8151A[c]	1-L AG w/ Teflon®-lined lid	Cool to 4°C	0.002 mg/L[d]	Lab-specific[e]	Lab-specific[e]
2,4,5-TP			4-oz. G w/ Teflon®-lined lid		0.00075 mg/L[d]		

Laboratory Chemical, Toxicity Characteristic Leaching Procedure, and Radiochemistry Analytical Requirements for New Mexico Sites
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Parameter or Analyte	Medium or Matrix	Analytical Method	Container Requirement	Preservative	Minimum Reporting Limit	Relative Percent Difference (RPD)[a]	Percent Recovery (%R)[b]
Total Petroleum Hydrocarbons (TPH)	Water Gasoline	8015B Modified[c]	Aqueous 1-L AG w/ Teflon®-lined lid	Cool to 4°C	0.1 mg/L[g]	Lab-specific[e]	Lab-specific[e]
	Soil Gasoline				0.5 mg/kg[g]		
	Water Diesel		Soil 4-oz. G w/ Teflon®-lined lid	Cool to 4°C	0.5 mg/L[g]		
	Soil Diesel				25 mg/kg[g]		
Explosives	Water	8330[c]	1-L AG w/ Teflon®-lined lid	Cool to 4°C	14 µg/L[c]	Lab-specific[e]	Lab-specific[e]
	Soil		4-oz. G w/ Teflon®-lined lid		2.2 mg/kg[c]		
Polychlorinated Dioxins and Furans	Water	8280A/8290[c]	1-L AG w/ Teflon®-lined lid	Cool to 4°C	0.05 µg/L[c]	Lab-specific[e]	Lab-specific[e]
	Soil		4-oz. G w/ Teflon®-lined lid		5 µg/kg[c]		

Laboratory Chemical, Toxicity Characteristic Leaching Procedure, and Radiochemistry Analytical Requirements for New Mexico Sites
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Parameter or Analyte	Medium or Matrix	Analytical Method	Container Requirement	Preservative	Minimum Reporting Limit	Relative Percent Difference (RPD)[a]	Percent Recovery (%R)[b]
INORGANICS							
Target Analyte List Metals							
Aluminum	Water	6010B[c]	Aqueous 600-mL P or G Soil 8-oz. P or G	Aqueous ph <2 w/ HNO_3 and Cool to 4°C Soil Cool to 4°C	100 µg/L[g,h]	20[h] For both Matrix Spike and Laboratory Control Sample	Matrix Spike 75-125[h] Laboratory Control Sample 80-120[h]
	Soil	6010B[c]			10 mg/kg[g,h]		
Antimony	Water	6010B[c]			20 µg/L[g,h]		
	Soil	6010B[c]			2 mg/kg[g,h]		
Arsenic	Water	6010B[c]			10 µg/L[g,h]		
	Soil	6010B[c]			1 mg/kg[g,h]		
Barium	Water	6010B[c]			200 µg/L[g,h]		
	Soil	6010B[c]			20 mg/kg[g,h]		
Beryllium	Water	6010B[c]			5 µg/L[g,h]		
	Soil	6010B[c]			0.5 mg/kg[g,h]		
Boron	Water	6010B[c]			100 µg/L[g,h]		
	Soil	6010B[c]			10 mg/kg[g,h]		
Cadmium	Water	6010B[c]			5 µg/L[g,h]		
	Soil	6010B[c]			0.5 mg/kg[g,h]		
Calcium	Water	6010B[c]			1,000 µg/L[g,h]		
	Soil	6010B[c]			100 mg/kg[g,h]		
Chromium	Water	6010B[c]			10 µg/L[g,h]		
	Soil	6010B[c]			1 mg/kg[g,h]		
Cobalt	Water	6010B[c]			10 µg/L[g,h]		
	Soil	6010B[c]			1 mg/kg[g,h]		

Laboratory Chemical, Toxicity Characteristic Leaching Procedure, and Radiochemistry Analytical Requirements for New Mexico Sites
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Parameter or Analyte	Medium or Matrix	Analytical Method	Container Requirement	Preservative	Minimum Reporting Limit	Relative Percent Difference (RPD)[a]	Percent Recovery (%R)[b]
Copper	Water	6010B[c]	Aqueous 600-mL P or G Soil 8-oz. P or G	Aqueous ph <2 w/ HNO_3 and Cool to 4°C Soil Cool to 4°C	10 µg/L[g,h]	20[h] For both Matrix Spike and Laboratory Control Sample	Matrix Spike 75-125[h] Laboratory Control Sample 80-120[h]
	Soil	6010B[c]			1 mg/kg[g,h]		
Iron	Water	6010B[c]			100 µg/L[g,h]		
	Soil	6010B[c]			10 mg/kg[g,h]		
Lead	Water	6010B[c]			3 µg/L[g,h]		
	Soil	6010B[c]			0.3 mg/kg[g,h]		
Lithium	Water	6010B[c]			10 µg/L[g,h]		
	Soil	6010B[c]			1 mg/kg[g,h]		
Magnesium	Water	6010B[c]			1,000 µg/L[g,h]		
	Soil	6010B[c]			100 mg/kg[g,h]		
Manganese	Water	6010B[c]			10 µg/L[g,h]		
	Soil	6010B[c]			1 mg/kg[g,h]		
Mercury	Water	7470A[c]			0.2 µg/L[g,h]		
	Soil	7471A[c]			0.1 mg/kg[g,h]		
Molybdenum	Water	6010B[c]			10 µg/L[g,h]		
	Soil	6010B[c]			1 mg/kg[g,h]		
Nickel	Water	6010B[c]			20 µg/L[g,h]		
	Soil	6010B[c]			2 mg/kg[g,h]		
Phosphorus	Water	6010B[c]			200 µg/L[g,h]		
	Soil	6010B[c]			20 mg/kg[g,h]		
Potassium	Water	6010B[c]			1,000 µg/L[g,h]		
	Soil	6010B[c]			100 mg/kg[g,h]		
Selenium	Water	6010B[c]			5 µg/L[g,h]		
	Soil	6010B[c]			0.5 mg/kg[g,h]		
Silica	Water	6010B[c]			50 µg/L[g,h]		
	Soil	6010B[c]			5 mg/kg[g,h]		
Silver	Water	6010B[c]			10 µg/L[g,h]		
	Soil	6010B[c]			1 mg/kg[g,h]		
Sodium	Water	6010B[c]			1,000 µg/L[g,h]		
	Soil	6010B[c]			100 mg/kg[g,h]		
Strontium	Water	6010B[c]			50 µg/L[g,h]		
	Soil	6010B[c]			1 mg/kg[g,h]		
Thallium	Water	6010B[c]			5 µg/L[g,h]		
	Soil	6010B[c]			0.5 mg/kg[g,h]		

Laboratory Chemical, Toxicity Characteristic Leaching Procedure, and Radiochemistry Analytical Requirements for New Mexico Sites
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Parameter or Analyte	Medium or Matrix	Analytical Method	Container Requirement	Preservative	Minimum Reporting Limit	Relative Percent Difference (RPD)[a]	Percent Recovery (%R)[b]
Tin	Water	6010B[c]	Aqueous 600-mL P or G Soil 8-oz. P or G	Aqueous ph <2 w/ HNO_3 and Cool to 4°C Soil Cool to 4°C	10 µg/L[g,h]	20[h] For both Matrix Spike and Laboratory Control Sample	Matrix Spike 75-125[h] Laboratory Control Sample 80-120[h]
	Soil	6010B[c]			2 mg/kg[g,h]		
Titanium	Water	6010B[c]			20 µg/L[g,h]		
	Soil	6010B[c]			1 mg/kg[g,h]		
Uranium	Water	6010B[c]			20 µg/L[g,h]		
	Soil	6010B[c]			20 mg/kg[g,h]		
Vanadium	Water	6010B[c]			10 µg/L[g,h]		
	Soil	6010B[c]			1 mg/kg[g,h]		
Zinc	Water	6010B[c]			20 µg/L[g,h]		
	Soil	6010B[c]			2 mg/kg[g,h]		
TCLP RCRA Metals							
Arsenic	Aqueous and Soil	1311/6010B[c] 1311/7470A[c]	Aqueous 600-mL P or G Soil 8-oz. P or G	Aqueous ph <2 w/ HNO_3 and Cool to 4°C Soil Cool to 4°C	0.10 mg/L[g,h]	20[h] For both Matrix Spike/Matrix Spike Duplicate and Laboratory Control Sample	Matrix Spike 75-125[h] Laboratory Control Sample 80-120[h]
Barium					2 mg/L[g,h]		
Cadmium					0.05 mg/L[g,h]		
Chromium					0.10 mg/L[g,h]		
Lead					0.03 mg/L[g,h]		
Mercury					0.002 mg/L[g,h]		
Selenium					0.05 mg/L[g,h]		
Silver					0.10 mg/L[g,h]		
Cyanide	Water	9010B[c]	Aqueous 600-mL P or G Soil 8-oz. P or G	Aqueous ph >12 w/ 10N NaOH and Cool to 4°C Soil Cool to 4°C	0.01 mg/L[h]		
	Soil				1.0 mg/kg[h]		
Sulfide	Water	9030B/9034[c]	250-mL P or G	4 drops 2N zinc acetate per 100mL, pH>9 w 6N NaOH, and Cool to 4°C	0.4 mg/L[c]	Lab-specific[e]	Lab-specific[e]
	Soil or Sediment		8-oz. P or G	Fill surface of solid w/ 2N zinc acetate until moistened	10 mg/kg[g]		
pH/Corrosivity	Water	9040B[c]	600-mL P or G	None required	NA		
	Soil	9045C[c]	8-oz. P or G				

Laboratory Chemical, Toxicity Characteristic Leaching Procedure, and Radiochemistry Analytical Requirements for New Mexico Sites
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Parameter or Analyte	Medium or Matrix	Analytical Method	Container Requirement	Preservative	Minimum Reporting Limit	Relative Percent Difference (RPD)[a]	Percent Recovery (%R)[b]
Ignitability	Water	1010[c]	250-mL AG	Cool to 4°C	NA	NA	NA
	Soil	1030[c]	4-oz. AG	Cool to 4°C			
Total Dissolved Solids	Water	160.1[i]	1-L P or G	Cool to 4°C	Lab-specific	Lab-specific	Lab-specific
Bromide	Water	EPA 300.0	1-L P or G	None required	100 µg/L[g]	Lab-specific	Lab-specific
	Soil	EPA 300.0	4-oz. AG		2 mg/kg[g]		
Chloride	Water	EPA 300.0	1-L P or G	None required	200 µg/L[g]		
	Soil	EPA 300.0	4-oz. AG		2 mg/kg[g]		
Fluoride	Water	EPA 300.0	1-L P or G	None required	200 µg/L[g]		
	Soil	EPA 300.0	4-oz. AG		2 mg/kg[g]		
Nitrate as NO_3	Water	EPA 300.0	1-L P or G	Cool to 4°C	200 µg/L[g]		
	Soil	EPA 300.0	4-oz. AG		2 mg/kg[g]		
Sulfate	Water	EPA 300.0	1-L P or G	Cool to 4°C	1,000 µg/L[g]		
	Soil	EPA 300.0	4-oz. AG		2 mg/kg[g]		
RADIOCHEMISTRY							
Gamma-Emitting Radionuclides[j]	Water	EPA 901.1[k]	1-L P or G	pH<2 w/ HNO_3	Isotope-specific[m]	20	Laboratory Control Sample Yield 80-120
	Soil/Biota	HASL 300[l]	250-mL P or G	None required		35	
Isotopic Plutonium[j]	Water	HASL 300[l] or ASTM D3865-97[n]	1-L P or G	pH<2 w/ HNO_3	0.1 pCi/L	20	Chemical Yield 30-105 Laboratory Control Sample Yield 80-120
	Soil/Biota	HASL 300[l] or ASTM C1001-90[n]	250-mL P or G	None required	0.05 pCi/g	35	
Isotopic Uranium[j]	Water	HASL 300[l]	1-L P or G	pH<2 w/ HNO_3	0.1 pCi/L	20	
	Soil/Biota	HASL 300[l]	250-mL P or G	None required	0.05 pCi/g	35	
Strontium - 90[j]	Water	ASTM D5811-95[n]	1-L P or G	pH<2 w/ HNO_3	1 pCi/L	20	
	Soil/Biota	HASL 300[l]	250-mL P or G	None required	0.5 pCi/g	35	
Americium-241	Water	HASL 300[l]	1-L P or G	pH<2 w/ HNO_3	0.1 pCi/L	20	
	Soil/Biota		250-mL P or G	None required	0.05 pCi/g	35	
Gross Alpha	Water	EPA 900.0[k]	1-L P or G	pH<2 w/ HNO_3	4 pCi/L	20	Laboratory Control Sample Yield 80-120
	Soil	Lab-Specific[o]	250-mL P or G	None required	4 pCi/g	35	
Gross Beta	Water	EPA 900.0[k]	1-L P or G	pH<2 w/ HNO_3	4 pCi/L	20	
	Soil	Lab-Specific[o]	250-mL P or G	None required	4 pCi/g	35	
Tritium[j]	Water	EPA 906.0[k]	250-mL P or G	None required	400 pCi/L	20	
	Soil	Lab-Specific[o]	250-mL P or G		1pCi/g	35	

Laboratory Chemical, Toxicity Characteristic Leaching Procedure, and Radiochemistry Analytical Requirements for New Mexico Sites

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Parameter or Analyte	Medium or Matrix	Analytical Method	Container Requirement	Preservative	Minimum Reporting Limit	Relative Percent Difference (RPD)[a]	Percent Recovery (%R)[b]
Radium-226	Water	EPA 903.1	1-L P or G	pH<2 w/ HNO_3	0.5 pCi/L	20	Chemical Yield 30-105 Laboratory Control Sample 75-125
	Soil	Lab-Specific	250-mL P or G	None required	0.5 pCi/g	35	
Radium-228	Water	EPA 904.0	1-L P or G	pH<2 w/ HNO_3	1 pCi/L	20	
	Soil	Lab-Specific	250-mL P or G	None required	1 pCi/g	35	
Carbon-14 (screening for C-14)	Water	Lab-Specific[o]	1-L P or G	None required	500 pCi/L	35	60-115
Carbon-14 (for groundwater dating in association w/ C-13)	Water	Lab-Specific[o]	1-L P or G	None required	1 Percent Modern Carbon	+/- 1 Percent Modern Carbon[p]	Within 1 Percent Modern Carbon[q]
STABLE ISOTOPES							
Carbon-13	Water	Lab-Specific[o]	1-L G	None required	NA[r]	+/- 0.2 per mil[p]	Within 0.4 per mil of Standard[q]
Oxygen-18			30-mL G with poly-lined lid				
Deuterium						+/- 1 per mil[p]	Within 2 per mil of Standard[q]

[a]RPD is used to Calculate Precision.
Precision is estimated from the relative percent difference of the concentrations measured for the matrix spike and matrix spike duplicate analyses of unspiked field samples, or field duplicates of unspiked samples. It is calculated by:
RPD = 100 x $\{(|C_1-C_2|)/[(C_1+C_2)/2]\}$, where C_1 = Concentration of the analyte in the first sample aliquot, C_2 = Concentration of the analyte in the second sample aliquot.

[b]%R is used to Calculate Accuracy.
Accuracy is assessed from the recovery of analytes spiked into a blank or sample matrix of interest, or from the recovery of surrogate compounds spiked into each sample. The recovery of each spiked analyte is calculated by: %R = 100 x (C_s-C_u/C_n), where C_s = Concentration of the analyte in the spiked sample, C_u = Concentration of the analyte in the unspiked sample, C_n = Concentration increase that should result from spiking the sample

[c]U.S. Environmental Protection Agency's (EPAs) *Test Methods for Evaluating Solid Waste*, 3rd Edition, Parts 1-4, SW-846 (EPA, 1996)

[d]Estimated Quantitation Limit as given in SW-846 (EPA, 1996)

[e]In-House Generated RPD and %R Performance Criteria
It is necessary for laboratories to develop in-house performance criteria and compare them to those in the methods. The laboratory begins by analyzing 15-20 samples of each matrix and calculating the mean %R for each analyte. The standard deviation (SD) of each %R is then calculated, and the warning and control limits for each analyte are established at ± 2 SD and ± 3 SD from the mean, respectively. If the warning limit is exceeded during the analysis of any sample delivery group (SDG), the laboratory institutes corrective action to bring the analytical system back into control. If the control limit is exceeded, the sample results for that SDG are considered unacceptable. These limits are reviewed after every 20-30 field samples of the same matrix and are updated at least semiannually. The laboratory tracks trends in both performance and control limits by the use of control charts. The laboratory's compliance with these requirements is confirmed as part of an annual laboratory audit. Similar procedures are followed in order to generate acceptance criteria for precision measurements.

[f] EPA *Contract Laboratory Program Statement of Work for Organic Analysis* (EPA, 1988b; and 1991)

[g]Minimum reporting level as directed to laboratory by contractor.

[h]EPA *Contract Laboratory Program Statement of Work for Inorganic Analysis* (EPA, 1988a; and 1994)

[i]*Methods for Chemical Analysis of Water and Wastes* (EPA, 1983)

[j]Isotopic minimum detectable concentrations are defined during the DQO process and specified in the CAIP, as applicable.

[k]*Prescribed Procedures for Measurements of Radioactivity in Drinking Water* (EPA, 1980) or equivalent method

Laboratory Chemical, Toxicity Characteristic Leaching Procedure, and Radiochemistry Analytical Requirements for New Mexico Sites

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Parameter or Analyte	Medium or Matrix	Analytical Method	Container Requirement	Preservative	Minimum Reporting Limit	Relative Percent Difference (RPD)[a]	Percent Recovery (%R)[b]

[l]*Environmental Measurements Laboratory Procedures Manual* (DOE, 1997), or equivalent method
[m]Isotope-Specific Minimum Reporting Limit to be specified in the work plan.
[n]*American Society for Testing and Materials,* or equivalent method.
[o]Laboratory-Specific Method, as preapproved by Analytical Services
[p]Measure of precision as directed to the laboratory by contractor.
[q]Measure of accuracy as directed to the laboratory by contractor.
[r]A ratio is reported; therefore, a minimum reporting limit is not applicable.

Definitions:
µg/kg = Microgram(s) per kilogram
mg/kg = Milligram(s) per kilogram
pCi/L = Picocurie(s) per liter
mL = Milliliter
L = Liter
oz. = Ounce
G = Glass
AG = Amber glass
P = Polyethylene
mg/L = Milligram(s) per liter
pCi/g = Picocurie(s) per gram
µg/L = Microgram(s) per liter
N = Normal
HCL = Hydrochloric acid
H_2SO_4 = Sulfuric acid
HNO_3 = Nitric acid
NaOH = Sodium Hydroxide

Table References

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Appendix C

Results of Gasbuggy Preliminary Field Investigation (August - September, 2000)

C.1.0 Introduction

This appendix presents the investigation activities and analytical results from the preliminary field investigation conducted at the Gasbuggy Site in Rio Arriba County, New Mexico, during August and September of 2000. The Gasbuggy Site is located approximately 55 air miles east of Farmington, New Mexico, in the Carson National Forest. The site is made up of five operational areas (i.e., Surface Ground Zero area, the Well GB-D area, the Recording Trailer Park, the Control Point, and the Helicopter Pad) (see Figure 2-1). Additional information on the site history is presented in the main body of the Site Characterization Work Plan (see Section 2.0) and will not be presented here.

C.1.1 Preliminary Field Investigation Objectives

The seven primary objectives for the preliminary field investigation of the surface/shallow subsurface were to:

- Complete necessary biological and cultural resource surveys for operational areas not previously surveyed (all except the SGZ area) so that a Special Use Permit may be obtained from the CNF, Jicarilla Ranger District, for future work in these areas.
- Complete surface geophysical investigations for all operational areas where shallow subsurface contamination is suspected to identify suspect AOCs and refine sampling locations.
- Collect soil samples to identify the presence and nature of COPCs at the SGZ area.
- Locate the shallow groundwater table in the SGZ area with planned equipment (direct-push), if possible.
- Collect shallow groundwater samples in the SGZ area, if shallow groundwater is found.
- Verify location of septic tanks in the SGZ.
- Verify septic tanks in SGZ area were closed.

Biological and cultural resource surveys were completed by a contractor approved by the CNF. Surface geophysical investigations were carried out using several electromagnetic (EM) techniques (e.g., EM31 and EM61) and ground-penetrating radar (GPR). Soil samples were collected from within the SGZ area and analyzed as planned.

The other objectives were not met. Limitations of the direct-push technology and site conditions limited the depth to which subsurface observations could be made. Several boreholes were drilled beyond 20 ft bgs and one to 36 ft bgs without contacting groundwater. No shallow groundwater samples were collected. The septic tanks indicated by historical documentation were not definitively located; therefore, closure was not verified. The investigation strategies for the shallow groundwater and septic tanks are presented in Section 4.0 of the Work Plan.

Additionally, two tasks were planned for the subsurface investigation. These included sampling and video logging of Well EPNG 10-36. A qualified subcontractor could not be located to perform the specified work within the project schedule. Therefore, these tasks have been added to the planned future investigation activities (see Section 5.0) of the Work Plan.

C.1.2 Report Content

This appendix is intended to provide information and data to support the corrective action investigation strategy described in the Site Characterization Work Plan. The content of this appendix is as follows:

- Section C.1.0 describes the investigation background, objectives, and the report content.
- Section C.2.0 provides information regarding the biological and cultural resource surveys.
- Section C.3.0 summarizes the results of the geophysical investigation and presents the data collected in map format.
- Section C.4.0 provides information regarding the sampling methods.
- Section C.5.0 summarizes the results of the laboratory analysis from the soil investigation of the SGZ area.
- Section C.6.0 provides a discussion on the results of the geophysical and soil sampling investigations of the SGZ area.
- Section C.7.0 discusses the quality assurance (QA) and QC procedures that were followed and the results of the QA and QC activities.

- Section C.8.0 summarizes the significant results pertaining to the Gasbuggy preliminary field investigation.

- Section C.9.0 cites references used to prepare this appendix.

To make this report a concise summary, the complete field documentation and laboratory data (e.g., Field Activity Daily Logs, Sample Collection Logs, Analysis Request/Chain of Custody Forms, Visual Classification of Soils Forms, laboratory certificates of analyses, and analytical results) are not contained in this report. These documents are retained in project files as both hard copy files and electronic media.

C.2.0 Biological and Cultural Resources Surveys

Biological and cultural resource surveys were completed for all operational areas excluding the SGZ area. Surveys for the SGZ area were completed in 1993 (DOE/NV, 1993a and b). These surveys were performed to ensure that future planned site characterization activities would not disturb sensitive species or sites of historical significance. Copies of the final reports for both surveys (TRC, 2000a and b) will be sent to the Jicarilla Ranger District of the Carson National Forest.

C.2.1 Biological Survey

The biological survey was completed on September 7, 2000. A detailed report on the findings of the survey was prepared and will be kept in the project files. The report concluded that "no affect will occur to any U.S. Fish and Wildlife Service (USFWS) threatened, endangered, proposed candidate, or species of concern as a result of environmental studies taking place at the Gasbuggy Site. No affect will occur to State of New Mexico threatened, endangered, or species of concern, or USFS sensitive species as a result of environmental studies at the Gasbuggy Site" (TRC, 2000a).

C.2.2 Cultural Resources Survey

The cultural resources survey was completed on September 22, 2000, by a contractor on the USFS Jicarilla Ranger district list of archeological permittees. A detailed report on the findings of the survey was prepared and will be kept in the project files. The survey identified three "isolated occurrences" (IOs) and one newly recorded "site." Isolated occurrences are archaeological manifestations offering limited information because they lack identifiable cultural context. Sites, generally speaking, are larger in size and extent. One IO was recorded at each of the following areas: Well GB-D area, RTP, and the HP. The "site" was recorded on the ridge to the south of the CP area. The report concluded that cultural resource monitoring is recommended should any future ground-disturbing work occur south of the road (TRC, 2000b). Although the documented boundaries of the "site" overlap the CP boundaries, no ground-disturbing work is planned within the specified "site" boundaries at the current time.

C.3.0 Geophysical Investigations

Geophysical surveys were completed during August 2000 at all operational areas excluding the helicopter pad. Surveys were completed to locate and delineate shallow subsurface features.

C.3.1 Scope and Objectives of Geophysical Investigation

All shallow subsurface AOCs could not be accurately located exclusively through historical research and current site features. Therefore, a geophysical investigation was conducted to more accurately locate and delineate the known suspect shallow subsurface AOCs identified through the document search; locate other suspect areas; and map mud pits and subsurface features containing buried metal objects and/or debris such as landfills and septic tanks.

The geophysical surveys were conducted to accomplish the following objectives within each identified operational area:

Ground Zero Area

- Locate and delineate the drilling mud pits in the SGZ area associated with wells EPNG 10-36, GB-1, GB-2(R), GB-E(R), and GB-3.
- Locate the two septic tanks and potential associated influent and effluent lines (see Figure 2-8).
- Locate and delineate undocumented landfills including the potential landfill identified along the western edge of the large mud pit (Landfill E) (see Figure 2-5).
- Locate and delineate the landfills used to dispose of the drilling fluids and paraffin generated during the 1978 site restoration and well abandonment (Landfills A, C, and D) (see Figure 2-9).
- Locate and delineate the "unused" decontamination pad and other concrete pads buried during the 1978 site restoration (Landfill B) (see Figure 2-9).
- Locate and delineate undocumented subsurface features.

Well GB-D Area

- Locate and delineate the drilling mud pit.
- Locate and delineate undocumented subsurface features.

Recording Trailer Park

- Locate and delineate the pit identified in Figure 2-10.
- Locate and delineate undocumented subsurface features.

Control Point

- Locate the septic tank and associated influent and effluent lines (see Figure 2-13).
- Locate and delineate undocumented subsurface features.

No geophysical investigation was carried out at the helicopter pad. Based on a search of historical documents and process knowledge from other NNSA/NV Offsites locations, there is no reason to suspect shallow subsurface features at this site.

C.3.2 Demarcation of Geophysical Survey Areas

Prior to conducting the geophysical investigation, the lateral limits of the survey area were marked and base grids were established for each operational area. Using the base grids as a reference, north-south and/or east-west oriented survey lanes were flagged. A base map was created by mapping surface objects that could potentially affect the geophysical data (e.g., roads, fences, well locations, project related equipment) and/or help locate anomalies based on surface features. These objects were accurately mapped using GPS.

C.3.3 Data Acquisition and Processing

Data was digitally recorded and periodically downloaded into a field computer for quality assurance and preliminary interpretation. All geophysical data was recorded in association with GPS data to accurately place identified anomalies. Field maps were then created by overlaying the base maps with the geophysical data.

Geophysical data was collected at the Gasbuggy Site using two EM methods (i.e., EM31 and EM61) and GPR. The EM31 surveys were conducted at each of the four areas. The EM61 surveys were used to further refine the location and limitations of metallic anomalies found at the SGZ area. The GPR was used to further refine the location and limitations of anomalies in all four areas of investigation (SAIC, 2000).

C.3.3.1 EM31

The EM31 technology collects data on the electric and magnetic properties of subsurface materials. The "quadrature phase" measures differences in the conductivity of subsurface materials. The "inphase" reacts well to metal but not the natural conductivity of the earth. The technology measures to approximately 18 ft bgs. Data was collected every 2 seconds or approximately every 2.5 ft to 3 ft while carrying the EM31 antenna over the surface while walking. The GPS antenna was also carried and positioning data was collected once every second while walking.

Prior to each survey, the lateral limits of the area to be surveyed were marked and base grids were established for each site. Using the base grids as a reference survey lanes were flagged. These lanes ensured that transects were evenly spaced. Survey control was maintained by using GPS technology (SAIC, 2000).

C.3.3.2 EM61

The EM61 is a high-resolution metal detection survey that uses an antenna to transmit an electromagnetic pulse into the subsurface and then uses a second antenna to measure the decay rate of the electromagnetic field. The magnitude of the remnant electromagnetic field provides a measurement of the metallic presence in the subsurface and the difference in the fields. The antenna are pulled across the surface on a frame supported by wheels. The EM61 data was collected over areas where landfills or other potential subsurface features which are suspected to contain metal. Survey lanes were established on 5-ft transects over the area of interest. Survey control was maintained by using GPS technology (SAIC, 2000).

C.3.3.3 Ground-Penetrating Radar

Ground-penetrating radar data is collected by pulling an antenna along the ground surface. An electromagnetic pulse (much higher in frequency than is used in the EM61) is sent into the subsurface. When there is a contrast in the dielectric permeativity of the subsurface materials, some of the energy is reflected back to the ground surface, where it is recorded. The GPR surveys were conducted to investigate anomalies detected during the EM31 survey and to attempt to identify the location of several septic tanks documented in historical reports (SAIC, 2000).

C.3.4 Results of Geophysical Investigation

A detailed report on the results of the geophysical investigations is maintained in the project files (SAIC, 2000). The discussion and data presented here is a summary of this report.

C.3.4.1 Surface Ground Zero Area

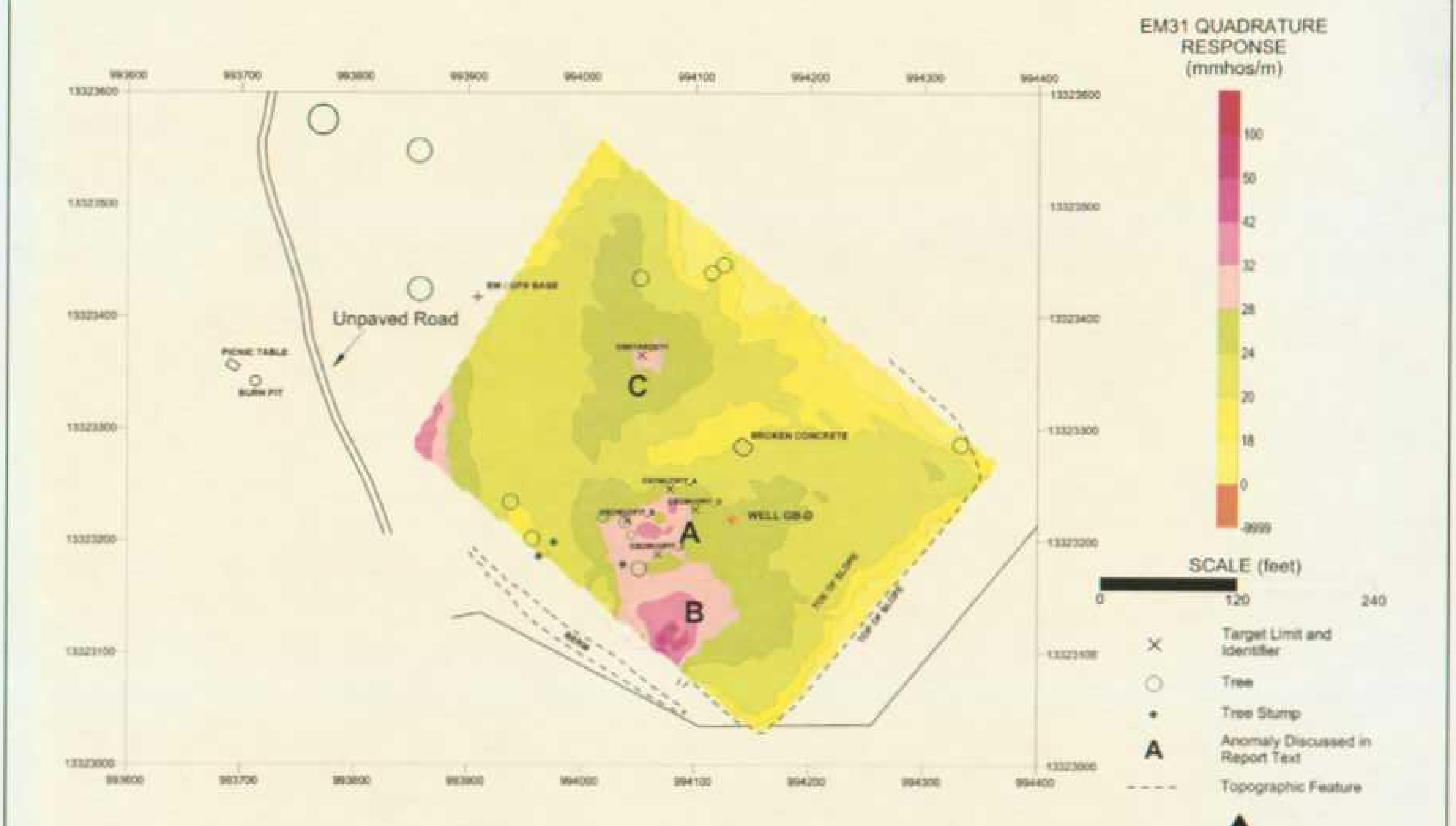
A detailed discussion of the combined geophysical and soil sampling investigation results for the SGZ area is provided in Section C.6.0.

C.3.4.2 Well GB-D Area

The EM31 was used for an initial geophysical survey of the Well GB-D area. EM31 data indicated three significant anomalies in the quadrature phase. These anomalies are labeled A, B, and C on (see Figure C.3-1). Additional data was collected for Anomalies A and C using GPR. Anomalies identified in the inphase were either attributed to known surface features (e.g., abandoned wellhead) or to isolated occurrences of shallow buried metal debris.

Based on the data from the geophysical investigations, process knowledge, and field observations, the following interpretations and conclusions were made:

- Anomaly A appears to be the mud pit used during the drilling of Well GB-D (see Figure 2-5). Further investigation of this anomaly will be based on this information.
- Anomaly B is located near a soil pile suggesting the anomaly may represent an excavation and fill event. Further investigation of this anomaly will be based on this information.
- Anomaly C appears to be a natural feature of the area based on interpretation of the EM31 data and lack of anomalous response during GPR survey (SAIC, 2000). Neither historical information nor field observation indicate any reason to suspect contamination due to DOE activities in this specific area. Therefore, this anomaly will not be further investigated.



mmhos/m - millimhos per meter
Coordinates in Universal Transverse Mercator, North 13, NAD 1927 (CONUS), Feet

Source: Modified from SAIC, 2000

Figure C.3-1
Location of Anomalies Identified by EM31 Survey Quadrature Phase Response at the Well GB-D Area

C.3.4.3 Recording Trailer Park

The EM31 was used for an initial geophysical survey of the RTP. EM31 data indicated seven significant anomalies in either the quadrature phase or the inphase. These anomalies are labeled A through G on Figure C.3-2 and/or Figure C.3-3. Additional data was collected for three of the anomalies (i.e., Anomalies A, C, and G) using GPR.

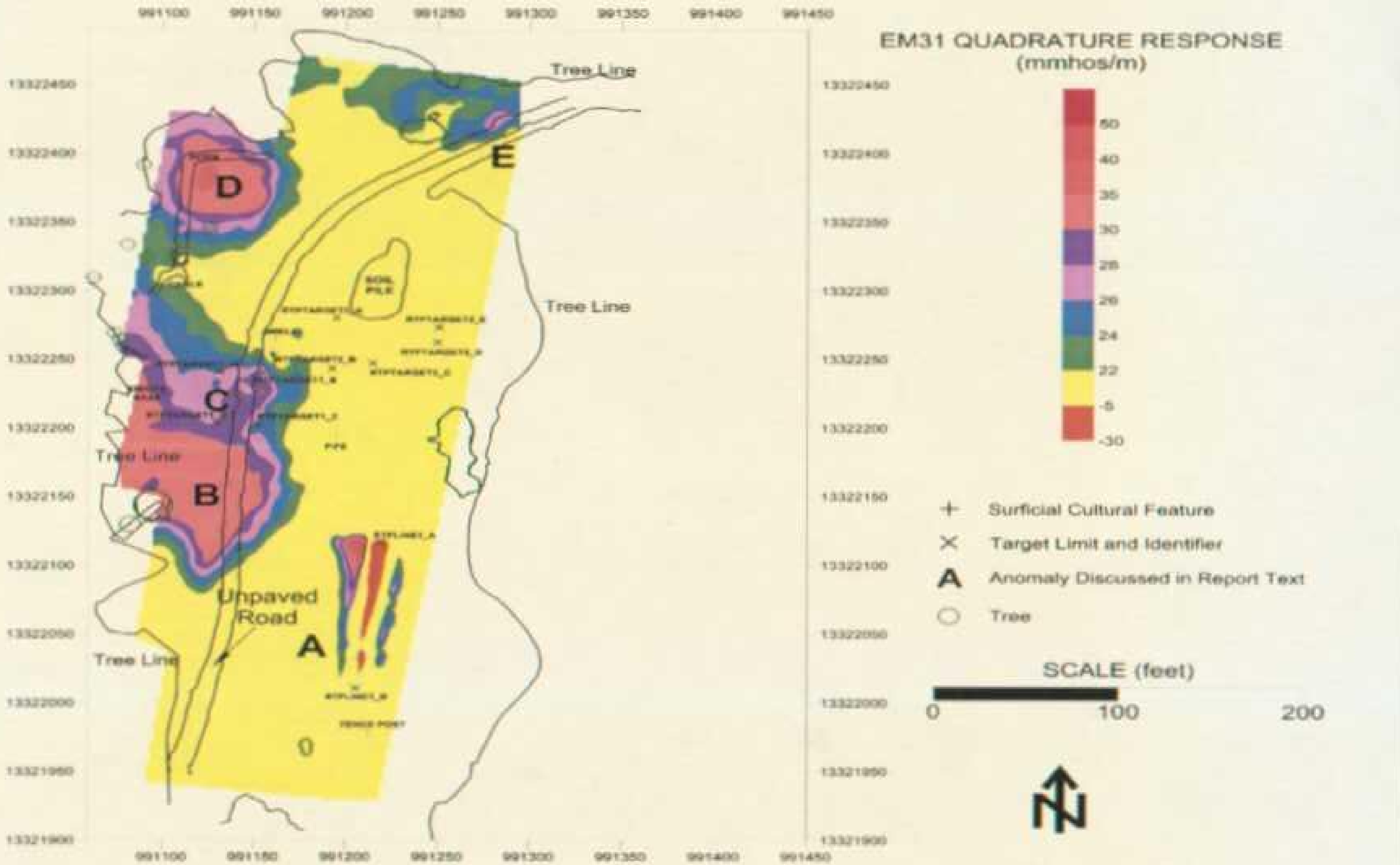
Based on the data from the geophysical investigations, process knowledge, and field observations, the following interpretations and conclusions were made:

- Anomaly A is linear and trends north to south. Based on the historical aerial photos of the RTP, this anomaly appears to be in the vicinity of the edge of the compacted earthen pad and driveway constructed at the site during the DOE presence (see Figure 2-11). The anomaly may represent the edge of the pad. The GPR traverses perpendicular to this anomaly indicated no evidence of a subsurface pipe or cable. Neither historical information nor field observation indicate any reason to suspect contamination due to DOE activities in this specific area. Therefore, this anomaly will not be further investigated.

- Anomaly B is located along the western edge of the surveyed area in an area of higher elevation. The EM31 data are indicative of a natural feature associated with changes in soil electric properties and increased soil moisture (SAIC, 2000). Therefore, this anomaly will not be further investigated.

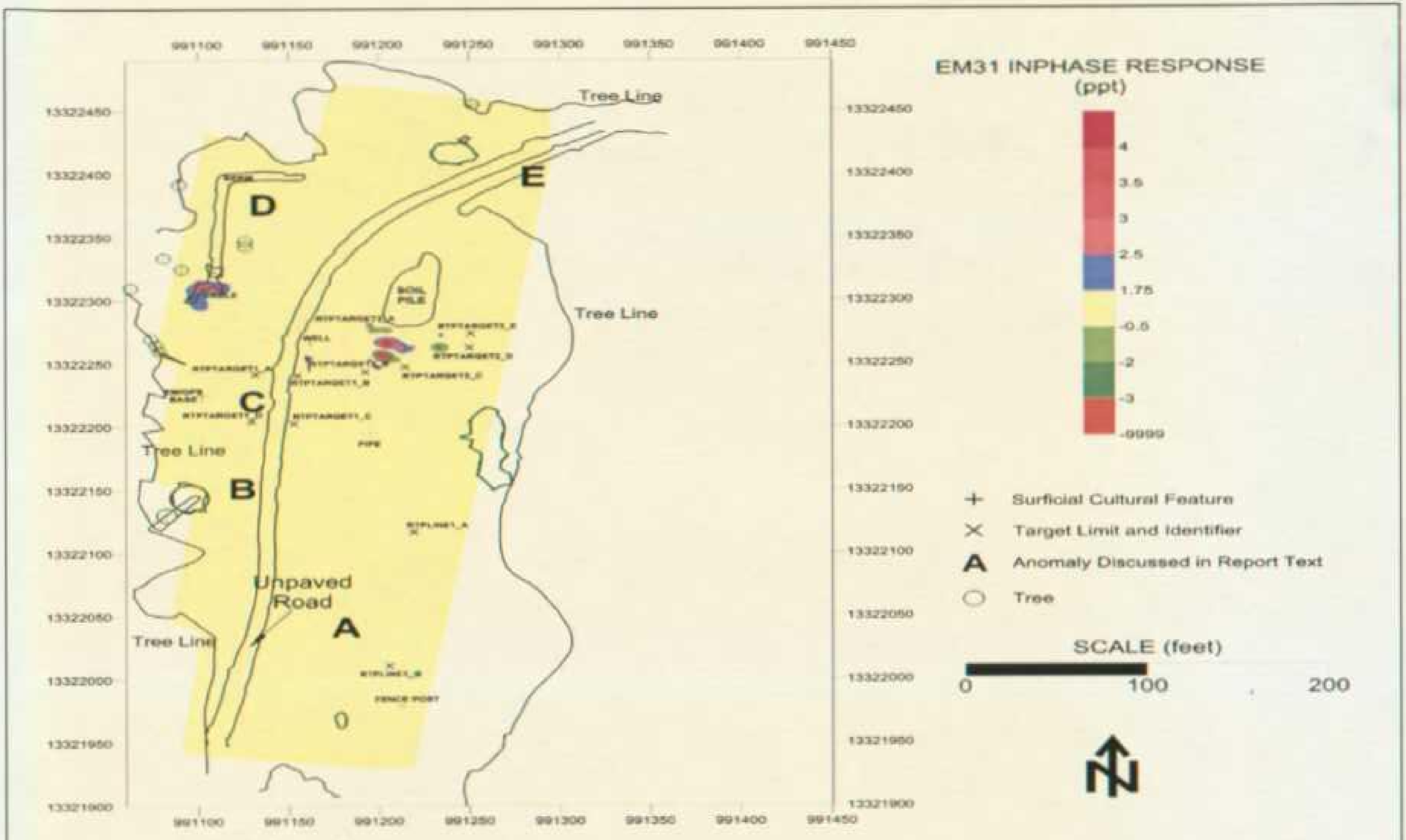
- Anomaly C is located due south of the abandoned natural gas well located on site. As indicated on the pipe marking the well, the well was operated by Meridian Oil and is referred to as San Juan 28-4. A search of the New Mexico Department of Natural Resources records indicates the well was completed in 1955. No abandonment date was found. An "existing" open pit is indicated on historic site drawings (see Figure 2-10), and is visible in a historic photograph of the area (see Figure 2-11). The GPR did not indicate any anomalies. The anomaly and the "existing" pit in the drawing are assumed to be the same feature (i.e, the sump associated with the on-site well). Therefore, this anomaly will not be further investigated.

- Anomaly D is located near an L-shaped berm in the northwest corner of the area. The anomaly appears to represent a gradual change in conductivity as would a natural feature. The DOE activities at the RTP were concentrated in the southern portion of the cleared area (see Figure 2-10). The berm may be related to the natural gas well located approximately 100 ft southeast of the berm. Neither historical information nor field observation indicate any reason to suspect contamination due to DOE activities in this specific area. Therefore, this anomaly will not be further investigated.



mmhos/m - millimhos per meter
Coordinates in Universal Transverse Mercator, North 13, NAD 1927 (CONUS), Feet
Source: Modified from SAIC, 2000

Figure C.3-2
Location of Anomalies Identified by EM31 Quadrature Phase Response at the Recording Trailer Park



ppt - parts per thousand
Coordinates in Universal Transverse Mercator, North 13, NAD 1927 (CONUS), Feet
Source: Modified from SAIC, 2000

Figure C.3-3
Location of Anomalies Identified by EM31 Inphase Response at the Recording Trailer Park

- Anomaly E is located adjacent to the dirt road at the entrance to the RTP. Based on interpretation of the geophysical results, Anomaly E appears to be a natural feature of the area (SAIC, 2000). Therefore, this anomaly will not be further investigated.

- Anomaly F is located where steel cables are visible on the surface and is attributed to a response to these cables. The cables are likely related to the natural gas well located approximately 100 ft southeast of the cables. Therefore, this anomaly will not be further investigated.

- Anomaly G is located near a soil pile suggesting the anomaly may represent an excavation and fill event. EM31 data indicated a strong metallic response and GPR traverses across this anomaly indicated numerous small hyperbolas, which may indicate buried metal cables. Further investigation of this anomaly will be based on this information.

C.3.4.4 Control Point

The EM31 was used for an initial geophysical survey of the CP. The EM31 data indicated five significant anomalies in the quadrature phase and/or the inphase. These anomalies are labeled A through E on Figure C.3-4 and/or Figure C.3-5. Additional anomalies were either attributed to known surface features (e.g., fence posts) or to isolated occurrences of shallow buried debris. Additional data was collected for two of the anomalies (i.e., Anomalies C and D) using GPR.

Based on the data from the geophysical investigations, process knowledge, and field observations, the following interpretations and conclusions were made:

- Anomaly A is located where site drawings indicate generators were located (see Figure 2-13). The anomaly is assumed to be a response to a concrete pad that is visible at the location. Therefore, no further investigation is proposed for this anomaly.

- Anomaly B is located where site photographs and drawings indicate generators were located (see Figure 2-12 and Figure 2-13). Although no concrete pad is visible at the site surface, it may have been covered by erosion. The geophysical signature (i.e., strong negative response in both the EM31 quadrature phase and inphase) of this anomaly is similar to that of Anomaly A, which was attributed to a concrete pad. Therefore, no further investigation is proposed for this anomaly.

- Anomaly C is located in the vicinity where drawings indicate a septic tank (see Figure 2-13). Numerous GPR traverses over this area indicated some man-made objects are present in the area, although the lack of continuity does not permit the interpretation of a septic tank or associated pipes (SAIC, 2000). Further investigation of this anomaly will be based on this information.

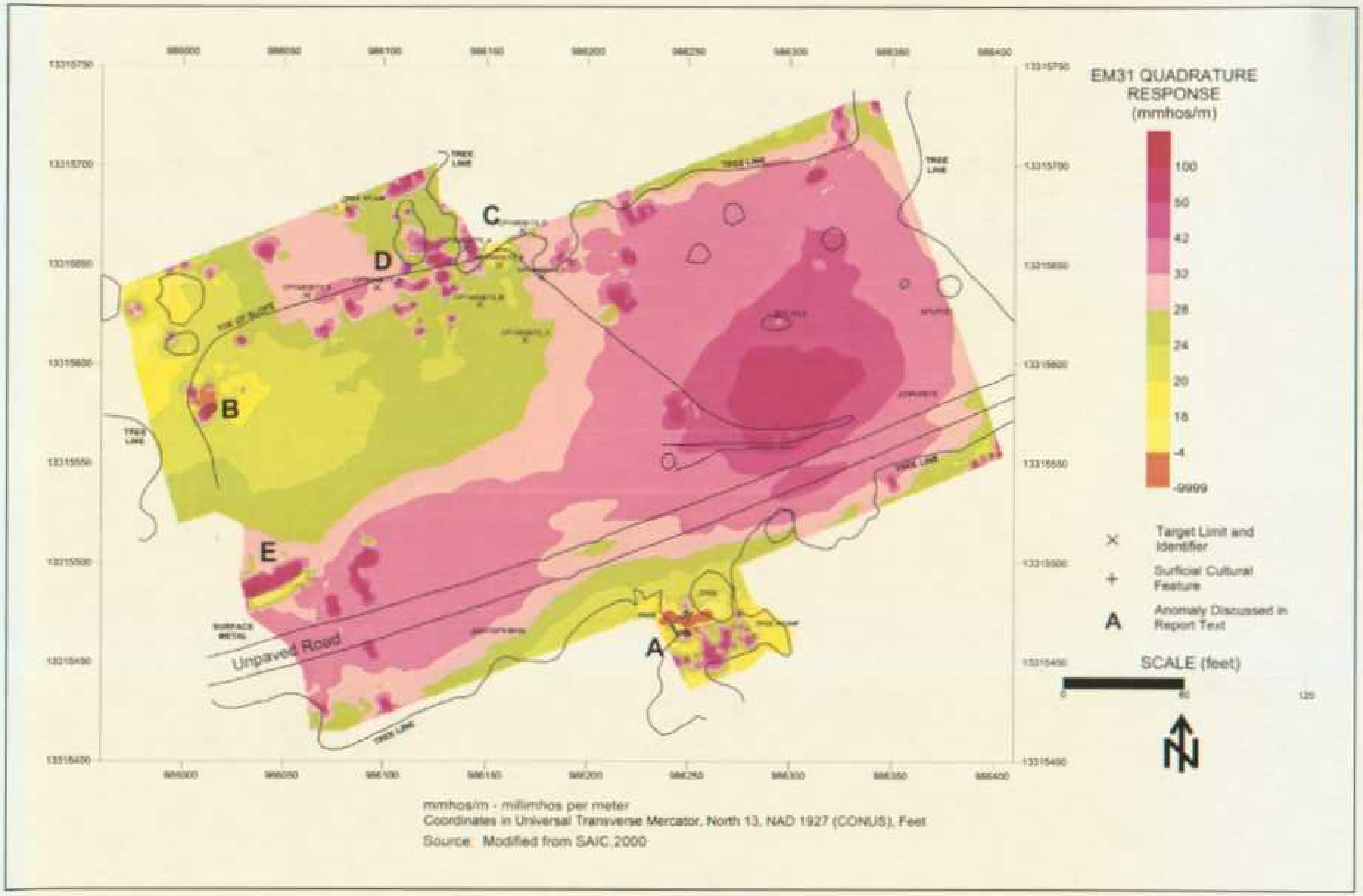


Figure C.3-4
Location of Anomalies Identified by EM31 Quadrature Phase Response at the Control Point

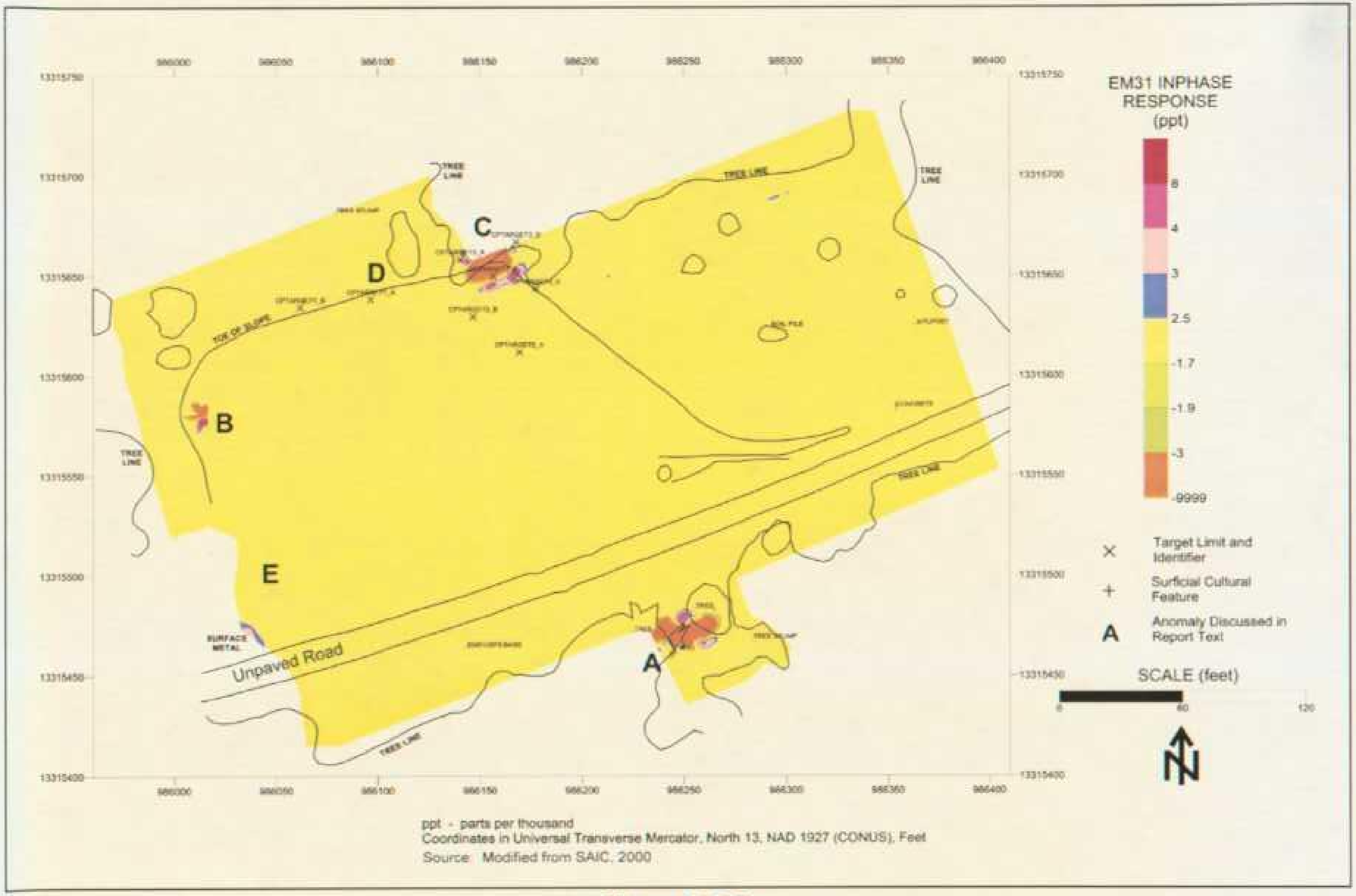


Figure C.3-5
Location of Anomalies Identified by EM31 Inphase Response at the Control Point

- Anomaly D is in the vicinity where the drawings indicate a leaching pipe for the septic tank (see Figure 2-13). This group of small anomalies are nonmetallic and consistent with a clay pipe (SAIC, 2000) and/or shallow buried pieces of broken up concrete. Therefore, no further investigation is proposed for this group of small anomalies.

- Anomaly E is in the vicinity of the southwest corner of the compacted earthen pad. The location and orientation of the anomaly may represent a man-made drainage feature as indicated in Figure 2-13. Due to the vicinity of this anomaly to the location of the mobile radiological laboratory as indicated in historical photos (Wofford, 2000), the origin of this anomaly will be further investigated. The notation "surface metal" south of Anomaly E is in reference to the location of a parked vehicle. The small "blip" in this location on the inphase figure (see Figure C.3-5) is believed to be in response to this vehicle.

C.4.0 Sampling Activities

Soil samples were collected exclusively from the SGZ area. Soil sampling was conducted in accordance with the NM QAPP presented in Appendix B. The samples were collected and documented by following approved sampling, chain of custody, and shipping procedures. Quality control samples (e.g., field blanks, equipment rinsate blanks, trip blanks, and sample duplicates) were collected as required by the NM QAPP and approved procedures.

C.4.1 Site Description and Conditions

The SGZ area is approximately 8 to10 acres in size. There are no buildings within the area. The only utility within the area is a underground gas pipeline that runs along the west side of USFS Road 357. Remaining surface features include four well markers, a ground water monitoring well (Well EPNG 10-36), a pipe stanchion, several concrete pads, and miscellaneous drilling rig anchors, fence posts, and other small historical features. Some soil berms and other surface contours from historical site activities are also still visible. There is a moderate amount of surface debris from historical site activities and recreational usage of the site.

C.4.2 Direct-Push Operation

Shallow subsurface soil samples were collected at 29 site characterization locations and 2 background locations by the direct-push method. All locations were biased based on the conceptual site model, historical knowledge, site features, and results of the geophysical investigation. The direct-push method works by mechanically pushing and/or hammering a core barrel into the soil to the desired depth. The core barrel used at the Gasbuggy Site was 48 in. long with an outside diameter of 2 in. The core barrel was lined with Lexan™ sleeves. Once brought to the surface, these sleeves were cut open along the length to allow for logging of soil type to the full depth of the borehole.

C.4.3 Sample Collection

The Lexan™ sleeve containing the recovered soil was removed from the direct-push equipment, the sleeve was capped, and the bottom cap was marked with the total depth. The sleeve was then brought to the sampling area and cut open. The core was screened for alpha/beta and VOC contamination to ensure worker safety. At no time did screening results meet or exceed hold points as listed in the site-specific health and safety plan. Samples to be analyzed for volatile parameters were collected first using decontaminated stainless steel utensils to place soil directly into sample bottles from the specified depth. Samples to be analyzed for nonvolatile parameters were then collected by placing soil into decontaminated mixing bowls for homogenization prior to filling the required sample bottles.

The assigned sample numbers indicate the location and depth at which the sample was collected as indicated in Table C.4-1. Samples were generally collected from a 2-ft interval to obtain the required volume to fill the necessary sample bottles. Sample intervals were decreased in several cases to collect the sample in a desired interval based on soil characteristics. Sample intervals were also increased in several cases to obtain the required volume. Samples were collected at the depths specified in Table C.4-2.

Table C.4-1
Sample Identification Examples

Sample Type	Example of Identification Number	Description
Soil	GBPS010406 or GBPB010406	GBP = Gasbuggy Preliminary Investigation
		S = Soil sample; or B = Background sample
		01 = Sequential boring number
		0406 = Depth interval sample obtained (e.g., 4-6 feet below ground surface)
Duplicate Soil Sample	GBPS01	01 = Sequential number for duplicate sample
Source Blank	GBP001	001 = Sequential number for QA/QC samples
Equipment Rinsate Blank		
Trip Blank		
Field Blank		

Table C.4-2
Sample Locations, Types, and Analyses
(Page 1 of 5)

Borehole Number[a]	Site Feature (soil samples) or Sample Type[b]	Sample Number[c]	Sample Matrix	Analyses[d]
GBP01	Well GB-2 Mud Pit and Well GB-E Mud Pit D[e]	**GBPS010609**[f]	Soil	SC, WQCC, WC
		GBPS010911[f]	Soil	SC, WQCC, WC
		GBPS011214	Soil	SC
		GBPS011921	Soil	SC
GBP02	Well GB-2 Mud Pit	**GBPS020610**[f]	Soil	SC, WQCC, WC
		GBPS021719	Soil	SC
GBP03	Well GB-E Mud Pit A	**GBPS030406**[f]	Soil	SC, WQCC, WC
		GBPS030911	Soil	SC
		GBPS031416	Soil	SC
GBP04	Landfill E	GBPS040406	Soil	SC, WQCC, WC
		GBPS040911	Soil	SC
		GBPS041416	Soil	SC
GBP05	Landfill E	GBPS050408	Soil	SC, WQCC, WC
		GBPS051012	Soil	SC
		GBPS051820	Soil	SC
		GBPS01	Soil	Duplicate of above
GBP06	Well EPNG 10-36 Sump	GBPS060608	Soil	SC, WQCC, WC
		GBPS061012	Soil	SC
		GBPS061618	Soil	SC
GBP07	Well GB-E Mud Pit E	**GBPS070608**[f]	Soil	SC, WQCC, WC
		GBPS071012	Soil	SC
		GBPS071618	Soil	SC
GBP08	Well GB-1 Drill Pad	GBPS080204	Soil	SC
		GBPS081416	Soil	SC
GBP09	Well GB-1 Drill Pad	GBPS090204	Soil	SC
		GBPS091416	Soil	SC
GBP10	Well GB-1 Drill Pad	GBPS100204	Soil	SC, WQCC, WC
		GBPS101416	Soil	SC
GBP11	Well GB-E Drill Pad	GBPS110204	Soil	SC, WQCC, WC
		GBPS111416	Soil	SC

Table C.4-2
Sample Locations, Types, and Analyses
(Page 2 of 5)

Borehole Number[a]	Site Feature (soil samples) or Sample Type[b]	Sample Number[c]	Sample Matrix	Analyses[d]
GBP12	Well GB-1 Mud Pit	**GBPS120204**[f]	Soil	SC, WQCC, WC
		GBPS120608	Soil	SC
		GBPS121719	Soil	SC
GBP13	Well GB-E Mud Pit A[g]	GBPS131920	Soil	SC
GBP14	Flare stack area	GBPS140304	Soil	Tritium
		GBPS140708	Soil	Tritium
		GBPS141112	Soil	Tritium
		GBPS141516	Soil	Tritium
		GBPS141920	Soil	Tritium
GBP15	Well EPNG 10-36 Drill Pad	GBPS150204	Soil	SC
		GBPS151416	Soil	SC
GBP16	Well EPNG 10-36 Drill Pad	GBPS160204	Soil	SC
		GBPS02	Soil	Duplicate of above
		GBPS161416	Soil	SC
GBP17	Well EPNG 10-36 Drill Pad	GBPS170204	Soil	SC, WQCC, WC
		GBPS171314	Soil	SC
		GBPS172123	Soil	SC
GBP18	Well GB-E Mud Pit E	GBPS180608	Soil	SC
		GBPS180911[f]	Soil	SC, WQCC, WC
		GBPS181416	Soil	SC
		GBPS182122	Soil	SC
GBP19	Well GB-3 Drill Pad	GBPS190204	Soil	SC
		GBPS191416	Soil	SC
GBP20	Well GB-3 Drill Pad	GBPS200204	Soil	SC
		GBPS201416	Soil	SC
GBP21	Well GB-2 Drill Pad	GBPS210204	Soil	SC, WQCC, WC
		GBPS210608	Soil	SC
		GBPS211416	Soil	SC
GBP22	Well GB-2 Drill Pad	GBPS220204	Soil	SC
		GBPS221416	Soil	SC
		GBPS03	Soil	Duplicate of above
		GBPS222021	Soil	SC

Table C.4-2
Sample Locations, Types, and Analyses
(Page 3 of 5)

Borehole Number[a]	Site Feature (soil samples) or Sample Type[b]	Sample Number[c]	Sample Matrix	Analyses[d]
GBP23	Water/gas separator area	GBPS230304	Soil	Tritium
		GBPS230708	Soil	Tritium
		GBPS231112	Soil	Tritium
		GBPS231516	Soil	Tritium
		GBPS231920	Soil	Tritium
GBP24	Well GB-E Mud Pit A	GBPS240304	Soil	Tritium
		GBPS240506[f]	Soil	SC, Tritium
		GBPS241112	Soil	Tritium
		GBPS241416	Soil	SC, Tritium
GBP25	Flare stack area	GBPS250304	Soil	Tritium
		GBPS250507	Soil	SC
		GBPS250708	Soil	Tritium
		GBPS251012	Soil	SC, Tritium
GBP26	Well GB-E Drill Pad	GBPS260204	Soil	SC
		GBPS261416	Soil	SC
		GBPS04	Soil	Duplicate of above
GBP27	Well GB-E Drill Pad	GBPS270204	Soil	SC
		GBPS271416	Soil	SC
GBP28	Berm that separates the Well GB-E Mud Pit A and the Well GB-2 Mud Pit	GBPS280608	Soil	SC
		GBPS281012	Soil	SC
		GBPS282224	Soil	SC
		GBPS283032	Soil	SC
		GBPS283436	Soil	SC
GBP29	Well GB-1 Mud Pit	**GBPS290103**[f]	Soil	SC
		GBPS291416	Soil	SC
GBPB01	Background	GBPB010204	Soil	BG, VOCs
		GBPB010912	Soil	BG, VOCs
GBPB03	Background	GBPB030407	Soil	BG
		GBPB031012	Soil	BG
		GBPB031416	Soil	BG
NA	Trip blank	GBP001	Water	VOCs
NA	Trip blank	GBP002	Water	VOCs

Table C.4-2
Sample Locations, Types, and Analyses
(Page 4 of 5)

Borehole Number[a]	Site Feature (soil samples) or Sample Type[b]	Sample Number[c]	Sample Matrix	Analyses[d]
NA	Trip blank	GBP003	Water	VOCs
NA	Trip blank	GBP004	Water	VOCs
NA	Trip blank	GBP005	Water	VOCs
NA	Trip blank	GBP006	Water	VOCs
NA	Trip blank	GBP007	Water	VOCs
NA	Trip blank	GBP008	Water	VOCs
NA	Trip blank	GBP009	Water	VOCs
NA	Field blank	GBP010	Water	SC, WQCC (except for NO_3, Br, Cl, F, and SO_4), tritium[h]
NA	Trip blank	GBP011	Water	VOCs
NA	Equipment rinsate blank	GBP012	Water	SC, WQCC (except for NO_3, Br, Cl, F, and SO_4), tritium[h]
NA	Trip blank	GBP013	Water	VOCs
NA	Trip blank	GBP014	Water	VOCs
NA	Source blank for decontamination water	GBP015	Water	SC, WQCC, tritium
NA	Trip blank	GBP016	Water	VOCs
NA	Source blank for Lexan™ tube[i]	GBP017	Water	SC, WQCC, tritium
NA	Trip blank	GBP018	Water	VOCs
NA	Equipment rinsate blank	GBP019	Water	NO_3, Br, Cl, F, and SO_4[j]
NA	Trip blank	GBP020	Water	VOCs
NA	Trip blank	GBP021	Water	VOCs
NA	Trip blank	GBP022	Water	VOCs
NA	Field blank	GBP023	Water	VOCs, WQCC, Tritium
NA	Trip blank	GBP024	Water	VOCs
NA	Field blank	GBP025	Water	SC, WQCC, tritium
NA	Trip blank	GBP026	Water	VOCs
NA	Trip blank	GBP027	Water	VOCs
NA	Field blank	GBP028	Water	SC, WQCC, tritium
NA	Trip blank	GBP029	Water	VOCs
NA	Source blank for Lexan™ tube[i]	GBP030	Water	SC, WQCC, tritium

Table C.4-2
Sample Locations, Types, and Analyses
(Page 5 of 5)

Borehole Number[a]	Site Feature (soil samples) or Sample Type[b]	Sample Number[c]	Sample Matrix	Analyses[d]
NA	Trip blank	GBP031	Water	VOCs
NA	Trip blank	GBP032	Water	VOCs

[a]The alphanumerical characters indicated that the borehole was drilled during the Gasbuggy preliminary investigation (GBP), which occurred in August-September of 2000, if it is a background borehole (GBPB) and the sequential boring number.
[b]If sample matrix is soil, the description in this column describes the site features (e.g., mud pit, landfill) that the samples from the borehole were intended to capture.
[c]See Table C.4-1 for an explanation of the sample nomenclature.
[d]See explanation of abbreviations below for the specific analysis.
[e]The Well GB-E Mud Pit D is located within the bounds of the Well GB-2 Mud Pit and appears to overlay the Well GB-2 Mud Pit.
[f]Visual observation of the soil core indicates this sample was collected from a suspect drilling mud layer.
[g]Visual observation of the soil core did not indicate a layer of drilling mud within this borehole.
[h]NO_3, Br, Cl, F, and SO_4 were not collected because the hold time for NO_3 is 48 hours, and since the sample was collected on Saturday it would not have been analyzed on time.
[i]Two different types of Lexan™ tubes were used to line the sample core. Samples were collected by pouring deionized water through the tube.
[j]NO_3, Br, Cl, F, and SO_4 were the only parameters collected in order to make up for them not being collected for sample GBP012.

SC = Site Characterization parameters are: total VOCs, total SVOCs, TAL metals, boron, molybdenum, uranium, TPH (diesel-range organics [DRO] and gasoline-range organics [GRO])
WQCC = New Mexico Water Quality Control Commission parameters are: nitrates (NO_3), cyanide, bromide (Br), chloride (Cl), fluoride (F), sulfate (SO_4), radium-226 and radium-228
WC = Waste Characterization parameters are: TCLP metals, TCLP VOCs, TCLP SVOCS, and Tritium.
NO_3 = Nitrates
Br = Bromide
Cl = Chloride
F = Fluoride
SO_4 = Sulfate
BG = Background parameters are: TAL metals, boron, molybdenum, uranium, total SVOCs, cyanide, Br, Cl, F, SO_4, NO_3, and radium-226/-228
NA = Not applicable

C.4.4 *Waste Management*

Eight drums of investigation-derived waste were generated during the investigation. The waste was characterized as sanitary (i.e., nonhazardous and nonradioactive). All waste was shipped to a licensed disposal facility.

C.4.5 *Geology*

The natural contour of the site slopes northeast into Leandro Canyon. Leandro Canyon is an ephemeral drainage and tributary of the ephemeral La Jara Creek.

Field descriptions performed by the field geologist for each boring were recorded on a Visual Classification of Soil Log. The stratigraphy is dominated by poorly graded red-brown to brown silty sand, poorly graded sand, and silt to a minimum of 30 ft bgs. The maximum depth of any boring was 36 ft bgs. Occasional clay layers exist at depths varying from 2 to 20 ft bgs. Bentonite chips were discovered interspersed in some of the borings. These chips are likely a product of the historic drilling operations at the site. Weathered sandstone bedrock was encountered between 14 to 24 ft bgs in a few of the borings in the northwest portion of the site.

C.4.6 Hydrology

No groundwater was encountered during the preliminary field investigation. Maximum depth of boreholes was 36 ft bgs.

C.5.0 Gasbuggy Preliminary Investigation Soil Sample Results

The analytical results of samples collected during the Gasbuggy preliminary field investigation have been compiled and summarized in the following subsections. The parameters analyzed for in this investigation are presented in Table C.4-2. The laboratory analytical methods utilized for this investigation are presented in Appendix B.

Samples were analyzed at Paragon Analytics in Fort Collins, Colorado. Complete analytical results are retained in project files as both hard copy files and electronic media.

C.5.1 Site Characterization Parameters

The site characterization parameters (i.e., TPH [DRO, GRO], VOCs, SVOCs, RCRA metals, and tritium) were selected through the application of site knowledge using the EPA's *Guidance for the Data Quality Objectives Process* (EPA, 1994a). The PALs for these parameters (i.e., the Region IX Industrial Soil PRGs [EPA, 1999a]) are presented in association with the results for these analyses. The results will be used as necessary to formulate corrective action decisions and/or as part of a risk assessment, if necessary.

C.5.1.1 Total Petroleum Hydrocarbon Analytical Results

The TPH analytical results are provided in Table C.5-1. Analytical results show that seven samples have TPH values greater than 100 milligrams per kilogram (mg/kg), indicating a significant detection. All of the samples in which TPH was detected above 100 mg/kg, except for two, were collected from a layer of drilling mud identified by visual observation within the mud pits. The exceptions (i.e., GBPS250507 and GBPS280608) were both collected from the berm that separates the Well GB-2 Mud Pit from Well GB-E Mud Pit A. The flare stack was located at the northern end of this berm. Based on visual observation, this berm appears to have been constructed at least partially by pushing up drill cuttings and drilling mud from the mud pits. These two samples were also the only two in which gasoline was detected at concentrations greater than 100 mg/kg. The source of the gasoline is not known. In all cases where TPH was detected at levels greater than 100 mg/kg, a sample collected at a lower depth in the same borehole indicated a TPH concentration of less than 100 mg/kg and/or a nondetect.

Table C.5-1
Soil Sample Results for TPH
(Page 1 of 3)

Borehole Location	Sample Number	Contaminants of Potential Concern (mg/kg)	
		Diesel	Gasoline
Well GB-2 Mud Pit and Well GB-E Mud Pit D[a]	**GBPS010609[b]**	2,100 (J)	3.1
	GBPS010911[b]	270	1.6
	GBPS011214	5.9 (U)	0.59 (U)
	GBPS011921	27	0.57 (U)
Well GB-2 Mud Pit	**GBPS020610[b]**	300	0.041(J)
	GBPS021719	5.9 (U)	0.59 (U)
Well GB-E Mud Pit A	**GBPS030406[b]**	720 (J)	0.58 (U)
	GBPS030911	5.6 (U)	0.56 (U)
	GBPS031416	5.6 (U)	0.56 (U)
Landfill E	GBPS040406	5.7 (U)	0.57 (U)
	GBPS040911	5.5 (U)	0.55 (U)
	GBPS041416	5.6 (U)	0.56 (UJ)
Landfill E	GBPS050408	5.8 (U)	0.58 (U)
	GBPS051012	5.3 (U)	0.53 (U)
	GBPS051820	5.5 (U)	0.55 (U)
	GBPS01[c]	5.5 (U)	0.55 (U)
Well EPNG 10-36 Sump	GBPS060608	8.2	0.52 (U)
	GBPS061012	6.4 (U)	0.53 (U)
	GBPS061618	6.3 (U)	0.58 (U)
Well GB-E Mud Pit E	**GBPS070608[b]**	5.7 (U)	0.57 (U)
	GBPS071012	7.6 (U)	0.57 (U)
	GBPS071618	5.6 (U)	0.56 (U)
Well GB-1 Drill Pad	GBPS080204	5.2 (U)	0.52 (U)
	GBPS081416	5.5 (U)	0.55 (U)
Well GB-1 Drill Pad	GBPS090204	5.4 (U)	0.54 (U)
	GBPS091416	5.3 (U)	0.53 (U)
Well GB-1 Drill Pad	GBPS100204	5.6 (U)	0.56 (U)
	GBPS101416	5.7 (U)	0.57 (U)

Table C.5-1
Soil Sample Results for TPH
(Page 2 of 3)

Borehole Location	Sample Number	Contaminants of Potential Concern (mg/kg)	
		Diesel	Gasoline
Well GB-E Drill Pad	GBPS110204	5.5 (U)	0.55 (U)
	GBPS111416	5.7 (U)	0.57 (U)
Well GB-1 Mud Pit	**GBPS120204**[b]	5.5 (U)	0.55 (U)
	GBPS120608	6.1 (U)	0.54 (U)
	GBPS121719	6.3 (U)	0.58 (U)
Well GB-E Mud Pit A	GBPS131920	5.6 (U)	0.56 (U)
Well EPNG 10-36 Drill Pad	GBPS150204	5.2 (U)	0.52 (U)
	GBPS151416	5.8 (U)	0.58 (U)
Well EPNG 10-36 Drill Pad	GBPS160204	5.2 (U)	0.52 (UJ)
	GBPS02[c]	5.2 (U)	0.52 (U)
	GBPS161416	6.3 (U)	0.58 (U)
Well EPNG 10-36 Drill Pad	GBPS170204	5.3 (U)	0.53 (U)
	GBPS171314	5.4 (U)	0.54 (U)
	GBPS172123	5.6 (U)	0.56 (U)
Well GB-E Mud Pit E	GBPS180608	14 (U)	0.55 (U)
	GBPS180911[b]	10	0.68 (U)
	GBPS181416	5.4 (U)	0.54 (U)
	GBPS182122	5.9 (U)	0.59 (U)
Well GB-3 Drill Pad	GBPS190204	5.4 (U)	0.54 (UJ)
	GBPS191416	5.9 (U)	0.53 (U)
Well GB-3 Drill Pad	GBPS200204	7.5 (U)	0.53 (U)
	GBPS201416	5.6 (U)	0.56 (U)
Well GB-2 Drill Pad	GBPS210204	5.5 (U)	0.55 (U)
	GBPS210608	5.3 (U)	0.53 (U)
	GBPS211416	6.4 (U)	0.58 (U)

Table C.5-1
Soil Sample Results for TPH
(Page 3 of 3)

Borehole Location	Sample Number	Contaminants of Potential Concern (mg/kg)	
		Diesel	Gasoline
Well GB-2 Drill Pad	GBPS220204	5.6 (U)	0.56 (U)
	GBPS221416	6.1 (U)	0.56 (U)
	GBPS03[c]	6.8 (U)	0.56 (U)
	GBPS222021	5.6 (U)	0.55 (U)
Well GB-E Mud Pit A	**GBPS240506[b]**	2,600 (J)	6.2 (J)
	GBPS241416	9.9 (UJ)	0.59 (U)
Flare stack area	GBPS250507	250 (J)	340
	GBPS251012	6.5 (UJ)	0.58 (U)
Well GB-E Drill Pad	GBPS260204	11 (J)	0.52 (U)
	GBPS261416	8.6 (UJ)	0.54 (U)
	GBPS04[c]	5.4 (U)	0.54 (U)
Well GB-E Drill Pad	GBPS270204	5.3 (U)	0.53 (U)
	GBPS271416	5.3 (U)	0.53 (U)
Berm that separates the Well GB-E Mud Pit A and the Well GB-2 Mud Pit	GBPS280608	360	3,300
	GBPS281012	10 (U)	0.57 (U)
	GBPS282224	5.6 (U)	0.56 (U)
	GBPS283032	5.9 (U)	0.59 (U)
	GBPS283436	6 (U)	0.6 (U)
Well GB-1 Mud Pit	**GBPS290103[b]**	5.5 (U)	0.55 (U)
	GBPS291416	5.8 (U)	0.58 (U)

[a]The Well GB-E Mud Pit D is located within the bounds of the Well GB-2 Mud Pit and appears to overlay the Well GB-2 Mud Pit.
[b]Visual observation of the soil core indicates this sample was collected in a suspect drilling mud layer.
[c]Sample is field duplicate of above sample.

Darker shaded area = Indicates analytical result exceeds 100 mg/kg
J = Estimated value
U = Undetected

C.5.1.2 Total Volatile Organic Compound Results

The total VOC analytical results above the minimum reporting limits, along with the associated PALs, are presented in Table C.5-2. Nondetects were not reported to limit the length of the report. 1,2,4-Trimethylbezene was detected in sample GBPS250507 at a concentration of 40,000 micrograms per kilogram (μg/kg) (PAL is 5,700 μg/kg). This sample was collected from a depth of 5 to 7 ft bgs from the borehole located at the historic location of the flare stack. This compound is known to be found in many petroleums (Merck, 1976). This sample also contained levels of diesel over 100 mg/kg, and is one of the two samples in which gasoline was detected over 100 mg/kg. The source of the contamination is not known but believed to be associated with production and flaring of natural petroleum hydrocarbons. The contamination is believed to be localized to this location. Further investigation will be conducted in the flare stack area to determine the nature and extent of this potential contamination. No other VOCs were detected at levels which exceeded PALs.

Other VOCs that were detected are either in samples in which TPH was detected above 100 mg/kg or are common laboratory contaminants (i.e., acetone and methylene chloride). The nonlaboratory contaminants are likely present as part of the TPH formulation. The only exceptions to this are contaminants (i.e., 1,2,4-trimethylbenzene; carbon tetrachloride, and chloroform) detected at concentrations less than 1 percent of the associated PAL in samples collected from borehole GBP28.

C.5.1.3 Total Semivolatile Organic Compound Results

The total SVOC analytical results above the minimum reporting limits, along with the associated PALs, are presented in Table C.5-3. Nondetects were not reported to limit length of report. Concentrations of TPH above 100 mg/kg were detected in seven of the eight samples in which SVOCs were detected. These SVOCs are likely present as part of the TPH formulation. The one sample in which SVOCs were detected but TPH was not detected above 100 mg/kg was sample GBPS270204. The only SVOC detected above minimum reporting limits in this sample was Bis(2-ethylhexyl) phthalate, which is a common laboratory contaminant. No SVOCs were detected at levels which exceeded PALs.

Table C.5-2
Soil Sample Results for VOCs (Detects Only)
(Page 1 of 4)

Sample No.	Contaminants of Potential Concern (µg/kg)																
	1,2,4-Trimethylbenzene	1,3,5-Trimethylbenzene	Acetone	Benzene	Carbon Disulfide	Carbon Tetrachloride	Chloroform	Ethylbenzene	Isopropylbenzene (Cumene)	Total Xylenes[a]	Methylene Chloride	Naphthalene	N-Butylbenzene	N-Propylbenzene	P-Isopropyltoluene	Sec-Butylbenzene	Toluene
Preliminary Action Levels[b]	5,700	70,000	6,200,000	1,500	720,000	530	520	230,000	520,000	210,000	21,000	190,000	240,000	240,000	NA	220,000	520,000
GBPS010609	780	220	--	5.3 (J)	--	--	--	14 (J)	15 (J)	200	--	1,200	57 (J)	35 (J)	160	39 (J)	--
GBPS010911	260	72	--	--	--	--	--	4.1 (J)	5.1 (J)	60	--	260	16 (J)	13	31	13	--
GBPS020610	44	78	--	--	--	--	--	--	--	--	--	280	--	3.6 (J)	34	6.8 (J)	--
GBPS021719	--	--	24	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GBPS030406	--	--	--	--	--	--	--	--	--	--	--	4.4 (J)	--	--	--	--	--
GBPS031416	--	--	19 (J)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GBPS031416	--	--	65	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GBPS040406	--	--	26	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GBPS040911	--	--	73	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GBPS041416	--	--	180	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GBPS050408	--	--	190	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GBPS051012	--	--	46	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GBPS01[c]	--	--	31	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GBPS061618	--	--	160	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GBPS071012	--	--	110	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table C.5-2
Soil Sample Results for VOCs (Detects Only)
(Page 2 of 4)

Sample No.	Contaminants of Potential Concern (µg/kg)																
	1,2,4-Trimethylbenzene	1,3,5-Trimethylbenzene	Acetone	Benzene	Carbon Disulfide	Carbon Tetrachloride	Chloroform	Ethylbenzene	Isopropylbenzene (Cumene)	Total Xylenes[a]	Methylene Chloride	Naphthalene	N-Butylbenzene	N-Propylbenzene	P-Isopropyltoluene	Sec-Butylbenzene	Toluene
Preliminary Action Levels[b]	5,700	70,000	6,200,000	1,500	720,000	530	520	230,000	520,000	210,000	21,000	190,000	240,000	240,000	NA	220,000	520,000
GBPS071618	--	--	97	--	--	--	--	--	--	--	110 (B)	--	--	--	--	--	--
GBPS080204	--	--	--	--	--	--	--	--	--	--	88 (B)	--	--	--	--	--	--
GBPS081416	--	--	130 (B)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GBPS101416	--	--	85	--	--	--	--	--	--	--	54 (B)	--	--	--	--	--	--
GBPS111416	--	--	--	--	--	--	--	--	--	--	66 (B)	--	--	--	--	--	--
GBPS120204	--	--	99	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GBPS121719	--	--	190	--	--	--	--	--	--	--	70 (B)	--	--	--	--	--	--
GBPS131920	--	--	150	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GBPS150204	--	--	130	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GBPS151416	--	--	170	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GBPS160204	--	--	52	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GBPS161416	--	--	30	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GBPS170204	--	--	14 (J)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GBPS171314 RR1	--	--	1,600	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table C.5-2
Soil Sample Results for VOCs (Detects Only)
(Page 3 of 4)

Sample No.	Contaminants of Potential Concern (µg/kg)																
	1,2,4-Trimethylbenzene	1,3,5-Trimethylbenzene	Acetone	Benzene	Carbon Disulfide	Carbon Tetrachloride	Chloroform	Ethylbenzene	Isopropylbenzene (Cumene)	Total Xylenes[a]	Methylene Chloride	Naphthalene	N-Butylbenzene	N-Propylbenzene	P-Isopropyltoluene	Sec-Butylbenzene	Toluene
Preliminary Action Levels[b]	5,700	70,000	6,200,000	1,500	720,000	530	520	230,000	520,000	210,000	21,000	190,000	240,000	240,000	NA	220,000	520,000
GBPS172123	--	--	21 (J)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GBPS180911	--	--	55 (J)	--	--	--	--	--	--	--	2.6 (J)	--	--	--	--	--	--
GBPS181416	--	--	16 (J)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GBPS182122	--	--	17 (J)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GBPS201416	--	--	24		--	--	--	--	--	--	--	--	--	--	--	--	--
GBPS210204	--	--	220	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GBPS211416	--	--	450	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GBPS03	--	--	15 (J)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GBPS222021	--	--	13 (J)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GBPS240506	650 (J)	220 (J)	80 (J)	12 (J)	1.3 (J)	--	--	160 (J)	68 (J)	810	--	730 (J)	35 (J)	120 (J)	32 (J)	36 (J)	55 (J)
GBPS241416	--	--	100	--	--	--	--	--	--	--	62 (J)	--	--	--	--	--	--
GBPS250507	40,000 (J)	24,000 (J)	--	23 (J)	--	6.3 (J)	--	1,900 (J)	6,600 (J)	38,000	--	3,300 (J)	8,100 (J)	6,700 (J)	8,500 (J)	4,800 (J)	2,400 (J)
GBPS260204	--	--	440	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GBPS251012	--	--	--	--	--	--	--	--	--	--	44 (J)	--	--	--	--	--	--
GBPS261416	--	--	73	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table C.5-2
Soil Sample Results for VOCs (Detects Only)
(Page 4 of 4)

Sample No.	Contaminants of Potential Concern (µg/kg)																
	1,2,4-Trimethylbenzene	1,3,5-Trimethylbenzene	Acetone	Benzene	Carbon Disulfide	Carbon Tetrachloride	Chloroform	Ethylbenzene	Isopropylbenzene (Cumene)	Total Xylenes[a]	Methylene Chloride	Naphthalene	N-Butylbenzene	N-Propylbenzene	P-Isopropyltoluene	Sec-Butylbenzene	Toluene
Preliminary Action Levels[b]	5,700	70,000	6,200,000	1,500	720,000	530	520	230,000	520,000	210,000	21,000	190,000	240,000	240,000	NA	220,000	520,000
GBPS280608	520	210	980	--	--	--	--	72	36	920	31 (J)	130	37	75	29	--	150
GBPS281012	3.4 (J)	--	--	--	--	--	--	--	--	--	--	11	--	--	--	--	--
GBPS282224	--	--	49	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GBPS283032	--	--	18 (J)	--	--	1.7 (J)	--	--	--	--	--	--	--	--	--	--	--
GBPS283436	--	--	--	--	--	--	1.1 (J)	--	--	--	--	--	--	--	--	--	--
GBPS291416	--	--	160	--	--	--	--	--	--	--	--	--	--	--	--	--	--

[a]Xylene results were reported as concentrations of m+p-xylene and o-xylene. The reported values were added to get total xylene.
[b]Environmental Protection Agency *Region IX Industrial Preliminary Remediation Goals* (EPA, 1999a).
[c]Sample GBPS01 is a field duplicate of GBPS051820. There were no VOC detects for GBPS051820.
[d]Sample is field duplicate of above sample.

-- = Analyte not detected above minimum reporting limits.
J = Estimated value
B = Analyte found in associated blank
Darker shaded area = Indicates analytical result exceeds PAL

Table C.5-3
Soil Sample Results for SVOC (Detects Only)

Sample No.	Contaminants of Potential Concern (µg/kg)				
	2-Methylnaphthalene	Fluorene	Naphthalene	Phenanthrene	Bis(2-ethylhexyl) phthalate
Preliminary Action Levels[a]	NA	33,000,000	190,000	NA	180,000
GBPS010609	3,100	570	1,000	660	--
GBPS010911	610	--	190 (J)	--	--
GBPS020610	1,400	--	--	200 (J)	--
GBPS030406	1,400	--	440	490	--
GBPS240506	15,000	990 (J)	6,600	1,300 (J)	--
GBPS250507	1,100	--	440	--	--
GBPS270204	--	--	--	--	67
GBPS280608	310	--	--	--	92

[a]Environmental Protection Agency *Region IX Industrial Preliminary Remediation Goals* (EPA, 1999a)

NA = Not applicable (There is no *Region IX Industrial Preliminary Remediation Goals* for this constituent.)
-- = Analyte not detected above minimum reporting limits.
J = Estimated value

C.5.1.4 Total RCRA Metals

The total RCRA metals analytical results, along with the associated PALs, are presented in Table C.5-4. Background sample results are located at the bottom of the table. Only arsenic was found in concentrations which exceeded the PAL. Statistical comparison of the arsenic results for the background samples and site characterization samples indicate the two sets of results are not "significantly different."

Table C.5-4
Soil Sample Results for RCRA Metals
(Page 1 of 4)

Sample Number	Contaminants of Potential Concern (mg/kg)							
	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
Preliminary Action Level[a]	2.7	100,000	810	450	1,000	610	10,000	10,000
GBPS010609	7	270	1.2 (U)	15	15	0.009 (UJ)	1.2 (U)	1.2 (U)
GBPS010911	1.7	260	0.59 (U)	9.7	62	0.015 (UJ)	0.59 (U)	1.2 (U)
GBPS011214	2.1	320	1.2 (UJ)	17	14	0.02 (UJ)	1.1 (B)	1.2 (U)
GBPS011921	1.4	88	0.57 (UJ)	11	12	0.081 (B)	0.42 (B)	1.1 (U)
GBPS020610	2.7	190	0.57 (U)	13	27	0.017 (UJ)	0.55 (B)	1.1 (U)
GBPS021719	1.5	380	0.59 (U)	9.9	11	0.088 (UJ)	0.59 (U)	1.2 (UJ)
GBPS030406	2.2	190	0.58 (U)	22	9.9	0.012 (UJ)	0.53 (B)	1.2 (U)
GBPS030911	3.7	220	0.56 (U)	13	7.7	0.112 (UJ)	0.48 (B)	1.1 (UJ)
GBPS031416	3.4	220	0.56 (U)	12	7.6	0.113 (UJ)	0.56 (U)	1.1 (UJ)
GBPS040406	3.1	220	0.57 (U)	14	7.4	0.011 (UJ)	0.53 (B)	1.1 (U)
GBPS040911	2.9	200	0.55 (U)	10	6.2	0.109 (UJ)	0.55 (U)	1.1 (UJ)
GBPS041416	3.1	230	0.56 (U)	13	8.2	0.113 (UJ)	0.56 (U)	1.1 (UJ)
GBPS050408	3.3	220	0.58 (U)	15	8.5	0.011 (UJ)	0.39 (B)	1.2 (U)
GBPS051012	2.7	160	0.53 (U)	8.8	5.8	0.106 (UJ)	0.53 (U)	1.1 (UJ)
GBPS051820	2.5	150	0.55 (U)	9.4	6.4	0.11 (UJ)	0.55 (U)	1.1 (UJ)
GBPS01[b]	2.9	190	0.55 (U)	10	7	0.11 (UJ)	0.55 (U)	1.1 (UJ)
GBPS060608	2.9	130	0.52 (U)	26	6.5	0.012 (UJ)	0.52 (U)	1 (U)
GBPS061012	2.2	140	0.53 (U)	11	5.4	0.005 (U)	0.57	1.1 (U)
GBPS061618	2	340	0.58 (U)	13	10	0.12 (U)	0.4 (B)	1.2 (U)
GBPS070608	2.7	310	0.57 (U)	12	14	0.006 (UJ)	0.41 (B)	1.1 (U)
GBPS071012	2.4	190	0.57 (U)	10	6.8	0.005 (U)	0.32 (B)	1.1 (U)
GBPS071618	2.3	290	0.56 (U)	10	6.1	0.003 (U)	0.56 (U)	1.1 (U)
GBPS080204	1.8	120	0.52 (U)	8.2	6	0.1 (U)	0.52 (U)	1 (U)
GBPS081416	2.3	150	0.55 (U)	8.8	6.1	0.11 (U)	0.55 (U)	1.1 (U)

Table C.5-4
Soil Sample Results for RCRA Metals
(Page 2 of 4)

Sample Number	Contaminants of Potential Concern (mg/kg)							
	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
Preliminary Action Level[a]	**2.7**	**100,000**	**810**	**450**	**1,000**	**610**	**10,000**	**10,000**
GBPS090204	2.8	210	0.54 (U)	13	8.3	0.007 (U)	0.49 (B)	1.1 (U)
GBPS091416	2.1	140	0.53 (U)	8.6	6.9	0.11 (U)	0.53 (U)	1.1 (U)
GBPS100204	3.3	230	0.56 (U)	16	11	0.023 (UJ)	0.75	1.1 (U)
GBPS101416	3.5	240	0.57 (U)	12	9.5	0.11 (U)	0.57 (U)	1.1 (U)
GBPS110204	3.1	240	0.55 (U)	13	7.3	0.007 (UJ)	0.43 (B)	1.1 (U)
GBPS111416	3.3	240	0.57 (U)	11	9	0.005 (U)	0.57 (U)	1.1 (U)
GBPS120204	1.9	430	0.033 (U)	15	17	0.088 (B)	0.54 (B)	1.1 (U)
GBPS120608	2.4	2,300	0.54 (U)	12	31	0.012 (U)	0.42 (B)	1.1 (U)
GBPS121719	2.2	180	0.58 (U)	12	9.6	0.12 (U)	0.58 (U)	1.2 (U)
GBPS131920	3	150	0.56 (UJ)	10	6.9	0.11 (UJ)	0.47 (B)	1.1 (U)
GBPS150204	2.3	160	0.52 (UJ)	11	6.3	0.1 (UJ)	0.58	1 (U)
GBPS151416	2.4	210	0.58 (UJ)	13	8.4	0.12 (UJ)	0.86	1.2 (U)
GBPS160204	2.6	180	0.52 (UJ)	13	7.2	0.002 (UJ)	0.72	1 (U)
GBPS02[b]	2.7	190	0.52 (U)	13	7.7	0.004 (UJ)	0.72	1 (U)
GBPS161416	1.8	160	0.58 (UJ)	12	7.4	0.12 (UJ)	0.58 (U)	1.2 (U)
GBPS170204	2.5	170	0.53 (U)	12	8.1	0.005 (UJ)	0.54	1.1 (U)
GBPS171314	2.8	160	0.54 (UJ)	10	6.5	0.11 (UJ)	0.37 (B)	1.1 (U)
GBPS172123	0.62 (B)	110	0.56 (UJ)	11	5	0.11 (UJ)	0.56 (U)	1.1 (U)
GBPS180608	2.7	210	0.55 (UJ)	14	14	0.005 (UJ)	0.67	1.1 (U)
GBPS180911	2.9	230	0.68 (U)	13	63	0.012 (UJ)	0.45 (B)	1.4 (U)
GBPS181416	3	160	0.54 (UJ)	11	6.8	0.11 (UJ)	0.54 (U)	1.1 (U)
GBPS182122	2.7	580	1.2 (UJ)	16	12	0.082 (UJ)	1.2 (U)	1.2 (U)
GBPS190204	3.3	290	1.1 (UJ)	14	13	0.014 (UJ)	1.1 (U)	1.1 (U)
GBPS191416	2.6	140	0.53 (U)	8.1	4.5	0.11 (UJ)	0.71	1.1 (U)

Table C.5-4
Soil Sample Results for RCRA Metals
(Page 3 of 4)

Sample Number	Contaminants of Potential Concern (mg/kg)							
	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
Preliminary Action Level[a]	**2.7**	**100,000**	**810**	**450**	**1,000**	**610**	**10,000**	**10,000**
GBPS200204	2.3	290	1.1	12	26	0.021 (UJ)	0.43 (B)	1.1 (U)
GBPS201416	2.7	170	0.56 (UJ)	10	6.2	0.11 (UJ)	0.59	1.1 (U)
GBPS210204	1.8	380	0.37 (B)	11	12	0.052 (B)	0.34 (B)	1.1 (U)
GBPS210608	2.7	170	0.53 (U)	9.5	5.6	0.11 (UJ)	0.54	1.1 (U)
GBPS211416	2.7	220	0.58 (U)	13	8.1	0.12 (UJ)	0.68	1.2 (U)
GBPS220204	2.5	1,500	1.1 (U)	20	13	0.029 (UJ)	1.1 (U)	1.1 (U)
GBPS221416	1.6	180	1.1 (U)	20	12	0.028 (UJ)	1.1 (U)	1.1 (U)
GBPS03[b]	1.6	150	1.1 (U)	19	12	0.028 (UJ)	1.1 (U)	1.1 (U)
GBPS222021	1.1	330	0.071 (B)	15	6.5	0.11 (UJ)	0.76	1.1 (U)
GBPS240506	3.1	210	0.6 (UJ)	30	19 (J)	0.01 (UJ)	1.1	1.2 (U)
GBPS241416	3.8	280	0.59 (UJ)	17	10 (J)	0.002 (UJ)	1.3	1.2 (U)
GBPS250507	2.7	230	0.56 (UJ)	39	13 (J)	0.11 (UJ)	0.85	1.1 (U)
GBPS251012	3.5	370	0.58 (UJ)	16	10 (J)	0.12 (UJ)	1	1.2 (U)
GBPS260204	2.1	120	0.52 (U)	8.3	5	0.1 (UJ)	0.52 (U)	1 (U)
GBPS261416	2.5	140	0.54 (U)	8.7	6.3	0.11 (UJ)	0.54 (U)	1.1 (U)
GBPS04[b]	3.2	200	0.54 (U)	11	7.1	0.11 (U)	0.54 (U)	1.1 (U)
GBPS270204	2.4	140	0.53 (U)	10	7	0.11 (U)	0.53 (U)	1.1 (U)
GBPS271416	2.9	190	0.53 (U)	10	6.5	0.11 (U)	0.3 (B)	1.1 (U)
GBPS280608	[illegible]	330	0.57 (U)	66	17	0.11 (U)	0.57 (U)	1.1 (U)
GBPS281012	3.3	390	0.57 (U)	15	9	0.11 (U)	0.57 (U)	1.1 (U)
GBPS282224	2.3	170	0.56 (U)	9.7	6.8	0.11 (U)	0.56 (U)	1.1 (U)
GBPS283032	2.6	240	0.59 (U)	12	9.3	0.12 (U)	0.39 (B)	1.2 (U)
GBPS283436	2.5	280	0.6 (U)	11	9.2	0.005 (UJ)	0.41 (B)	1.2 (U)
GBPS290103	2.3	410	1.1 (U)	16	12	0.018 (UJ)	1.1 (U)	1.1 (U)

Table C.5-4
Soil Sample Results for RCRA Metals
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Sample Number	Contaminants of Potential Concern (mg/kg)							
	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
Preliminary Action Level[a]	**2.7**	**100,000**	**810**	**450**	**1,000**	**610**	**10,000**	**10,000**
GBPS291416	1.6	320	0.58 (U)	14	8.1	0.12 (U)	0.58 (U)	1.2 (U)
GBPB010204[c]	1.8	310	0.53 (U)	11	5.6	0.11 (UJ)	0.53 (U)	1.1 (U)
GBPB010912[c]	1.6	250	1.1 (U)	15	7.2	0.008 (UJ)	1.1 (U)	1.1 (U)
GBPB030407[c]	3.2	280	0.54 (U)	13	8.5	0.11 (UJ)	0.54 (U)	1.1 (U)
GBPB031012[c]	2.5	240	0.56 (U)	13	9.9	0.003 (UJ)	0.31 (B)	1.1 (U)
GBPB031416[c]	1.5	290	1.1 (U)	9.7	11	0.11 (UJ)	1.1 (U)	1.1 (U)

[a]Environmental Protection Agency *Region IX Industrial Preliminary Remediation Goals* (EPA, 1999a)
[b]Sample is field duplicate of above sample.
[c]Sample collected at background location.

Darker shaded area = Indicates analytical result exceeds PAL
U = Undetected
J = Estimated value
B = Analyte found in associated blank

C.5.1.5 Tritium Results

The radioanalytical results for tritium are presented in Table C.5-5. There is no PAL for tritium. Samples were analyzed for tritium for two purposes, waste characterization and site characterization. The waste characterization samples were generally collected from a layer within the borehole in which drilling mud or other disturbed media could be identified. The site characterization samples were collected at arbitrary 4-ft intervals from four boreholes: GBP14, GBP23, GBP24, and GBP25.

Boreholes GBP14, GBP23, and GBP25 were completed at locations where some of the highest levels of tritium were detected during the 1978 sampling event. Borehole GBP14 was located approximately 25 ft east of the historic flare stack location. This is also the approximate location of profile set #14 from the 1978 sampling event. Borehole GBP23 was located at the approximate

Table C.5-5
Soil Sample Results for Tritium

Purpose	Sample Number	Tritium (pCi/g)	Purpose	Sample Number	Tritium (pCi/g)
WC	GBPS010609	0.033 (UJ)	WC	GBPS170204	0.001 (UJ)
WC	GBPS010911	0.039 (UJ)	WC	GBPS180911	1.6 (J)
WC	GBPS020610	0.038 (UJ)	WC	GBPS210204	0 (UJ)
WC	GBPS030406	0.037 (UJ)	Profile samples from location of gas/water separator	GBPS230304	0.008 (U)
WC	GBPS040406	-0.004 (UJ)		GBPS230708	0.011 (U)
WC	GBPS050408	0.024 (UJ)		GBPS231112	0.072 (U)
WC	GBPS060608	0.028 (UJ)		GBPS231516	0.079 (U)
WC	GBPS070608	0.142 (J)		GBPS231920	0.261 (LT)
WC	GBPS100204	-0.01 (UJ)	Profile samples from location west of flare stack	GBPS240304	0.011 (U)
WC	GBPS110204	0.001 (UJ)		GBPS240506	0.07 (U)
WC	GBPS120204	-0.004 (UJ)		GBPS241112	0.007 (U)
Profile samples from location just east of flare stack	GBPS140304	0.263 (J)		GBPS241416	0.005 (U)
	GBPS140708	7.32 (J)	Profile samples from location of flare stack	GBPS250304	0.402 (LT)
	GBPS141112	3.36 (J)		GBPS250708	0.56 (LT)
	GBPS141516	1.73 (J)		GBPS251012	0.29 (LT)
	GBPS141920	2.5 (J)			

WC = Waste characterization
pCi/g = Picocuries per gram
U = Undetected
J = Estimated value
LT = Result is less than requested minimum detectable concentration (MDC), but greater than sample-specific MDC.

location of the gas/water separator used during flaring operations. This is also the approximate location of profile set #1 from the 1978 sampling event. Borehole GBP25 was located at the approximate historic location of the flare stack and at the approximate location of profile set #24 from the 1978 sampling event. The highest concentration of tritium in soil moisture (i.e., 1,303 pCi/mL) detected during the 1978 sampling was detected at this location. See Appendix A for results of the 1978 profile sampling. Borehole GBP24 was completed approximately 50 ft west of the historic location of the flare stack and within Well GB-E Mud Pit A.

Of the 31 soil samples analyzed for tritium, 5 samples produced results higher than 1.0 picocuries per gram (pCi/g). Four of these samples were collected from Borehole GBP14. The highest concentration of tritium detected was 7.32 pCi/g in sample GBPS140708 collected at 7 to 8 ft bgs. Samples taken in the same borehole below the depth of sample GBPS140708 indicate lower concentrations of tritium. Based on the preliminary dose/risk assessment provided in Appendix D, these levels do not pose a risk to human health.

C.5.2 New Mexico Oil Conservation Division-Required Parameters

A second category of parameters were analyzed for indirect comparison to the NM WQCC action levels listed in Title 20 NMAC 6.2.3103, "Standards for Ground Water of 10,000 mg/L Total Dissolved Solids Concentration or Less" (NMAC, 1996b). These parameters (i.e., TAL metals, boron, molybdenum, uranium, bromide, chloride, cyanide, fluoride, nitrates, sulfates, and radium-226/-228) were specified by the NM OCD to show drilling fluids and drill cuttings were disposed of "in a manner to prevent contamination to surface or subsurface waters," as stated in 19 NMAC 15.C.105 (NMAC, 1996b). Sampling activities for these parameters were designed to collect samples at locations where the potential for contamination was highest (i.e., from layers of drilling mud).

All characterization samples collected during the preliminary field investigation were soil samples (i.e., no groundwater was encountered), thus the results cannot be directly compared to the NM WQCC water quality standards in 20 NMAC 6.2.3103 (NMAC, 1996a). The Region IX Industrial Soil PRGs (EPA, 1999a) are presented in association with the results for comparison. Further analysis of the data was not done at this time. This data may be used in the corrective action decision document to support decisions made on the closure of the mud pits.

C.5.2.1 Target Analyte List Metals, Boron, Molybdenum, and Uranium Results

The TAL metals (not including the RCRA metals) plus boron, molybdenum, and uranium analytical results above the minimum reporting limits, along with the associated Region IX PRGs (EPA, 1999a), as applicable, are presented in Table C.5-6. Nondetects were not reported to limit the length of the report. None of these COPCs were detected above the associated Region IX PRGs (EPA, 1999a).

Table C.5-6
Soil Sample Results for TAL Metals (Except RCRA Metals) and Molybdenum, Boron, and Uranium
(Page 1 of 6)

Sample No.	Contaminants of Potential Concern (mg/kg)																	
	Aluminium	Antimony	Beryllium	Boron	Calcium	Cobalt	Copper	Iron	Magnesium	Manganese	Molybdenum	Nickel	Potassium	Sodium	Thallium	Uranium	Vanadium	Zinc
PRG*	100,000	820	2,200	79,000	NA	100,000	76,000	100,000	NA	32,000	10,000	NA	NA	NA	NA	NA	14,000	100,000
GBPS010609	7,300	0.84 (J)	0.79	--	4,100	8.1	16	24,000	2,100	270	0.95 (B)	11	1,400 (J)	350 (J)	--	--	30	33
GBPS010911	6,700	--	0.81	--	4,900	5.7	13	12,000	1,900	230	--	9.3	1,300 (J)	1,000 (J)	--	--	18	30
GBPS011214	14,000	1.2 (B)	1.7	--	9,500	9.7	46	30,000	4,700	700	1 (B)	20	2,100	520	--	53	54	63
GBPS011921	12,000	0.59 (B)	1.3	--	6,700	5.5	55	17,000	3,200	160	0.87 (B)	11	2,400	990	--	20 (B)	47	51
GBPS020610	7,600	0.38 (J)	0.66	--	3,900	7.5	13	16,000	2,400	340	0.69 (B)	10	1,500 (J)	350 (J)	--	16 (B)	25	38
GBPS021719	11,000	0.72 (B)	1.2	--	7,100	4	36	18,000	2,900	150	--	10	1,500	320	--	--	39	41
GBPS030406	6,900	0.61 (J)	0.62	--	5,500	7	12	15,000	2,300	330	--	9.8	1,500 (J)	1,100 (J)	--	12 (B)	24	35
GBPS030911	7,800	0.44 (B)	0.7	--	3,300	8	11	16,000	2,500	440	--	11	1,100	100 (B)	--	--	25	35
GBPS031416	8,000	--	0.68	--	4,000	7.4	10	16,000	2,600	390	--	10	910	--	--	--	25	33
GBPS040406	9,000	0.41 (J)	0.74	--	3,100	7.7	12	18,000	2,500	420	0.64 (B)	11	1,600 (J)	190 (J)	--	34	28	38
GBPS040911	6,100	0.54 (B)	0.52 (B)	--	2,300	6.5	8.3	13,000	2,000	340	--	8.4	930	240	--	--	21	28
GBPS041416	8,600	0.81 (B)	0.74	--	3,400	7.9	11	17,000	2,700	430	--	11	1,100	130	--	--	27	37
GBPS050408	9,600	0.65 (J)	0.83	--	3,700	8.7	13	19,000	2,800	520	--	12	1,600 (J)	140 (J)	--	34	30	42
GBPS051012	5,400	0.43 (B)	0.49 (B)	--	2,300	5.9	7.8	12,000	1,900	300	--	8	690	--	--	--	19	26

Table C.5-6
Soil Sample Results for TAL Metals (Except RCRA Metals) and Molybdenum, Boron, and Uranium
(Page 2 of 6)

Sample No.	Contaminants of Potential Concern (mg/kg)																
	Aluminium	Antimony	Beryllium	Boron	Calcium	Cobalt	Copper	Iron	Magnesium	Manganese	Molybdenum	Nickel	Potassium	Sodium	Thallium	Uranium	Vanadium	Zinc
PRG[a]	100,000	820	2,200	79,000	NA	100,000	76,000	100,000	NA	32,000	10,000	NA	NA	NA	NA	NA	14,000	100,000
GBPS051820	5,900	0.52 (B)	0.51 (B)	--	3,100	6.9	7.8	13,000	2,000	370	--	8.5	850	--	--	--	21	27
GBPS01[b]	6,700	0.31 (B)	0.57	--	3,300	7.6	8.6	14,000	2,300	400	--	9.7	950	--	--	16 (B)	23	32
GBPS060608	5,200	0.35 (J)	0.46 (B)	--	2,200	5.9	7.7	12,000	1,600	290	--	7.5	780 (J)	170 (J)	--	--	19	31
GBPS061012	4,700	--	0.42 (J)	--	1,700	6	6.2	10,000	1,600	320	0.64 (B)	7.1	550 (J)	470	--	--	16	23
GBPS061618	9,800	--	1.2 (J)	--	5,600	11	23	20,000	3,500	310	0.71 (B)	14	1,200 (J)	180	--	38	38	48
GBPS070608	7,800	--	0.71	--	4,500	6.5	13	17,000	2,500	240	--	10	1,300 (J)	410 (J)	--	20 (B)	27	35
GBPS071012	6,400	--	0.59 (J)	--	3,000	6.7	9.1	13,000	2,300	370	--	9	940 (J)	310	--	--	20	31
GBPS071618	5,700	--	0.51 (J)	--	3,000	6.5	7.8	12,000	2,100	340	--	8.3	730 (J)	98 (B)	--	--	19	27
GBPS080204	4,300	--	0.39 (J)	--	2,000	5.4	8.4	9,700	1,700	280	--	7.2	1,300 (J)	170	--	--	17	28
GBPS081416	5,300	--	0.51 (J)	--	2,400	7.2	7.9	13,000	1,900	350	--	8.2	750 (J)	--	--	--	20	28
GBPS090204	7,400	--	0.72 (J)	--	3,600	8.5	13	16,000	2,500	530	--	11	1,800 (J)	160	--	22	26	40
GBPS091416	5,100	--	0.44 (J)	--	2,600	5.7	6.9	11,000	1,800	310	--	7.4	780 (J)	--	--	--	17	24
GBPS100204	8,800	0.47 (J)	0.75	--	3,500	9.2	13	19,000	2,700	550	0.55 (B)	12	1,800 (J)	160 (J)	--	32	30	42
GBPS101416	8,500	--	0.71 (J)	--	3,200	8.7	11	17,000	2,800	420	--	11	1,200 (J)	--	--	14 (B)	28	36

Table C.5-6
Soil Sample Results for TAL Metals (Except RCRA Metals) and Molybdenum, Boron, and Uranium
(Page 3 of 6)

Sample No.	Contaminants of Potential Concern (mg/kg)																	
	Aluminium	Antimony	Beryllium	Boron	Calcium	Cobalt	Copper	Iron	Magnesium	Manganese	Molybdenum	Nickel	Potassium	Sodium	Thallium	Uranium	Vanadium	Zinc
PRG[a]	100,000	820	2,200	79,000	NA	100,000	76,000	100,000	NA	32,000	10,000	NA	NA	NA	NA	NA	14,000	100,000
GBPS110204	8,100	0.45 (J)	0.7	--	3,100	7.6	10	17,000	2,400	440	--	10	1,300 (J)	150 (J)	--	25	27	34
GBPS111416	8,200	--	0.77 (J)	--	4,400	7.5	11	15,000	2,700	460	--	11	1,200 (J)	--	--	18 (B)	23	36
GBPS120204	14,000	0.87 (J)	1.6	--	8,700	12	44	22,000	4,600	340	--	20	2,000 (J)	660 (J)	--	38	39	68
GBPS120608	7,900	--	0.78 (J)	--	17,000	7.8	15	16,000	2,900	380	--	11	1,300 (J)	770	--	14 (B)	22	40
GBPS121719	10,000	--	0.89 (J)	--	4,300	9	16	17,000	3,200	370	--	13	1,400 (J)	250	--	31	26	43
GBPS131920	7,400	--	0.53 (J)	--	2,700	7	8.8	14,000	2,200	380	0.85 (B)	9.1	1,100	68 (B)	--	14 (B)	23	30
GBPS150204	6,200	0.5 (J)	0.46 (J)	--	2,100	6.6	8.6	13,000	1,900	390	0.73 (B)	8.2	1,400	260	--	12 (B)	22	30
GBPS151416	11,000	0.66 (J)	1.1 (J)	--	5,300	7.4	20	20,000	3,200	730	0.58 (B)	19	1,400	88 (B)	--	20 (B)	35	42
GBPS160204	7,300	0.59 (J)	0.55 (J)	--	2,700	7.7	10	16,000	2,200	460	0.99 (B)	9.8	1,600	170	--	24	26	36
GBPS02[b]	7,600	0.44 (B)	0.57	--	3,000	7.7	11	16,000	2,500	470	0.61 (B)	9.8	1,700	180	--	14 (B)	26	37
GBPS161416	10,000	0.68 (J)	0.81 (J)	--	4,100	7.7	14	18,000	3,400	360	--	11	1,800	99 (B)	--	28	27	48
GBPS170204	7,500	0.38 (J)	0.66	--	2,600	8.4	14	16,000	2,300	450	0.48 (B)	11	1,600 (J)	130 (J)	--	26	28	37
GBPS171314	6,600	0.56 (J)	0.49 (J)	--	2,400	7.1	8.3	14,000	2,200	380	0.53 (B)	9	860	82 (B)	--	19 (B)	23	29
GBPS172123	10,000	--	0.76 (J)	--	14,000	8.2	19	15,000	4,100	230	--	13	1,300	200	--	--	22	50

Table C.5-6
Soil Sample Results for TAL Metals (Except RCRA Metals) and Molybdenum, Boron, and Uranium
(Page 4 of 6)

Sample No.	Contaminants of Potential Concern (mg/kg)																	
	Aluminium	Antimony	Beryllium	Boron	Calcium	Cobalt	Copper	Iron	Magnesium	Manganese	Molybdenum	Nickel	Potassium	Sodium	Thallium	Uranium	Vanadium	Zinc
PRG[a]	100,000	820	2,200	79,000	NA	100,000	76,000	100,000	NA	32,000	10,000	NA	NA	NA	NA	NA	14,000	100,000
GBPS180608	8,400	0.44 (J)	0.64 (J)	--	3,800	7.2	12	16,000	2,500	270	0.82 (B)	10	1,500	440	--	15 (B)	26	39
GBPS180911	8,400	0.42 (J)	0.72	--	21,000	7.4	15	15,000	2,600	370	0.74 (B)	11	1,600 (J)	1300 (J)	--	--	24	36
GBPS181416	7,600	--	0.55 (J)	--	3,100	7.4	8.8	15,000	2,400	410	0.98 (B)	9.6	910	210	--	18 (B)	25	32
GBPS182122	13,000	1.2 (J)	1.5 (J)	--	11,000	5.9	24	29,000	3,400	230	0.98 (B)	11	2,000	820	--	30 (B)	68	50
GBPS190204	9,600	0.84 (J)	0.88 (J)	--	4,400	8.9	19	21,000	3,100	390	1.6	13	1,800	200	--	--	33	46
GBPS191416	5,000	0.57 (B)	0.38 (B)	--	1,800	4.4	6.9	11,000	1,500	220	--	6.2	610	64 (B)	--	--	19	21
GBPS200204	7,600	0.33 (J)	0.7 (J)	--	5,900	7.2	15	16,000	2,500	360	--	10	1,700	390	--	14 (B)	23	39
GBPS201416	7,100	0.32 (J)	0.53 (J)	--	3,700	6.6	8.3	14,000	2,200	350	--	9	880	70 (B)	--	14 (B)	23	28
GBPS210204	11,000	--	1.3	--	13,000	8.1	36	17,000	3,500	200	--	15	1,700 (J)	230 (J)	--	--	31	51
GBPS210608	6,100	0.46 (B)	0.46 (B)	--	2,200	5.5	6.2	12,000	1,700	290	--	7.6	1,100	63 (B)	--	--	21	24
GBPS211416	11,000	0.63 (B)	0.89	--	4,300	9.4	15	20,000	3,200	370	--	12	1,400	330	--	28	35	39
GBPS220204	14,000	0.83 (B)	1.4	--	8,400	13	31	28,000	4,800	330	--	19	1,400	320	--	--	38	73
GBPS221416	14,000	0.91 (B)	1.4	--	6,700	17	49	32,000	6,900	410	--	27	2,600	720	--	48	49	96
GBPS03[b]	14,000	1.1 (B)	1.4	--	6,200	16	43	33,000	6,500	400	--	27	2,700	710	0.85 (B)	43 (B)	50	94
GBPS222021	11,000	0.9 (B)	0.93	--	5,100	12	24	22,000	5,100	280	--	19	2,200	610	--	54	31	70

Table C.5-6
Soil Sample Results for TAL Metals (Except RCRA Metals) and Molybdenum, Boron, and Uranium
(Page 5 of 6)

Sample No.	Contaminants of Potential Concern (mg/kg)																	
	Aluminium	Antimony	Beryllium	Boron	Calcium	Cobalt	Copper	Iron	Magnesium	Manganese	Molybdenum	Nickel	Potassium	Sodium	Thallium	Uranium	Vanadium	Zinc
PRG[a]	100,000	820	2,200	79,000	NA	100,000	76,000	100,000	NA	32,000	10,000	NA	NA	NA	NA	NA	14,000	100,000
GBPS240506	7,800	--	0.82	--	6,800	7.6 (J)	24	16,000	2,800	270	0.52 (B)	14	1,800	1,600	--	--	21 (J)	41
GBPS241416	13,000	--	0.96	--	4,600	9.6 (J)	14	23,000	3,800	510	--	14	1,700	96 (B)	--	34	33 (J)	48
GBPS250507	9,900	--	0.73	9.7 (J)	16,000	7.6 (J)	13	16,000	2,600	310	--	10	2,000	500	--	16 (B)	28 (J)	41
GBPS251012	12,000	--	0.97	--	4,700	9.9 (J)	15	22,000	3,500	560	0.92 (B)	14	2,000	100 (B)	--	25	32 (J)	48
GBPS260204	4,400	0.65 (B)	0.38 (B)	--	1,700	5	5.4	9,900	1,500	290	--	6.4	800	98 (B)	--	--	16	23
GBPS261416	5,700	--	0.5 (B)	--	2,800	6.5	7.9	12,000	2,000	350	--	8.4	760	--	--	--	18	26
GBPS04[b]	7,200	0.42 (J)	0.58 (J)	--	5,500	6.4	8.7	14,000	2,200	370	0.52 (B)	8.9	1,000 (J)	--	--	--	24	30
GBPS270204	5,500	0.61 (J)	0.47 (J)	--	2,300	5.8	7.2	12,000	1,800	340	--	7.4	1,100 (J)	120 (J)	--	16 (B)	20	34
GBPS271416	6,600	0.36 (J)	0.53 (J)	--	4,900	6	7.9	12,000	2,000	350	0.54 (B)	8.3	960 (J)	--	--	13 (B)	22	28
GBPS280608	9,300	0.68 (J)	0.83 (J)	13	15,000	8.2	17	17,000	2,900	460	1.1	11	1,800 (J)	690 (J)	--	17 (B)	25	47
GBPS281012	10,000	0.83 (J)	0.92 (J)	--	4,700	9.1	14	19,000	3,200	500	1.1 (B)	13	1,700 (J)	120 (J)	--	35	30	42
GBPS282224	6,100	0.55 (J)	0.55 (J)	--	2,600	7.1	8.7	13,000	2,100	420	0.64 (B)	8.9	950 (J)	--	--	12 (B)	21	33
GBPS283032	7,600	0.44 (J)	0.65 (J)	--	3,400	10	9.2	16,000	2,400	640	0.5 (B)	13	1,100 (J)	--	--	19 (B)	26	47
GBPS283436	8,500	0.66 (J)	0.89 (J)	--	4,700	15	15	19,000	2,800	370	--	14	1,000 (J)	170 (J)	--	29	30	39

Table C.5-6
Soil Sample Results for TAL Metals (Except RCRA Metals) and Molybdenum, Boron, and Uranium
(Page 6 of 6)

Sample No.	Contaminants of Potential Concern (mg/kg)																	
	Aluminium	Antimony	Beryllium	Boron	Calcium	Cobalt	Copper	Iron	Magnesium	Manganese	Molybdenum	Nickel	Potassium	Sodium	Thallium	Uranium	Vanadium	Zinc
PRG[a]	100,000	820	2,200	79,000	NA	100,000	76,000	100,000	NA	32,000	10,000	NA	NA	NA	NA	NA	14,000	100,000
GBPS290103	12,000	0.65 (J)	1 (J)	--	5,700	11	21	21,000	3,900	720	--	17	1,400 (J)	160 (J)	--	--	39	59
GBPS291416	12,000	0.66 (J)	1 (J)	--	5,200	8.2	20	21,000	3,600	220	--	13	1,100 (J)	160 (J)	--	47	38	47
GBPB010204[c]	7,300	0.52 (B)	0.56	--	3,200	6.2	6.9	14,000	2,700	370	--	8.9	780	--	--	--	21	31
GBPB010912[c]	12,000	0.54 (B)	0.83	--	6,400	9.6	13	21,000	5,200	460	--	14	1,100	390	--	--	28	48
GBPB030407[c]	8,200	0.51 (B)	0.77	--	3,900	8.1	11	16,000	2,700	390	--	11	1,100	85 (B)	--	--	24	35
GBPB031012[c]	10,000	0.45 (B)	0.93	--	5,100	8.8	15	18,000	3,300	390	--	13	1,400	310	--	--	30	45
GBPB031416[c]	9,600	0.95 (B)	1.4	--	7,200	5.8	20	22,000	2,700	230	--	14	1,600	420	--	--	47	45

[a]Environmental Protection Agency *Region IX Industrial Preliminary Remediation Goals* (EPA, 1999a)
[b]Sample is field duplicate of above sample.
[c]Sample collected at background location.

J = Estimated value
B = Analyte found in associated blank

C.5.2.2 Bromide, Chloride, Fluoride, Nitrates, Sulfate, and Cyanide Results

The bromide, chloride, fluoride, nitrates, sulfate, and cyanide analytical results above the minimum reporting limits, along with the associated Region IX PRGs (EPA, 1999a), as applicable, are presented in Table C.5-7. Nondetects were not reported to limit the length of report. None of these COPCs were detected above the associated Region IX PRGs (EPA, 1999a).

C.5.2.3 Radium Results

The radioanalytical results for radium are presented in Table C.5-8. Radium is not a COPC associated with underground nuclear detonations or other DOE activities at the site.

C.5.3 Waste Characterization Parameters

Additional parameters including TCLP metals, TCLP VOCs, and TCLP SVOCs were analyzed for use in characterization of investigation-derived waste. The EPA regulatory limits for hazardous waste (CFR, 1999) are presented in association with the results of these analyses.

C.5.3.1 Toxicity Characteristic Leaching Procedure Metal Results

The TCLP metals analytical results above the minimum reporting limits, along with the associated regulatory limit (CFR, 1999), are presented in Table C.5-9. Nondetects were not reported to limit the length of the report. No COPCs were detected above regulatory limits.

C.5.3.2 Toxicity Characteristic Leaching Procedure Volatile Organic Compound and Semivolatile Organic Compound Results

The TCLP VOCs and TCLP SVOCs analytical results above the minimum reporting limits, along with the associated regulatory limit (CFR, 1999), are presented in Table C.5-10. Nondetects were not reported to limit the length of the report. None of these COPCs were detected above the regulatory limits.

C.5.4 Rejected Data

The data presented in Table C.5-11 was rejected (not usable for site characterization). These constituents, except for antimony, were not detected in other site characterization samples. Antimony was detected at very low levels (i.e., <2 mg/kg) in comparison to the PRG (i.e., 820 mg/kg). Rejected data did not impact the characterization.

Table C.5-7
Soil Sample Results for Bromide, Chloride, Fluoride, Nitrates, Sulfate, and Cyanide (Detects Only)

Sample Numbers	Contaminants of Potential Concern (mg/kg)					
	Bromide	Chloride	Fluoride	Nitrate	Sulfate	Cyanide
PRG[a]	NA	NA	53,000	NA	NA	NA
GBPS010609	--	5	5.3	1.8 (J)	39	--
GBPS010911	--	6.7	7.5	2.3 (J)	43	--
GBPS020610	1.2 (J)	4.3	2.4 (J)	11	150	0.5 (J)
GBPS030406	--	7	4.2 (J)	2.9	480	0.29 (J)
GBPS040406	--	2.2 (J)	3.9 (J)	2.6	16	0.41 (J)
GBPS050408	--	2.7	4.3 (J)	3.2	41	0.44 (J)
GBPS060608	--	1.2 (J)	2 (J)	1.3 (J)	41 (J)	--
GBPS070608	--	12 (J)	8.2 (J)	3.9 (J)	130 (J)	--
GBPS100204	--	1 (J)	3.7 (J)	2.3 (J)	53 (J)	--
GBPS110204	--	1.1 (J)	4.5 (J)	1.3 (J)	36 (J)	--
GBPS120204	--	3.6 (J)	13 (J)	1.8 (J)	110 (J)	--
GBPS170204	--	4.6	3.7	2.3	16	0.25 (J)
GBPS180911	1.4 (J)	120	6.9	3.8	380	0.42 (J)
GBPS210204	--	2 (J)	6.7 (J)	1.4 (J)	17 (J)	--
GBPS270204	--	1.7 (J)	1.5	2 (J)	70	--
GBPS271416	--	10	5.3	1.3 (J)	6.1 (J)	--
GBPB010204[b]	--	1.1 (J)	2.7 (J)	1.2 (J)	16	--
GBPB010912[b]	--	66	9.1 (J)	1.9 (J)	42	--
GBPB030407[b]	--	3.4	4.8 (J)	1.9 (J)	8.7 (J)	--
GBPB031012[b]	--	27	14 (J)	1.2 (J)	32	--
GBPB031416[b]	--	11	13 (J)	1.3 (J)	63	--

[a]Environmental Protection Agency *Region IX Industrial Preliminary Remediation Goals* (EPA, 1999a)
[b]Sample collected at background location.

NA = Not applicable (There is no *Region IX Industrial Preliminary Remediation Goals* for this constituent)
-- = Analyte not detected above minimum reporting limits.
J = Estimated value

Table C.5-8
Soil Sample Results for Radium-226 and Radium-228

Sample Number	Radium-226 (pCi/g)	Radium-228 (pCi/g)
GBPS010609	1.54	1.36
GBPS010911	1.5	1.3
GBPS020610	1.38	1.03
GBPS030406	1.4	1.29
GBPS040406	1.54	1.06
GBPS050408	1.62	1.43
GBPS060608	1.49	1.47
GBPS070608	2.4	1.93
GBPS100204	1.49	1.2
GBPS110204	1.77	0.96
GBPS120204	3.06	2.52
GBPS170204	1.44	1.13
GBPS180911	1.73	1.17
GBPS210204	2.49	2.29
GBPB010204[a]	1.32	1.26
GBPB010912[a]	1.56	1.69
GBPB030407[a]	1.83	1.25
GBPB031012[a]	1.99	1.33
GBPB031416[a]	2.86	2.15

[a]Sample collected at background location.

Table C.5-9
Soil Sample Results for TCLP Metals (Detects Only)

Sample Number	Constituents of Potential Concern (mg/L)		
	Barium	Chromium	Lead
Regulatory Limit[a]	**100**	**5.0**	**5.0**
GBPS010609	2.1	--	0.029 (B)
GBPS010911	1.9	--	0.07
GBPS020610	1.4	--	--
GBPS030406	0.89 (B)	--	--
GBPS040406	1	--	--
GBPS050408	0.97 (B)	--	--
GBPS060608	0.93 (B)	0.023 (B)	--
GBPS070608	1.2	--	--
GBPS100204	1.1	--	--
GBPS110204	0.92 (B)	--	--
GBPS120204	1.4	--	--
GBPS170204	0.9 (B)	--	--
GBPS180911	1.1	--	--
GBPS210204	2.1	--	--

[a]40 CFR 261.24, "Identification and Listing of Hazardous Waste" (CFR, 1999)

-- = Analyte not detected above minimum reporting limits.
B = Analyte found in associated blank.

Table C.5-10
TCLP VOCs and SVOCs (Detects Only)

Sample Number	Contaminants of Potential Concern (mg/L)	
	Chloroform	**2-Butanone (MEK)**
Regulatory Limit[a]	**6.0**	**200**
GBPS020610	0.00099 (J)	--
GBPS060608	--	.0073 (J)
GBPS070608	.0067 (J)	0.00023 (J)
GBPS110204	.0064 (J)	--

[a]40 CFR 261.24, "Identification and Listing of Hazardous Waste" (CFR, 1999)

MEK = Methyl ethyl ketone
-- = Analyte not detected above minimum reporting limits.
J = Estimated value

Table C.5-11
Rejected Data
(Page 1 of 2)

Sample Number	Contaminants of Potential Concern[a]																	
	Metals (mg/kg)	VOCs (µg/kg)													SVOCs (µg/kg)			
	Antimony	1,1,2,2-Tetrachloroethane	1,2,3-Trichlorobenzene	1,2,3-Trichloropropane	1,2,4-Trichlorobenzene	1,2-Dibromo-3-Chloropropane	1,2-Dichlorobenzene	1,3-Dichlorobenzene	1,4-Dichlorobenzene	2-Chlorotoluene	4-Chlorotoluene	Bromobenzene	Hexachlorobutadiene	Tert-Butylbenzene	2,4-Dinitrophenol	3-Nitroaniline	Benzoic Acid	Hexachlorocyclopentadiene
GBPB010204	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,800	--	1,800	350
GBPB010912	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,800	--	1,800	360
GBPB030407	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,800	360
GBPB031012	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,900	370
GBPB031416	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,900	370
GBPS010609	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2,000	--	--
GBPS010911	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2,000	--	370
GBPS020610	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,900	--	--
GBPS030911	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	370
GBPS031416	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	380
GBPS040406	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,900	--	--
GBPS041416	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	380
GBPS051012	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	350
GBPS051820	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	370
GBPS01[b]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	370
GBPS060608	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,700	--	--
GBPS170204	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,800	--	--
GBPS180911	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2,300	--	--
GBPS210608	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	360
GBPS211416	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	390
GBPS220204	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	370
GBPS221416	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	370
GBPS03[b]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	370

Table C.5-11
Rejected Data
(Page 2 of 2)

Sample Number	Contaminants of Potential Concern[a]																	
	Metals (mg/kg)	VOCs (µg/kg)													SVOCs (µg/kg)			
	Antimony	1,1,2,2-Tetrachloroethane	1,2,3-Trichlorobenzene	1,2,3-Trichloropropane	1,2,4-Trichlorobenzene	1,2-Dibromo-3-Chloropropane	1,2-Dichlorobenzene	1,3-Dichlorobenzene	1,4-Dichlorobenzene	2-Chlorotoluene	4-Chlorotoluene	Bromobenzene	Hexachlorobutadiene	Tert-Butylbenzene	2,4-Dinitrophenol	3-Nitroaniline	Benzoic Acid	Hexachlorocyclopentadiene
GBPS222021	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	370
GBPS240506	0.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,600
GBPS241416	2.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2,000	390
GBPS250507	2.2	28	28	28	28	56	28	28	28	28	28	28	28	28	--	--	--	370
GBPS251012	0.48	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	390
GBPS260204	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,700	--	1,700	350
GBPS261416	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,800	--	1,800	360
GBPS283436	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2,000	--	--
GBPS290103	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,800	--	--
GBPS291416	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,900	--	--
GBP025[c]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	48 µg/l[c]	--	9.5 µg/l[c]
GBP028[c]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	48 µg/l[c]	--	--
GBP030[c]	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	47 µg/l[c]	--	--

[a]Value shown in the table is the result reported by the laboratory.
[b]Sample is field duplicate of above sample.
[c]Sample is a field or source blank (see Table C.4-2) and is a water sample.

-- = Data for this constituent was not rejected.

C.6.0 Discussion of Investigation Results for the Surface Ground Zero Area

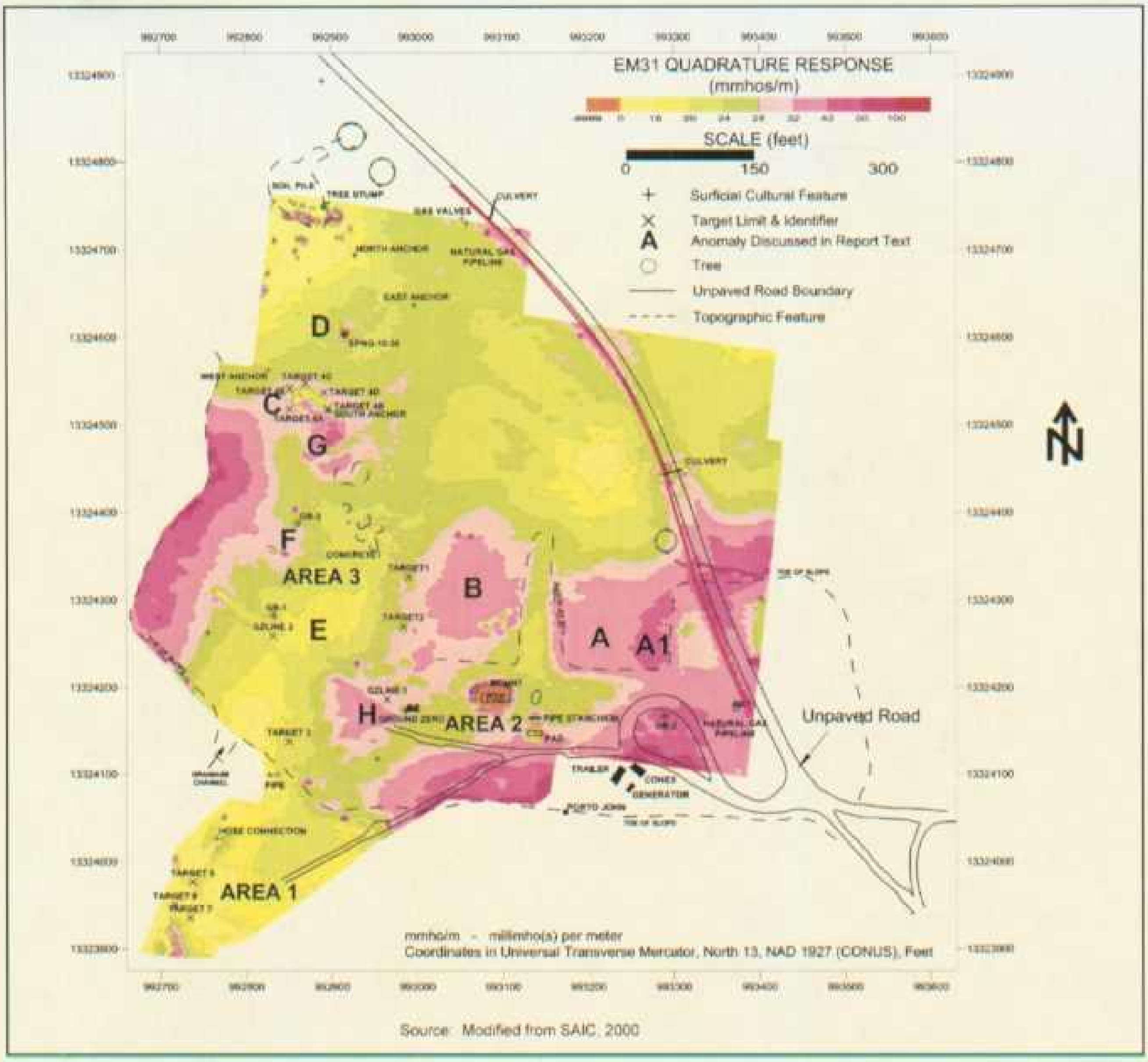
This section provides a summary of the geophysical and soil sampling findings of the preliminary field investigation in the SGZ area, and offers assumptions as to how the data can be interpreted. Conclusions presented in this portion of the document are meant only to provide direction for further investigation and not to draw final conclusions on the nature and extent of contamination.

The EM31 was used for an initial geophysical survey of the SGZ area. The EM31 data indicated numerous anomalies in both the quadrature phase and the inphase (see Figure C.6-1 and Figure C.6-2). Additional data was collected using EM61 in Areas 1, 2, and 3, as indicated in Figure C.6-1 and Figure C.6-2. Data was also collected using GPR at the locations specified as Targets 1 through 8 on Figure C.6-1 and Figure C.6-2. Many of the targets identified could be recognized as specific site features based on historical site photos and plans. Many of these features were further investigated through soil boring and soil sampling (see Figure C.6-3).

A summary of the SGZ area features identified during the investigation is provided in Table C.6-1.

C.6.1 Mud Pits

The geophysical survey was able to locate and roughly delineate the mud pits, approximately where historical documentation indicated they would be (see Figure C.6-1). As indicated in Table C.6-1, several of the mud pits indicated in historical photos or assumed to exist were not found as distinct anomalies. It is assumed this is because these mud pits overlap others or did not alter the shallow subsurface enough to create a distinct geophysical anomaly. Further investigation of these mud pits (i.e., Well GB-E Mud Pits B and C, and Well GB-3 Mud Pit) will be covered by the investigation of known mud pits.



Source: Modified from SAIC, 2000

Figure C.6-1
Location of Anomalies Identified by EM31 Survey Quadrature Phase Response at Surface Ground Zero

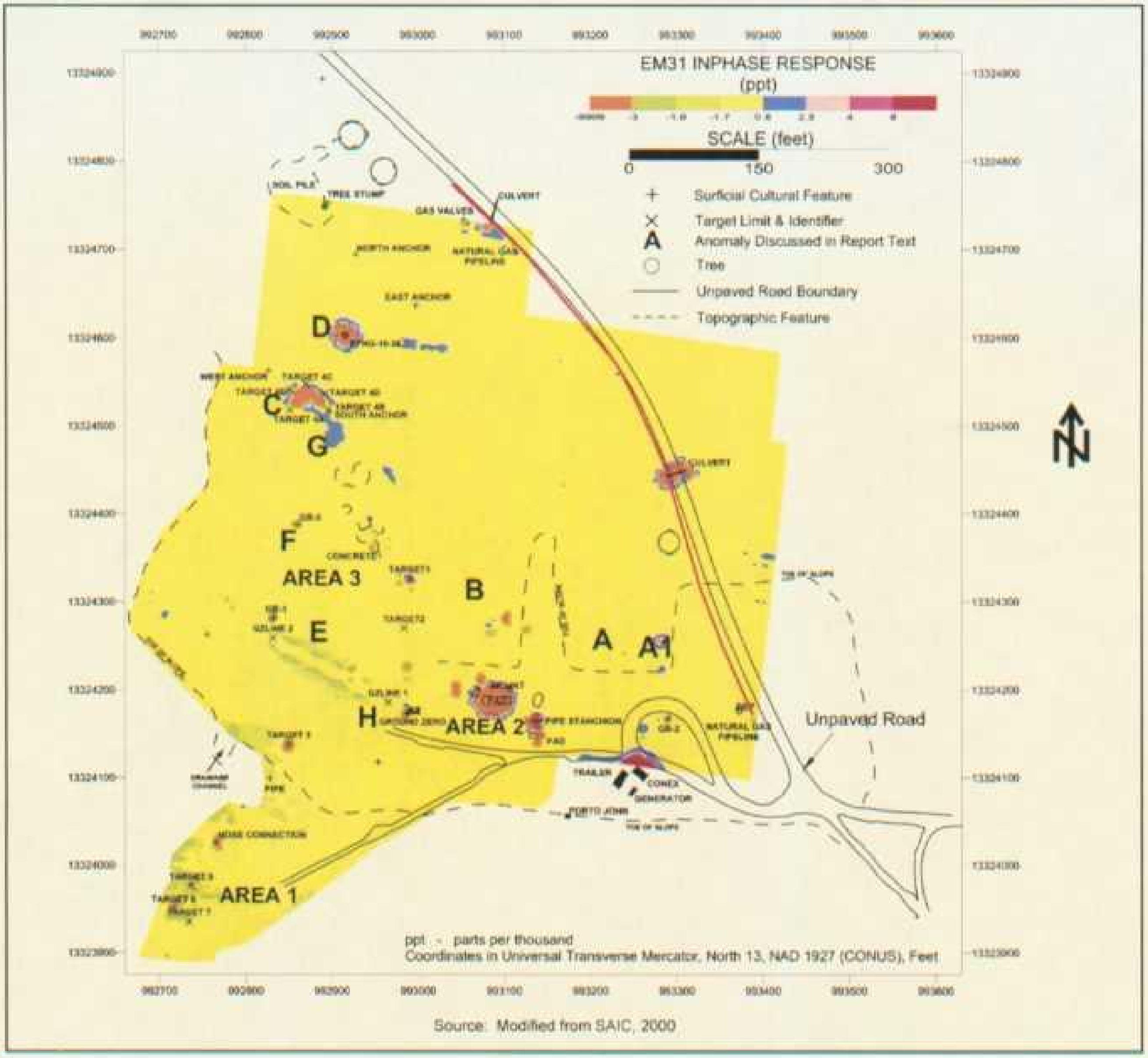


Figure C.6-2
Location of Anomalies Identified by EM31 Survey Inphase Response at Surface Ground Zero

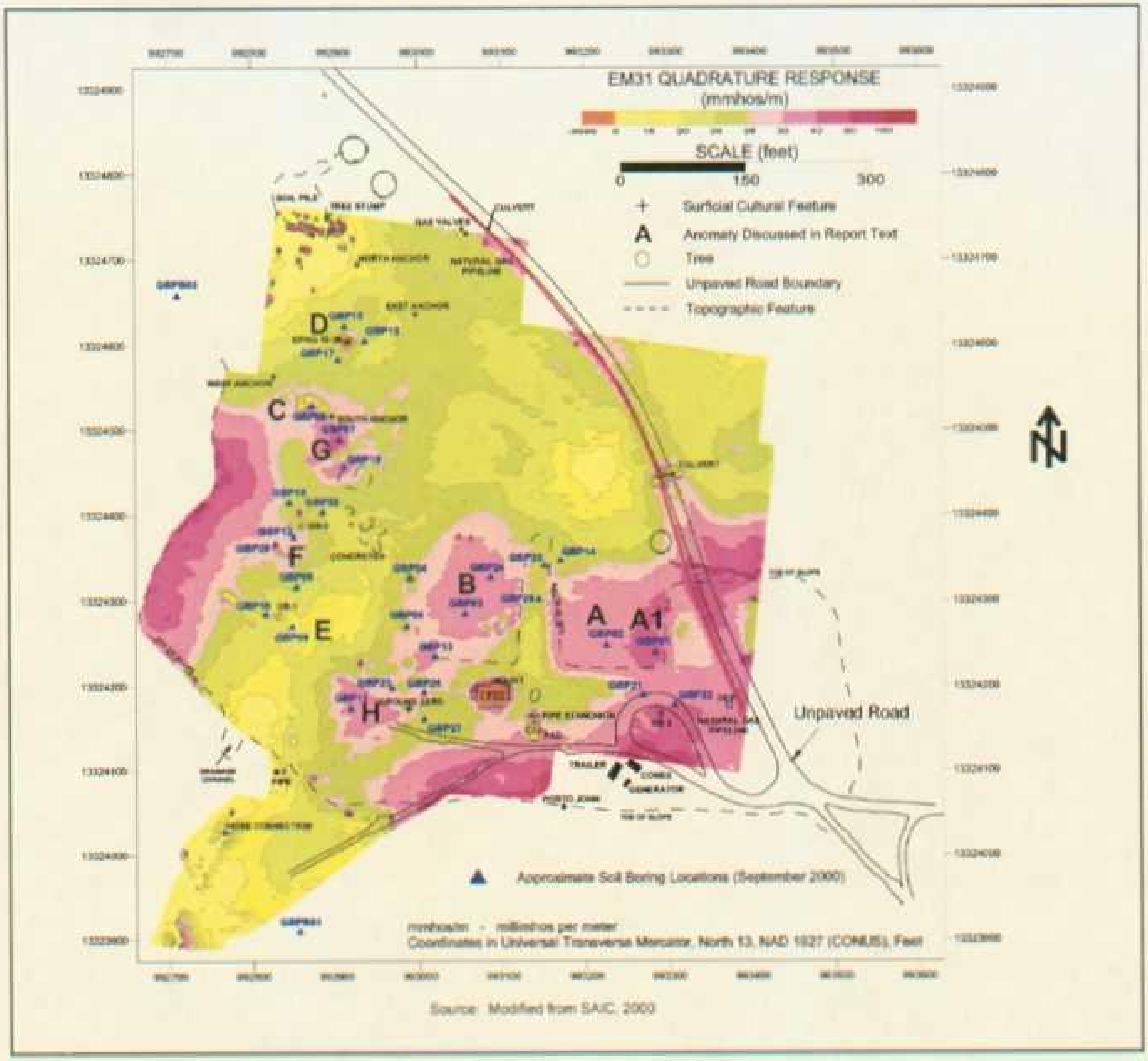


Figure C.6-3
Direct-Push Borehole Locations at Surface Ground Zero

Table C.6-1
Known and Suspect Site Features
(Page 1 of 5)

Unique Identifier	How Feature was Identified[a]	Summary of Geophysical Results	Summary of Borehole Observations	Summary of Analytical Results[b]	Discussion
Well EPNG 10-36 Sump	Historical photos (Figure 2-2) Geophysics - Anomaly C (Figure C.6-1 and Figure C.6-2)	EM31 data indicated an anomaly in area where sump is expected. EM61 data indicate buried metal in area.	One borehole (GBP06) drilled in approximate center of GP anomaly. No mud was evident in boring.	Diesel detected at levels < 100 mg/kg.	Further investigation planned to define nature and extent of potential contamination.
Well GB-1 Mud Pit	Historical plans (Figure 2-3) Geophysics - Anomaly F (Figure C.6-1)	EM31 data indicated an anomaly where mud pit is expected. Site drawings indicate mud pit should be centered approximately 100 ft NE of center of anomaly.	One borehole (GBP12) drilled where center of mud pit indicated by site drawing. One borehole (GBP29) drilled in center of GP anomaly. Evidence of mud observed in both boreholes within 4 ft bgs.	No COPCs detected above PALs.	Based on the results of the GP survey, it is likely these mud pits overlap or are not significant enough to give a distinct GP profile. For the purposes of further investigation, these mud pits will be characterized together. Further investigation is planned to define extent of this mud pit(s).
Well GB-E Mud Pit B	Historical photos (Figure 2-4)	Not specifically identified by GP.	No boreholes specifically drilled for this feature.	No samples collected.	
Well GB-E Mud Pit C					
Well GB-2 Mud Pit	Historical plans (Figure 2-3) Geophysics - Anomaly A (Figure C.6-1) Current site features (berms)	EM31 data indicate anomaly where mud pit expected.	One borehole (GBP02) drilled in approximate center of GP anomaly. Second borehole (GBP01) also intersected mud pit. Evidence of mud observed in both borings at approximately 9-10 ft bgs. Mud also observed at 6-9 ft in GBP01, believed to be layer associated with Well GB-E Mud Pit D.	Diesel detected at approximately 300 mg/kg in both samples collected within mud layer associated with Well GB-2 Mud Pit.	Further investigation planned to define extent of mud pit.
Well GB-E Mud Pit A	Historical photos (Figure 2-4) Geophysics - Anomaly B (Figure C.6-1) Current site features (berms)	EM31 data indicate an anomaly in the area where mud pit expected.	Two boreholes (GBP03 and GBP24) drilled in anomaly. Evidence of mud observed in both borings less than 6 ft bgs. Third borehole (GBP13) did not intersect mud pit.	Diesel detected at concentrations of 720 and 2,600 mg/kg at 4-6 ft bgs.	Further investigation planned to define extent of mud pit.

Table C.6-1
Known and Suspect Site Features
(Page 2 of 5)

Unique Identifier	How Feature was Identified[a]	Summary of Geophysical Results	Summary of Borehole Observations	Summary of Analytical Results[b]	Discussion
Well GB-E Mud Pit D	Historical photo (Figure 2-5) Geophysics - Anomaly A1 (Figure C.6-1) Current features (berms)	EM31 data indicate slight difference in conductivity at location where mud pit expected. This mud pit overlays the location of the Well GB-2 Mud Pit.	One borehole (GBP01) drilled in approximate center of anomaly. Evidence of two distinct mud layers observed at approximately 8 ft bgs and 10 ft bgs. The second layer is likely from the Well GB-2 Mud Pit, as discussed above.	Highest incidence of arsenic (7 mg/kg) detected in layer of mud associated with this mud pit. Diesel detected at 2,100 mg/kg.	Further investigation planned to define extent of mud pit.
Well GB-E Mud Pit E	Historical photo(Figure 2-6) Geophysics - Anomaly G (Figure C.6-1)	EM31 data indicated an anomaly where mud pit expected.	Two boreholes (GBP07 and GBP18) drilled in anomalous area. Evidence of mud layer observed in GBP018 only, at approximately 10 ft bgs.	No COPCs were detected above PALs.	Further investigation planned to define extent of mud pit.
Well GB-3 Mud Pit	No historical references to this mud pit were found during the records search nor did any site observations indicate a mud pit.	Mud pit not detected by GP.	No boreholes specifically drilled for this feature.	No samples were collected.	Based on proximity, it is assumed that either the Well GB-1 Mud Pit or the Well GB-E Mud Pit E, was likely used during the drilling of Well GB-3. This mud pit will not be further investigated.
Landfill A Landfill C Landfill D	Historical diagram (Figure 2-9)	Landfill not detected by GP.	No boreholes specifically drilled for this feature.	No samples were collected.	Further investigation planned to determine nature and extent of potential contamination.
Landfill B	Historical diagram (Figure 2-9)	Landfill not detected by GP.	No boreholes specifically drilled for this feature.	No samples were collected.	Landfill contains only construction debris. No further investigation planned.
Landfill E	Historical photos (Figure 2-5) Geophysics - targets 1 and 2 (Figure C.6-2)	EM31 data indicate two small anomalies where landfill is expected. GP data indicate buried metal in area.	Two boreholes (GBP04 and GBP05) drilled in approximate center of each anomaly to 16 and 20 ft bgs, respectively. No evidence of contamination observed.	No COPCs were detected above PALs.	No further investigation planned.

Table C.6-1
Known and Suspect Site Features
(Page 3 of 5)

Unique Identifier	How Feature was Identified[a]	Summary of Geophysical Results	Summary of Borehole Observations	Summary of Analytical Results[b]	Discussion
Septic Tank A	Historical diagram (Figure 2-8) Historical photo (Figure 2-4) Current site features (tree line)	EM31 data indicated several anomalies in the general area. These were further investigated with EM61 and GPR. GPR indicated a subsurface feature that could represent a septic tank.	An excavation was dug to approximately 2.5 ft bgs in area where tank was indicated. No evidence of septic tank was found. Seven boreholes were drilled to 4 ft bgs and one to 8 ft bgs. No indication of septic tank was evident.	No samples were collected.	Further investigation planned to verify tank has been closed in accordance with NM regulations.
Septic Tank B	Historical diagram (Figure 2-9)	Interpretation of GP data collected by all three methods does not indicate a septic tank.	No boreholes specifically drilled for this feature.		
Well EPNG 10-36 Drill Pad	Current site features (wellhead) Wellhead shows as geophysics - Anomaly D (Figure C.6-2)	No anomalies other than that interpreted as the well were detected.	Two boreholes (GBP15 and GBP16) drilled approximately 20 ft from well to 16 ft bgs. No evidence of contamination observed. Third borehole (GBP17) approximately 25 ft from center of well advanced to 24 ft bgs. Possible evidence of staining observed between 14 to 15 ft bgs. Sample collected at this interval.	No COPCs were detected above PALs.	No further investigation planned.
Well GB-1 Drill Pad	Current site features (abandoned wellhead)	No anomalies other than that interpreted as the well were detected.	Two boreholes (GBP09 and GBP10) drilled approximately 20 ft from well to 16 ft bgs. One borehole (GBP08) located approximately 30 ft from well also advanced to 16 ft bgs. No evidence of contamination observed in any of the three boreholes.	No COPCs were detected above PALs.	No further investigation planned.

Table C.6-1
Known and Suspect Site Features
(Page 4 of 5)

Unique Identifier	How Feature was Identified[a]	Summary of Geophysical Results	Summary of Borehole Observations	Summary of Analytical Results[b]	Discussion
Well GB-2 Drill Pad	Current site features (abandoned wellhead)	No anomalies other than that interpreted as the well were detected.	Two boreholes (GBP21 and GBP22) drilled approximately 20-25 ft from well to depth of 16 ft and 22 ft bgs, respectively. Evidence of possible contamination observed in both holes from approximately 0-6 ft bgs. Samples collected in this interval.	No COPCs were detected above PALs.	No further investigation planned.
Well GB-E Drill Pad	Historical photos (Figure 2-4) Geophysics - Anomaly H (Figure C.6-1) Current site features (SGZ marker)	EM31 data indicate an anomaly to the south and west of Well GB-E. This is likely a compacted pad used to stabilize the ground for the drill rig.	One borehole (GBP11) drilled in approximate center of anomaly (approximately 90 ft west of Well GB-E) to 16 ft bgs. Two additional boreholes (GBP26 and GBP27) drilled approximately 20 ft from Well GB-E to 16 ft bgs. No evidence of contamination observed in any of the three holes.	No COPCs were detected above PALs.	No further investigation planned.
Well GB-3 Drill Pad	Current site features (abandoned wellhead)	No anomalies other than that interpreted as the well were detected.	Two boreholes (GBP19 and GBP20) drilled approximately 20 ft from well to 16 ft bgs. No evidence of contamination observed.	No COPCs were detected above PALs.	No further investigation planned.
SGZ Cable Trench	Historical site photos (Figure 2-6) Geophysics- Anomaly E (Figure C.6-2)	EM31 data indicates a linear anomaly trending northwest from Well GB-E. Anomaly is likely remnants of the cable trench visible in historical photographs.	No boreholes were specifically drilled for this feature.	No samples were collected.	No further investigation planned.
Water Line	Historical photos (location of water tank) Geophysics (EM61 data not shown) Current site features (surface depression and hose bib visible on surface)	EM31 and EM61 data indicate a linear anomaly trending north from the southwest corner of the site. Based on site drawings and photographs this is likely a historical water line.	No boreholes were specifically drilled for this feature.	No samples were collected.	No further investigation is planned.

Table C.6-1
Known and Suspect Site Features
(Page 5 of 5)

Unique Identifier	How Feature was Identified[a]	Summary of Geophysical Results	Summary of Borehole Observations	Summary of Analytical Results[b]	Discussion
Gas flaring system	Historical photos (Figure 2-7) Historical diagram (Figure A.4-2) and documentation Current site features (berm)	NA	One borehole drilled at the historical location of the flarestack (GBP25). Two others were drilled in the vicinity of the flare stack (GBP14 and GBP24). Another borehole was drilled at the location of the gas/water separator (GBP23). Profile sets collected for tritium analysis in these boreholes.	Highest concentration of tritium (7.32 pCi/g) detected in sample collected from borehole just east of flare stack location (GBP14). The VOC (1,2,4-Trimethylbezene) was detected above the PAL at sample collected 5-7 ft bgs in borehole at former flare stack location. Diesel and gasoline were detected above 100 mg/kg in same sample.	VOC contaminants detected are likely from production and flaring of petroleum hydrocarbons. Contamination is assumed to be localized to the specific location of the flare stack. Further investigation is planned to define the extent of the contamination.
Berm that separates Well GB-2 Mud Pit and Well GB-E Mud Pit A	Current site features	NA	One borehole (GBP28) drilled through berm approximately midway along the length. Borehole drilled to total depth of 36 ft bgs. No groundwater was observed.	Diesel and gasoline were detected above 100 mg/kg.	Berm is assumed to be contaminated from Well GB-E Mud Pit A and Well GB-2 Mud Pit and will be further investigated along with these mud pits and the flare stack area investigation.

[a]Anomalies identified by geophysics are listed by the unique identifiers assigned to them in the report of the results of the geophysical survey (SAIC, 2000).
[b]COPCs not specifically discussed unless detected above the associated PAL. Arsenic hits above PALs not specifically called out. For the purposes of this table, 100 mg/kg will be assumed to be the PAL for TPH.

NE = Northeast
GP = Geophysics
NM = State of New Mexico

A minimum of one borehole was drilled within each identified mud pit. Samples were generally collected within the mud layer, if identifiable; 4 ft below this layer; and again 10 ft below the mud layer. Samples within the mud layer generally indicated levels of TPH diesel above 100 mg/kg. Gasoline was not detected in samples collected within the mud pits. In all cases, except in borehole GBP01, where two distinct layers of mud are evident, the samples collected below the mud layer did not indicate diesel above 100 mg/kg. Thus, it appears that contamination is not migrating. No other COPCs were identified above PALs in mud pits except arsenic. The values of arsenic detected in samples from mud layers or other intervals are not significantly different from those detected in background samples. The highest concentration of arsenic detected, 7 mg/kg, was from a sample collected in the mud layer associated of Well GB-E Mud Pit D. Samples collected at 2 and 3 ft below this sample had levels of arsenic of 1.7 and 2.1 mg/kg, respectively (below the PAL of 2.7 mg/kg). Further sampling is needed in this mud pit to ensure a representative value for arsenic is obtained. Further sampling is planned to more accurately define the nature and extent of potential contamination in the mud pits.

Landfills

The following sections discuss the results of the investigation with regard to the various types of landfills expected to be encountered.

Landfills A, C, and D (Mud Landfills)

These landfills were not identified by the geophysical survey; therefore, no boreholes were drilled in these features during the preliminary field investigation. Their general location is known through historical documentation and further investigations including sampling and analysis are planned.

Landfill B

The geophysical survey did not identify this landfill. The contents and location of this landfill are known through historical documentation as indicated in Section 2.2.1 of the Work Plan. Since no hazardous constituents are indicated, no further investigation of this feature is planned.

Landfill E

The EM31 and EM61 geophysical surveys indicate several anomalies in the general vicinity of where Landfill E was indicated in historical photos. Additional surveys with GPR identified numerous possible metal targets scattered throughout the suspected area. Boreholes GBP04 and GBP05 were drilled in the center of the two "highest" EM31 anomalies. Visual observation of the soil cores did not indicate any evidence of a landfill. Analytical results did not indicate any COPCs above PALs. It is believed this landfill contains metal and other construction debris. No further investigation of this feature is planned.

C.6.2 Septic Tanks

Geophysics surveys were unable to definitively locate either Septic Tank A (in the southwest portion of the site) or Septic Tank B (near Well GB-E). All three geophysical methods were employed. The EM31and EM61 both indicated several anomalies in the southwest portion of the site that were further investigated with GPR. The results of the GPR investigation indicated one likely target. One borehole was drilled to 8 ft bgs in the center of this target and seven boreholes were drilled to 4 ft bgs within a 3 ft radius of this target. Visual observation of the soil cores did not indicate any evidence of a septic tank.

No likely targets were identified by any of the three geophysical methods in the area where Septic Tank B is indicated by historical documentation. Further investigation of the septic tanks is planned.

C.6.3 Other Anomalies

Several other distinct anomalies which did not represent known features (e.g., wellhead, road, or culvert pipe) were identified by geophysical methods. A linear anomaly extending roughly from Well GB-E approximately 250 ft to the northwest was identified. Based on interpretation of historical photos, this feature is likely a trench used to run cables from Well GB-E during the experiment (see Figure 2-6). No further investigation of this feature is planned.

A second linear anomaly was identified entering the southwest corner of the site. The anomaly extends approximately 50 ft to the north-northwest, then abruptly turns and extends approximately 250 ft to the northeast. Evidence of this linear anomaly can be seen on the site surface extending an additional 240 ft, where it ends near the southeast corner of the large concrete pad east of Well GB-E. It is believed that both the geophysical anomaly and the surface depression represent a water line. The water storage tank used during the experiment was located on the hill to the southwest of the site. The path cleared through the trees to construct the water line is still visible. Portions of this water line likely remain in place. No further investigation of this feature is planned.

Numerous small anomalies were identified in the northwest corner of the site near a soil pile. It is possible these anomalies represent small pieces of concrete at or near the surface. The origin of the soil pile is not known. It is not visible in historical photographs taken prior to the original closure (covering) of the Well GB-E mud pits in November-December, 1967 (see Figure 2-4). The pile appears to be visible in photographs taken on the day of the detonation (Wofford, 2000b). Further investigation of this soil pile is planned.

C.7.0 Quality Assurance

The results of the QA/QC activities for the Gasbuggy preliminary field investigation sampling events are summarized in the following text. Detailed information regarding the QA program is contained in the NM QAPP (see Appendix B).

Quality control results are typically judged in terms of precision, accuracy, representativeness, completeness, and comparability and are described in the following sections.

C.7.1 Precision

Precision is a quantitative measure of the variability of a group of measurements from their average value. Precision is assessed for inorganic analysis by collecting and analyzing duplicate field samples and comparing the results with the original sample. Precision is also assessed by creating, preparing, analyzing, and comparing laboratory duplicates from one or more field samples in inorganic analyses and MS/MSD samples for organic analyses. Precision is reported as RPD, which is calculated as the difference between the measured concentrations of duplicate samples, divided by the average of the two concentrations, and multiplied by 100. Any deviation from these requirements has been documented, explained, and the related data qualified accordingly.

C.7.2 Accuracy

Analytical accuracy is defined as the nearness of a measurement to the true or accepted reference value. It is the composite of the random and systematic components of the measurement system and measures bias in the measurement system. The random component of accuracy is measured and documented through the analyses of spiked samples. Sampling accuracy is assessed by evaluating the results of spiked samples and laboratory control samples. Accuracy measurements are calculated as percent recovery by dividing the measured sample concentration by the true concentration and multiplying the quotient by 100.

Field accuracy is assessed by confirming that the documents of record track the sample from its origin, through transfer of custody, to disposal. The goal of field accuracy is for all samples to be collected from the correct locations at the correct time, placed in a correctly labeled container with the correct preservative, and sealed with custody tape to prevent tampering. All samples in this sampling event were properly collected and forwarded to the laboratories as described above.

C.7.3 Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition (EPA, 1987). Sample representativeness was achieved through the implementation of a sampling program designed to ensure proper sampling locations, number of samples, and the use of validated analytical methods. Representativeness was assessed through analysis of duplicate samples. Representativeness of the samples taken in this sampling event was assured by collecting the specified number of samples and by analyzing them by the approved analytical methods shown in the NM QAPP (see Appendix B).

C.7.4 Completeness

Completeness is defined as a percentage of measurements made that are judged to be valid. A sampling and analytical requirement of 80 percent completeness was established and achieved for this project. This criteria was taken from the "EPA Guidance for Quality Assurance Project Plans" (EPA, 1998).

The specified sampling locations were utilized as planned. All samples were collected as planned. All sample containers reached the laboratory intact and properly preserved (when applicable). Sample temperatures were maintained during shipment to the laboratory and sample chain of custody was maintained during sample storage and/or shipment.

C.7.5 Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared to another (EPA, 1987). To ensure comparability, sampling activities were performed and documented in accordance with approved procedures, and all samples were collected in accordance with the NM QAPP (see Appendix B). Approved standardized methods and procedures were also used to analyze and report the data (e.g., CLP and/or CLP-like data packages). This approach ensures that the data from this project can be compared to other data sets. Based on the minimum comparability requirements specified in the NM QAPP (see Appendix B), all requirements were met.

Field (i.e., sample handling) documentation, laboratory nonconformance reports, and the precision and accuracy of quality-control sample results were evaluated for their effect on the results of the associated environmental sediment samples. The environmental sample results were then qualified according to processes outlined in the following sections. Documentation of the data qualifications resulting from these reviews is retained in project files as both hard copy and electronic media.

C.7.6 Tier I and Tier II Data Evaluations

All laboratory data from samples collected during the Gasbuggy preliminary field investigation have been evaluated for data quality according to the EPA Functional Guidelines (EPA, 1994b and 1999b). These guidelines are implemented in a tiered process and are presented in the following text. No data rejected during the data evaluation process were used to draw the conclusions. Only valid data, whether estimated (i.e., J-qualified) or not, were used.

The adjustments to data and data qualifiers resulting from the data evaluation process were documented in the project files and were summarized in memoranda for each sample delivery group. These memoranda are maintained in the project files.

C.7.6.1 Tier I Evaluation

Tier I evaluation for both chemical and radiological analysis examines (but is not limited to):

- Sample count/type consistent with chain of custody
- Analysis count/type consistent with chain of custody
- Correct sample matrix
- Significant problems stated in cover letter or case narrative
- Completeness of certificates of analysis
- Completeness of CLP or CLP-like packages
- Completeness of signatures, dates, and times on chain of custody
- Condition-upon-receipt variance form included
- Requested analyses performed on all samples
- Date received/analyzed given for each sample
- Correct concentration units indicated
- Electronic data transfer supplied

- Results reported for field and laboratory QC samples
- Whether or not the deliverable met the overall objectives of the project

C.7.6.2 Tier II Evaluation

Tier II evaluation for both chemical and radiological analysis examines (but is not limited to):

Chemical:

- Sample date, preparation date, and analysis date for each sample
- Holding time criteria met
- QC batch association for each sample
- Cooler temperature upon receipt
- Sample pH for aqueous samples, as required
- Detection limits properly adjusted for dilution, as required
- Blank contamination evaluated and applied to sample results/qualifiers
- MS/MSD percent recoveries (%R) and RPDs evaluated and applied to laboratory results/qualifiers
- Field duplicate RPDs evaluated using professional judgement and applied to laboratory results/qualifiers
- Laboratory duplicate RPDs evaluated and applied to laboratory results/qualifiers
- Surrogate %R evaluated and applied to laboratory results/qualifiers
- Laboratory control sample %R evaluated and applied to laboratory results/qualifiers
- Initial and continuing calibration evaluated and applied to laboratory results/qualifiers
- Internal standard evaluated and applied to laboratory results/qualifiers
- Recalculation of 10 percent of laboratory results from raw data
- Mass spectrometer tuning criteria
- Initial and continuing calibration verification
- Internal standard evaluation
- Organic compound quantification
- Inductively coupled plasma (ICP) interference check sample evaluation
- Graphite furnace atomic absorption quality control
- ICP serial dilution effects

Radioanalytical:

- Blank contamination evaluated and validation data qualifier applied to sample results
- Certificate of Analysis consistent with data package documentation
- Quality control sample results (e.g., duplicates, laboratory control samples, MS/MSD) evaluated and validation data qualifiers applied to sample results
- Sample results, error, and minimum detectable activity evaluated and applied to laboratory result qualifiers
- Detector system calibrated to NIST-traceable sources
- Calibration sources preparation was documented, demonstrating proper preparation and appropriateness for sample matrix, emission energies, and concentrations
- Detector system response to daily, weekly, and monthly background and calibration checks for peak energy, peak centroid, peak full-width half-maximum, and peak efficiency
- Tracers NIST-traceable, appropriate for the analysis performed, and recoveries that met QC requirements
- Documentation of all QC sample preparation complete and properly performed
- Spectra lines, emissions, particle energies, peak areas, and background peak areas support the identified radionuclide and its concentration

C.7.6.3 Tier III Evaluation

Data quality considerations that are included in EPA data review functional guidelines (EPA, 1994b and 1999b) as a Tier III review include the additional evaluations:

Chemical:

- Recalculation of all laboratory results from raw data

Radioanalytical:

- QC sample results (e.g., calibration source concentration, percent recovery, and RPD) verified
- Radionuclides and their concentration appropriate considering their decay schemes, half-lives, and process knowledge and history of the facility and site
- Each identified line in spectra verified against emission libraries and calibration results
- Independent identification of spectra lines, area under the peaks, and quantification of radionuclide concentration in a random number of sample results

Tier III review of at least five percent of the sample analytical data is planned.

C.7.7 Field Quality Control Samples

There were 23 trip blanks, 4 field blanks, 2 equipment rinsate blanks, 3 source blanks, 4 field duplicates, and 4 MS/MSD collected and submitted for off-site laboratory analysis as shown in Table C.4-2. In addition, 19 laboratory duplicates were analyzed. The samples and duplicates were assigned individual sample numbers and sent to the laboratory "blind." The field blanks were taken by placing deionized water into appropriate sample bottles at the sampling location and preserving them according to the requirements specified in the NM QAPP (see Appendix B). The equipment rinsate blank was obtained by collecting deionized water, which was poured over the decontaminated sampling equipment, into the appropriate sample bottles, and preserved as applicable. The field duplicates were taken at the same location as the environmental sample and MS/MSD. The trip blanks, which were received preserved and sealed from the laboratory, were placed in each shipping cooler containing samples for VOC analysis. The source blank for the rinsate water was obtained by collecting rinsate source water (Farmington municipal source) directly from the container used to store the water on site, into the appropriate sample bottles and preserved as applicable. The two source blanks for the Lexan™ tubes (liners for the sample collection core barrel) were collected in the same fashion as the equipment rinsate blank. The MS/MSD samples were collected as duplicate volumes of environmental samples. The results of the QC samples are discussed in the following sections.

C.7.7.1 Field Blank Analysis

Review of the field-collected blank analytical data for the Gasbuggy preliminary field investigation indicates that contamination from field methods may have occurred during sample collection. Samples were analyzed for the parameters listed in Table C.4-2. Acetone and chloroform were detected in several equipment rinsate and field blanks at concentrations that exceeded the Contract-Required Detection Limit (CRDL). Acetone was also detected in trip blank sample 25400547 at a concentration that was at the CRDL. An overall review of the data indicated that field and shipping cross-contamination may have occurred. Although concentrations were above the CRDL, the PALs were not exceeded and the results did not have an impact on the investigation.

C.7.7.2 Field Duplicate Analysis

During the sampling event, four field duplicate samples were sent as blind samples to the laboratory to be analyzed for the investigation parameters listed in Table C.4-2. For these samples, the precision of duplicate sample results (i.e., RPDs between the environmental sample results and their corresponding field duplicate sample results) were evaluated to the guidelines set forth in EPA Functional Guidelines (EPA, 1994b and 1999b). The EPA Functional Guidelines state that there are no required review criteria for field duplicate analyses comparability, but allow the data reviewer to exercise professional judgement in qualifying data based upon the results of the field duplicates. The RPD between the environmental samples results and their corresponding field duplicates exceeded the 20 percent criteria for water and the 35 percent for soil (EPA, 1994b).

C.7.7.3 Matrix Spike Analysis

A total of four field samples were selected for use as MS/MSD samples. The percent recoveries of these samples (a measure of accuracy) and the relative percent differences in these sample results (a measure of precision) were compared to EPA Functional Guidelines criteria (EPA, 1994b and 1999b). The results were used to qualify associated environmental sample results accordingly.

The EPA Functional Guidelines for review of organic data state that no data qualification action is taken on the basis of MS/MSD results alone. As allowed by EPA Functional Guidelines, the data reviewer exercises professional judgement in considering these results in conjunction with the results of laboratory control samples (LCSs) and other QC criteria in applying qualifications to the data.

Generally, if the spike recovery is greater than the upper acceptance limits (>125 percent), nondetections are acceptable for use. If the spike recovery is greater than the upper acceptance limits (>125 percent) or less than the lower acceptance limits (<75 percent), positive results are qualified as estimated (J). If spike recovery is within the range of 30-74 percent, nondetections are qualified as estimated (UJ). If spike recovery is less than 30 percent (grossly low), positive results are not qualified and nondetections were qualified as unusable (R).

C.7.8 Laboratory Quality Control Samples

Analysis of QC method blanks, LCSs, and surrogate spikes for organic analyses (and method blanks, preparation blanks, initial and continuing calibration blanks, and LCSs for metals) were performed for each sample delivery group by Paragon Analytics, Inc. The results of these analyses were used to qualify associated environmental sample results according to EPA Functional Guidelines (EPA, 1994b and 1999b).

The EPA Functional Guidelines (EPA, 1994b and 1999b) state that no qualification action is taken if a compound is found in a sample, but not in the associated blank. The action taken when a compound is detected in both the sample and the associated blank varies depending upon the analyte involved, and is described in the "The 5X/10X Rule."

For most VOCs, SVOCs, TPH (i.e., DRO and GRO), and radionuclides, if an analyte is detected in the sample and is also detected in an associated blank, the result is qualified as undetected (U) if the sample concentration is less than five times (5X) the blank concentration. However, for the common laboratory contaminants (e.g., methylene chloride, acetone, 2-butanone [methyl ethyl ketone], and phthalate esters [especially bis(2-ethylhexyl)phthalate]), the factor is raised to ten times (10X) the blank concentration. The sample result is elevated to the quantitation limit if it is less than the quantitation limit, or remains unaltered if the sample result is greater than or equal to the quantitation limit.

For inorganics (i.e., metals), sample results greater than the instrument detection limit, but less than five times (5X) the amount found in an associated blank, are qualified as undetected (U). There are no metallic common laboratory contaminants, so there is no "10X Rule" for metals, and the sample result is never altered. When applying the 5X criteria to soil sample data or calibration blank data, the raw data results are used to evaluate and qualify the reported results on the Certificate of Analysis. Preparation blanks (PB) are evaluated for each matrix, with every sample delivery group, or with each batch of samples digested, whichever is more frequent. The analyte concentration in the PB should be below the CRDL. If any analyte concentration in the PB is above the CRDL, the lowest concentration of that analyte in the associated samples must be ten times (10X) the PB concentration. Otherwise, all samples associated with the PB with the analyte's concentration less than 10X the PB concentration, and above the CRDL, should be redigested and reanalyzed. If the concentration of the PB is less than or equal to the CRDL, no corrective action to the associated sample is required.

C.7.8.1 Laboratory Surrogate Spikes

Surrogate spikes (e.g., system monitoring compounds) are added to the environmental samples analyzed by chromatographic techniques for VOCs, SVOCs, TPH (i.e., DRO and GRO). Surrogate compounds are analytes that are not expected to be present in associated environmental samples, but behave the same as similar target compounds chromatographically. Known amounts of each surrogate are added prior to sample preparation and are carried throughout the preparation and analysis procedures. The percent recoveries of these surrogate compounds give some measure of the anticipated recoveries of the target compounds whose chromatographic behavior they mimic.

If any surrogate percent recoveries are out of the acceptable range (which differs for each surrogate in each method), laboratory protocol requires the sample to be reprepared and/or reanalyzed. When the surrogate recoveries are acceptable on the second run, only the second analysis results are reported. When both analyses yield the same unacceptable range, the results of both analyses are reported.

The evaluation of surrogate spike percent recovery results is not straightforward. The functional guidelines suggest several optional approaches, but require the data reviewer to exercise professional judgement in reviewing surrogate data and qualifying associated data as estimated (J or UJ for detections or nondetections, respectively) or unusable (R).

C.7.8.2 Laboratory Duplicate Analysis

The laboratory duplicate samples were compared to the criteria set forth in the EPA Functional Guidelines (EPA, 1994b and 1999b), and the associated sample results were qualified accordingly. Both detections and nondetections have been qualified as estimated (J and UJ, respectively), if the relative percent difference between an environmental sample and its laboratory duplicate fell outside established criteria.

One laboratory duplicate analysis for metals was performed for each sample delivery group and sample matrix that reported metals. The duplicate results were compared to the results of the original sample to give a measure of analytical laboratory precision. If the results from a duplicate analysis for a particular analyte fall outside the control limits, the EPA Functional Guidelines for Inorganic Data Review (EPA, 1994b) call for all results for that analyte in all associated samples of the same matrix to be qualified as estimated (J).

Laboratory control samples, also known as blank spikes, consist of known quantities of target compounds added to purified sand or deionized water prepared and analyzed along with the environmental samples in the sample delivery group. The percent recoveries of the compounds in the LCS give a measure of laboratory accuracy. The functional guidelines call for the data reviewer to use professional judgement to qualify associated data according to established criteria.

C.7.9 Field Nonconformances

During the Gasbuggy preliminary field investigation, the DOE contractor QA representatives provided field guidance and oversight to verify that sampling activities were performed in accordance with applicable requirements. Quality assurance representatives did not observe findings, deficiencies, or nonconformances with sampling activities. There were no nonconformances found during data review and validation.

C.7.10 Laboratory Nonconformances

Laboratory nonconformances are generally due to inconsistencies in analytical instrumentation operation, sample preparations, extractions, and fluctuations in internal standard and calibration results. Several nonconformances were documented for this project. These nonconformances have been accounted for in the data qualification process. Documentation of these results is retained in the Gasbuggy preliminary field investigation project files.

C.8.0 Summary

Analysis of data and observations from the surface and shallow subsurface preliminary field investigation conducted at the Gasbuggy Site indicate the following:

- The report on the results of the biological survey concluded that "no affect will occur to any USFW threatened, endangered, proposed candidate, or species of concern as a result of environmental studies taking place at the Gasbuggy Site. No affect will occur to State of New Mexico threatened, endangered, or species of concern or USFS Sensitive Species as a result of environmental studies at the Gasbuggy Site" (TRC, 2000a).

- The cultural resources survey identified one site on the south side of the road through the CP that could potentially impact future investigations. The report on the survey findings concluded that cultural resource monitoring is recommended should any future ground-disturbing work occur south of the road (TRC, 2000b). Although the documented boundaries of the "site" overlap the CP boundaries, no ground-disturbing work is planned within the specified "site" boundaries at the current time.

- Geophysical surveys in the Well GB-D area identified two anomalies that will be further investigated. One is believed to be the mud pit used during drilling of Well GB-D. The second anomaly is believed to be associated with a nearby soil pile, and may be representative of an excavation and fill event. Further investigation at the Well GB-D area will be based on this information.

- Geophysical surveys at the RTP identified one anomaly that will be further investigated. This anomaly is believed to be associated with a nearby soil pile, and may be representative of an excavation and fill event. Further investigation at the RTP will be based on this information.

- Geophysical surveys at the CP identified several anomalies believed to be associated with the septic system located at this site. Further investigation will be conducted to determine if the septic tank was closed (filled) in accordance with State of New Mexico regulations. Geophysical surveys also identified an anomaly near the historic location of the mobile radiological trailer. This anomaly will be further investigated by sampling and analysis.

- Geophysical surveys in the SGZ area identified and defined most of the predicted mud pits. Those not identified by geophysics are believed either to have not existed (e.g., no mud pit was specifically constructed during the drilling of Well GB-3, but instead existing mud pits such as Well GB-E Mud Pit E were used) or the mud pits were not significant enough to produce an identifiable EM signature. Geophysical data will be used, where applicable, to delineate the lateral extent of the mud pits.

- Samples collected from observed mud layers within several of the mud pits indicated potential diesel contamination. Further sampling and analysis is planned to further refine the nature and extent of contamination in the mud pits.

- Geophysical surveys in the SGZ area did not identify the Landfills (A, C, and D) used to dispose of the drilling fluids generated during the abandonment of site wells in 1978. These landfills were not sampled during the preliminary field investigation. Sampling and analysis to define the nature and extent of potential contamination within these landfills is planned.

- Geophysical surveys in the SGZ area did not identify Landfill B used to dispose of concrete and asphalt pads. No further investigation of this landfill is proposed.

- Geophysical surveys identified two small anomalous areas where Landfill E was predicted. Samples from boreholes in these areas did not detect any COPCs above PALs. No further investigation of this landfill is proposed.

- Geophysical surveys in the SGZ area did not definitively define or eliminate from consideration the septic tanks indicated by historical documentation to be located in this area. Further investigation will be conducted to determine if the septic tanks were closed (filled) in accordance with State of New Mexico regulations.

- Concentrations of TPH were detected above 100 mg/kg in seven samples. Five of these seven samples were collected from a layer of drilling mud identified by visual observation within the mud pits. TPH diesel was detected above 100 mg/kg in all of these samples. Gasoline was not detected above 100 mg/kg in these samples. The remaining two of seven were collected from the berm that separates the Well GB-2 Mud Pit from Well GB-E Mud Pit A, one of these from the northern end of the berm at the historic location of the flare stack. Each of these two samples had detections of TPH, both in the diesel and gasoline range, over 100 mg/kg. In all cases where TPH was detected at levels greater than 100 mg/kg, a sample collected at a lower depth in the same borehole indicated a TPH concentration of less than 100 mg/kg and/or a nondetect. The diesel contamination will be further investigated as part of the investigations of the mud pits. The gasoline contamination will be further investigated as part of the flare stack area investigation.

- The only VOC detected above PALs was 1,2,4-Trimethylbenzene. This contaminant was detected at the 5 to 7 ft bgs interval in a borehole drilled at the historic location of the flare stack. The contamination is believed to be localized to this location. The source of the contamination is not known but believed to be associated with production and flaring of natural petroleum hydrocarbons. Further investigation will be conducted in the flare stack area to determine the nature and extent of this potential contamination.

- No SVOCs were detected at levels which exceeded PALs.

- Arsenic was the only metal detected above PALs. Based on statistical analysis, arsenic levels in background and site characterization samples appear to be not significantly different from each other. Additional site characterization and background samples will be collected.

- Tritium levels, detected in samples collected from locations where the highest levels of tritium were detected in 1978, indicate a range of less than the minimum detectable concentration to 7.32 pCi/g of tritium. Based on the preliminary dose/risk assessment provided in Appendix D, these levels do not pose a risk to human health.

- The COPCs requested to be analyzed for by NM OCD were compared against Region IX PRGs, if applicable. None of these COPCs exceeded its corresponding PRG. Further analysis of the data was not done at this time. This data may be used in the corrective action decision document to support decisions made on the closure of the mud pits.

- Analysis of samples by TCLP did not detect any COPCs which exceeded RCRA regulatory limits (CFR, 1999).

- Rejected data did not impact the characterization.

- Groundwater was not found in the areas investigated. The maximum depth of investigation was 36 ft bgs. The deepest contamination detected was at 9 to 11 ft bgs.

C.9.0 References

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Appendix D

Gasbuggy Site Surface Radiological Dose/Risk Assessment

D.1.0 Introduction

This appendix addresses the overall baseline human health effects of exposure to radionuclides of potential concern in surface soil, shallow subsurface soil, air, and shallow groundwater at the Gasbuggy Site. This assessment focuses on the potential dose to a human receptor for three potentially exposed populations. The objective of this assessment was to determine the need for additional data on tritium concentrations in the surface and shallow subsurface soil. Based on the findings of this assessment, no further samples for tritium in surface and shallow subsurface soil at the Gasbuggy Site need to be collected.

The human health dose assessment was performed to estimate the potential risk which may occur at the Gasbuggy Site under normal operating conditions. This dose assessment was performed using the RESRAD computer code, Version 5.95 (ANL, 1993b and 1999). The use of the maximum contaminant concentration and/or other maximum parameter values in this appendix is not meant to set precedent. Use of maximum values is not in accordance with the guidance given in DOE Order 5400.5 or the guidance given in the guides for implementing RESRAD (ANL, 1993a and b). Maximum parameter values were used to simplify the modeling process. Using the more conservative parameter values resulted in an estimated risk from radiological contaminants at the Gasbuggy Site below acceptable action levels (CFR, 1999).

D.2.0 Identification of Radionuclides of Potential Concern

The historical radiological survey and sampling results for the surface and shallow subsurface soil at the Gasbuggy Site are summarized in Appendix A. Based on the information and conclusions presented in Appendix A, tritium is the only radionuclide of potential concern for the surface/shallow subsurface at the Gasbuggy Site.

Tritium samples were collected at the Gasbuggy Site during the preliminary field investigation in August and September 2000. The results of the sampling are summarized in Appendix C. The maximum detected tritium activity found during the preliminary field investigation was 7.32 pCi/g at a depth of 7 to 8 ft bgs. This activity was used throughout this assessment.

D.3.0 Human Health Dose Assessment

This human health assessment was performed in accordance with applicable state and federal guidance.

D.3.1 Exposure Assessment

This section identifies exposure pathways and quantifies radionuclide exposure. The purpose of this exposure assessment is to estimate the type and magnitude of exposure to humans.

D.3.1.1 Exposure Pathways

For exposure and potential risks to occur, complete exposure pathways must exist. A complete pathway requires the following elements (EPA, 1989):

- A source and mechanism for release of contamination
- A transport or retention medium
- A point of potential human contact (exposure point)
- An exposure route at the exposure point

If any one of these elements is missing, the pathway is not considered complete. Following is a brief discussion of the exposure pathway elements.

For the purposes of this assessment, the contamination source is assumed to be the flaring of contaminated gas and water vapor that took place as part of the Gasbuggy Project. The transport/retention mediums of concern for this assessment are surface and shallow subsurface soil.

Exposure points are locations of human contact with contaminated media. Exposure points consider human activity patterns and the location of potentially exposed individuals relative to the location of contaminated media. The Gasbuggy Site is surrounded by national forest and the primary land use for Gasbuggy is recreational or open space. However, there is cattle grazing in the vicinity of Gasbuggy and the potential for on-site ranching does exist. In addition, the Jicarilla Apache reservation is also adjacent to the Gasbuggy Site. Therefore, there is also the potential for Native American recreational land use at the site, including the potential for on-site hunting. On-site recreational hunting is assumed to be similar to a Native American hunter; therefore, the doses are similar. Only the Native American hunter will be presented in this assessment. To maintain the conservative methodology, the contact point for soil, both surface and shallow subsurface, contamination in all exposure scenarios is located at the contaminant source (i.e., direct contact is assumed). It is assumed the Native American will not reside at the site.

The following exposure routes were examined:

- Ingestion
- Inhalation
- Dermal absorption
- External exposure (tritium is a beta emitter; therefore, the dose due to external exposure is negligible)
- Ingestion of on-site cattle (rancher scenario only)
- Ingestion of on-site deer (native American scenario only)

The potentially complete exposure pathways include exposure to surface soil, shallow subsurface soil (under limited conditions), air, and groundwater (as modeled by RESRAD). Table D.3-1 lists the complete human exposure pathways for current and future land use. This table also indicates which pathways have been selected for risk characterization, and presents the rationale for inclusion or exclusion of each pathway.

Table D.3-1
Potentially Complete Human Exposure Pathways at Gasbuggy
(Page 1 of 2)

Environmental Medium	Exposure Route	Potentially Exposed Population	Pathway Selected for Evaluation	Reason for Selection or Exclusion
Surface Soil	Inhalation Ingestion Dermal Absorption External Exposure[a]	Residential Occupational	No	Gasbuggy is surrounded by national forest land and the land use is expected to remain similar in the future.
Surface Soil	Inhalation Ingestion Dermal Absorption External Exposure[a]	Recreational Rancher Native American	Yes	Potential intermittent recreational exposure is likely under current and future conditions. Ranching is known to occur in the general vicinity of the Gasbuggy Site.
Shallow Subsurface Soil	Inhalation Ingestion Dermal Absorption External Exposure[a]	Residential Occupational	No	Gasbuggy is surrounded by national forest land and the land use is expected to remain similar in the future.
Shallow Subsurface Soil	Inhalation Ingestion Dermal Absorption External Exposure[a]	Recreational Rancher Native American	Yes	Potential intermittent exposure is likely under current and future conditions. Direct contact with shallow subsurface soil is assumed.
Soil	Ingestion of Meat	Residential Occupational Recreational	No	Gasbuggy is surrounded by national forest land and the land use is expected to remain similar in the future.
Soil	Ingestion of Meat	Rancher Native American	Yes	Ranching is known to occur in the general vicinity of the Gasbuggy Site. It is assumed the ranchers ingest meat from on-site cattle. For the Native American scenario, on-site recreation use is assumed, including hunting and ingestion of on-site deer.
Surface Water	Inhalation Ingestion External Exposure[a]	Residential Occupational Recreational Rancher Native American	No	There are no permanent on-site surface water bodies at Gasbuggy.

Table D.3-1
Potentially Complete Human Exposure Pathways at Gasbuggy
(Page 2 of 2)

Environmental Medium	Exposure Route	Potentially Exposed Population	Pathway Selected for Evaluation	Reason for Selection or Exclusion
Shallow Groundwater	Inhalation Ingestion Dermal Absorption External Exposure[a]	Residential Occupational	No	Gasbuggy is surrounded by national forest land. The established institutional controls and land use is expected to remain similar in the future.
Shallow Groundwater	Inhalation Ingestion Dermal Absorption External Exposure[a]	Recreational Rancher Native American	Yes	Potential intermittent recreational exposure is likely under current and future conditions. Ranching is known to occur in the general vicinity of the Gasbuggy Site. Groundwater doses were based on modeled tritium concentrations from soil. Depth to shallow groundwater was not encountered during the preliminary field investigation. During the investigation, boreholes were routinely drilled to 20 ft bgs and a maximum of 36 ft bgs. Depth to shallow groundwater was assumed to be approximately 30 ft bgs.

[a]Tritium is a beta emitter; therefore, the dose due to external exposure is negligible.

Note: For the recreational, rancher, and Native American scenarios, it was assumed that food and water consumed on site will be brought in by the respective individuals.

Since land use at Gasbuggy is expected to remain similar, future pathways will be similar to the current pathways listed above. Therefore, this risk assessment assumes that restrictions currently in place (see Section 2.1.1 of the Work Plan) will remain for the foreseeable future.

Under these conditions, the current and future human health risks are identical (i.e., the pathways and receptors are the same). For the remainder of the document, these risks/doses will be linked to the same receptors with no further consideration of whether the exposure is current or future.

D.3.1.2 Quantification of Exposure

This section describes the estimation of exposure for tritium that may come into contact with human receptors. The process involves the following:

- Identification of applicable human exposure models (i.e., RESRAD) and input parameters
- Determination of the concentration of each contaminant in environmental media at the point of human exposure
- Estimation of human doses

For each potentially complete exposure pathway identified in Section D.3.1.1, a reasonable maximum exposure (RME) scenario has been developed. The RME is the highest exposure that is reasonably expected to occur at a site (EPA, 1989). The intent of the RME, as defined by EPA, is to estimate a conservative exposure case (i.e., well above the average case) that is still within the possible range of exposures. The RME is both protective and reasonable but is not the worst possible case (EPA, 1991b).

D.3.1.3 Exposure Models

RESRAD is a computer code developed at Argonne National Laboratory for DOE to calculate site-specific residual radioactive material guidelines as well as radiation dose and excess lifetime cancer risk to a chronically exposed on-site receptor (ANL, 1993b). A soil release guideline is defined as the radionuclide concentration in soil that is acceptable if the site is to be used without radiological restrictions. Soil is defined as unconsolidated earth material, including rubble and debris that might be present. These guidelines are based on the following principles: (1) the annual radiation dose received by a member of the critical population group from the residual radioactive material (i.e., predicted by a realistic but reasonably conservative analysis and calculated as committed effective dose equivalent [CEDE]) should not exceed 25 millirem per year (mrem/yr), and (2) doses should be kept as-low-as-reasonable-achievable (ALARA).

RESRAD uses a pathway analysis method in which the relation between radionuclide concentrations in soil and the dose to a member of a critical population group is expressed as a pathway sum, which is the sum of products of "pathway factors." Pathway factors correspond to pathway segments connecting compartments in the environment between which radionuclides can be transported or radiation emitted. Radiation doses, health risks, soil guidelines, and media concentrations are calculated over user-specified time intervals. The source is adjusted over time to account for radioactive decay and ingrowth, leaching, erosion, and mixing. For tritium, the transport coefficient used was 1.0. In addition, RESRAD includes an estimate for dermal contact of tritium within the internal radiation exposure pathway. RESRAD results are presented as CEDE.

D.3.1.4 Exposure Parameters

Three types of parameters are used in exposure models to estimate potential dose:

- Radionuclide-related parameters (e.g., exposure-point concentrations, dose conversion factors)
- Site-specific parameters (e.g., wind speed, precipitation)
- Parameters that describe the exposed population (e.g., contact rate, exposure frequency, and duration)

The exposed population and exposure-related parameters are summarized in Table D.3-2. The exposure parameters were taken from available site information, EPA guidance, and best professional judgement using site-specific information, where available. Upper-bound values are generally 90th or 95th percentile values, depending on the data available for each parameter. Because of the preliminary nature of this dose calculation, the more conservative 90th or 95th percentile value is used instead of the mean, which is more appropriate for a RME dose calculation. If no site-specific information was available, the RESRAD default was used as a reasonable upper bound estimate (ANL, 1993a). A combination of upper-bound and average exposure parameters were used to estimate the RME for each scenario.

Table D.3-2
RESRAD Parameters for Gasbuggy
(Page 1 of 6)

Parameters	Recreational Scenario	Native American Scenario	Rancher Scenario	Source of Parameter Data
Area of contaminated zone (m^2)	32,000	32,000	32,000	Total site area - approximately 8 acres (estimate based on aerial photo, see Figure 2-1)
Initial input concentration for tritium (pCi/g)	7.32[a]	7.32[a]	7.32[a]	Maximum measured radionuclide concentrations (see Appendix C)
Thickness of contaminated zone (m)	0.3048	0.3048	0.3048	Assumes one foot[b]
Length parallel to aquifer flow (m)	300	300	300	Maximum length of site cross section parallel to aquifer flow based on site dimensions (see Figure 2-1)
Basic radiation dose limit (mrem/yr)	25	25	25	See Section D.3.2
Time since placement of radioactive material (yr)	0	0	0	Based on current tritium levels in soil
Cover depth (m)	0	0	0	Assumes surface contamination (conservative assumption)
Density of cover material (g/cm^3)	NA	NA	NA	NA
Cover depth erosion rate (m/yr)	NA	NA	NA	NA
Density of contaminated zone (g/cm^3)	1.5	1.5	1.5	RESRAD default
Contaminated zone erosion rate (m/yr)	0.001	0.001	0.001	RESRAD default
Contaminated zone total porosity	0.4	0.4	0.4	RESRAD default
Contaminated zone effective porosity	0.2	0.2	0.2	RESRAD default
Contaminated zone hydraulic conductivity (m/yr)	10	10	10	RESRAD default
Contaminated Zone B parameter	5.3	5.3	5.3	RESRAD default

Table D.3-2
RESRAD Parameters for Gasbuggy
(Page 2 of 6)

Parameters	Recreational Scenario	Native American Scenario	Rancher Scenario	Source of Parameter Data
Evapotranspiration coefficients	0.8	0.8	0.8	Conservative value based on regional data[c]
Precipitation (m/yr)	0.43	0.43	0.43	Regional climate center[c]
Irrigation (m/yr)	0.0	0.0	0.0	No on-site irrigation
Irrigation mode	Overhead	Overhead	Overhead	RESRAD default
Runoff coefficient	0.2	0.2	0.2	RESRAD default
Watershed area from nearby stream or pond (m^2)	10^6	10^6	10^6	RESRAD default
Accuracy for water/soil computations	0.001	0.001	0.001	RESRAD default
Density of saturated zone (g/cm^3)	1.5	1.5	1.5	RESRAD default
Saturated zone total porosity	0.4	0.4	0.4	RESRAD default
Saturated zone effective porosity	0.2	0.2	0.2	RESRAD default
Saturated zone hydraulic conductivity (m/yr)	100	100	100	RESRAD default
Saturated zone hydraulic gradient	0.02	0.02	0.02	RESRAD default
Saturated Zone B parameter	5.3	5.3	5.3	RESRAD default
Water table drop rate (m/yr)	0.001	0.001	0.001	RESRAD default
Well pump intake depth (m below water table)	10	10	10	RESRAD default
Model: Nondispersion (ND) or Mass-Balance (MB)	ND	ND	ND	RESRAD default
Well pumping rate (m^3/yr)	Not used	Not used	Not used	NA
Number of Uncontaminated unsaturated zone strata	1	1	1	Assumed value
Unsaturated Zone 1, thickness (m)	10	10	10	Conservative assumption based on preliminary field investigation (see Appendix C)
Unsaturated Zone 1, soil density (g/cm^3)	1.5	1.5	1.5	RESRAD default

Table D.3-2
RESRAD Parameters for Gasbuggy
(Page 3 of 6)

Parameters	Recreational Scenario	Native American Scenario	Rancher Scenario	Source of Parameter Data
Unsaturated Zone 1, total porosity	0.4	0.4	0.4	RESRAD default
Unsaturated Zone 1, effective porosity	0.2	0.2	0.2	RESRAD default
Unsaturated Zone 1, soil-specific b parameter	5.3	5.3	5.3	RESRAD default
Unsaturated Zone 1, hydraulic conductivity (m/yr)	10	10	10	RESRAD default
Exposure Frequency (d/yr) (not used as input value)	14	14	30	Assumed value
Daily inhalation rate (m^3/d) (not used as input value)	20	20	20	EPA, 1991a
Annual inhalation rate (m^3/yr)	280	280	600	EPA, 1991a
Daily drinking rate (L/d) (not used as input value)	2	2	2	EPA, 1991a
Annual drinking rate (L/yr)	28	28	60	EPA, 1991a
Mass loading for inhalation (g/m^3)	0.00001	0.00001	0.00001	Anspaugh et al., 1974
Exposure duration (yr)	30	30	25	EPA, 1991a
Shielding factor, inhalation	1.0	1.0	1.0	No indoor shielding
Shielding factor, external gamma	1.0	1.0	1.0	Conservative assumption - no shielding
Fraction of time spent indoors	0.0	0.0	0.0	No on-site indoor exposure
Fraction of time spent outdoors (on site per year)	0.038	0.038	0.082	Based on fraction of time spent on site
Shape factor, external gamma	1.0	1.0	1.0	RESRAD default
Fruits, vegetables, and grain consumption (kg/yr)	NA	NA	NA	NA
Leafy vegetable consumption (kg/yr)	NA	NA	NA	NA
Meat consumption (kg/yr)	NA	63	63	RESRAD default

Table D.3-2
RESRAD Parameters for Gasbuggy
(Page 4 of 6)

Parameters	Recreational Scenario	Native American Scenario	Rancher Scenario	Source of Parameter Data
Milk consumption (L/yr)	NA	NA	NA	Milk ingestion not considered; primarily beef cattle and deer
Soil ingestion rate (g/yr)	1.4	1.4	3.0	Based on 100 mg/d (EPA, 1991a)
Household water fraction contaminated	1	1	1	RESRAD default[d]
Livestock water fraction contaminated	NA	1.0	1.0	Conservative assumption
Milk consumption (L/yr)	NA	NA	NA	Milk ingestion not considered; primarily beef cattle and deer
Irrigation water fraction contaminated	NA	1	1	Site/scenario-specific[e]
Contaminated fraction of plants	NA	NA	NA	NA
Contaminated fraction of meat	NA	0.016	0.08	Assumed value
Livestock fodder intake for meat (kg/d)	NA	68[f]	68	RESRAD default
Livestock water intake for meat (l/d)	NA	50	50	RESRAD default
Livestock intake for soil (kg/d)	NA	0.5	0.5	RESRAD default
Mass loading for foliar deposition (g/m^3)	NA	0.00001	0.00001	Anspaugh et al., 1974
Depth of soil mixing layer (m)	0	0	0	RESRAD default
Depth of roots (m)	NA	0.9	0.9	RESRAD default
Household fractional usage from groundwater	NA	NA	NA	NA
Irrigation fractional usage from groundwater	NA	1	1	Site/scenario-specific[e]

Table D.3-2
RESRAD Parameters for Gasbuggy
(Page 5 of 6)

Parameters	Recreational Scenario	Native American Scenario	Rancher Scenario	Source of Parameter Data
Livestock fractional usage from groundwater	NA	1	1	Conservative assumption - fraction of usage from groundwater is unknown
Storage times for contaminated foodstuffs				
Fruits, nonleafy vegetables and grains (d)	NA	NA	NA	NA
Leafy vegetables (d)	NA	NA	NA	NA
Meat (d)	NA	20	20	RESRAD default
Milk (d)	NA	NA	NA	NA
Water well (d)	1	1	1	RESRAD default
Water surface (d)	NA	NA	NA	NA
Livestock fodder (d)	NA	45	45	RESRAD default
Thickness of material (m)				
In the foundation	NA	NA	NA	NA
In contamination zone soil	NA	NA	NA	NA
Density of material (g/cm^3)				
In the foundation	NA	NA	NA	NA
In the contaminated soil	NA	NA	NA	NA
Total porosity of material				
In the foundation	NA	NA	NA	NA
In the contaminated soil	NA	NA	NA	NA
Volumetric water content				
In the foundation	NA	NA	NA	NA
In the contaminated soil	NA	NA	NA	NA
Diffusion coefficient for radon gas (m/sec)				
In the foundation	NA	NA	NA	NA
In the contaminated soil	NA	NA	NA	NA
Contamination zone radon diffusion coefficient	NA	NA	NA	NA

Table D.3-2
RESRAD Parameters for Gasbuggy
(Page 6 of 6)

Parameters	Recreational Scenario	Native American Scenario	Rancher Scenario	Source of Parameter Data
Radon vertical dimension of mixing	NA	NA	NA	NA
Average annual wind speed (m/sec)	2.0	2.0	2.0	RESRAD Default
Average building air exchange rate (1/hr)	NA	NA	NA	NA
Height of the building (room) (m)	NA	NA	NA	NA
Building interior area factor	NA	NA	NA	NA
Building depth below ground surface (m)	NA	NA	NA	NA
Emanating power of Rn-222 gas	NA	NA	NA	NA
Emanating power of Rn-220 gas	NA	NA	NA	NA

[a]A concentration of 7.32 pCi/g was the highest detection of tritium encountered during the preliminary field investigation (Appendix C). Since this investigation focused on areas where previous sampling indicated the highest levels of tritium and a limited number of samples were collected, a mean value was not calculated; therefore, 7.32 pCi/g was used as a conservative value.

[b]Direct contact with soil was assumed (i.e., surface soil). Therefore, the one-foot depth of contamination is a conservative estimation assuming that all of the soil is at the maximum tritium activity of 7.32 pCi/g.

[c]Based on climatological data from Gavilan, New Mexico (i.e., closest site to Gasbuggy) (WRCC, 2000)

[d]This parameter value cannot be edited in the application input file.

[e]Although there is no on-site irrigation, it was conservatively assumed to exist for the Native American and Rancher scenarios to account for the possibility of deer/cattle drinking on-site water (e.g., runoff).

[f]The deer ingestion rate was assumed to be identical to the cattle ingestion rate due to the lack of site-specific data. This is conservative due to the fact that deer eat considerably less than cattle.

NA = Not applicable
m^2 = Square meters
pCi/g = Picocuries per gram
m = Meters
mrem/yr = Millirem per year
yr = Year
g/cm^3 = Grams per cubic centimeter
m/yr = Meters per year
m^3/yr = Square meters per year
d/yr = Days per year
m^3/d = Cubic meters per day
L/d = Liters per day
L/yr = Liters per year
kg/yr = Kilograms per year
g/yr = Grams per year
mg/d = Milligrams per day
kg/d = Kilograms per day
d = Days
m/sec = Meters per second
L/hr = Liters per hour

D.3.2 Dose/Risk Characterization

This section provides a characterization of the potential doses/risks associated with the exposure to tritium at the Gasbuggy Site. This assessment employs a health-protective bias that leads to the overestimation of potential dose. Individuals are exposed to an RME (see Section D.3.1.1), and exposure is evaluated (see Section D.3.1.2) to provide estimates of annual exposure.

D.3.2.1 Dose/Risk Criteria

Summarized below are dose criteria guidelines from existing and proposed regulations and guidance. The dose criteria are used in the corrective action level evaluation by determining what level of residual concentrations of contaminants in the soil is acceptable and do not exceed established guidelines. The following is a brief summary of the applicable DOE and Nuclear Regulatory Commission (NRC) regulations. Also included is a discussion of the ALARA analysis as outlined in each of the regulations. The following regulatory dose standards are summarized below:

- DOE Order 5400.5, *Radiation Protection of the Public and the Environment* (DOE, 1993)
- 10 CFR Part 20, *Standards for Protection Against Radiation* (CFR, 2000).

DOE Order 5400.5

The primary dose limits for members of the public from all DOE activities, including remedial actions, are established in Chapters II and IV in DOE Order 5400.5 (DOE, 1993). Chapter II of DOE Order 5400.5 states, "the exposure of members of the public to radiation sources as a consequence of all routine DOE activities shall not cause, in a year, an effective dose equivalent greater than 100 mrem."

The primary dose limit is expressed as a CEDE, a term developed by the International Commission on Radiological Protection (ICRP) for their risk-based system, which requires the risk-weighted summation of doses to various tissues and organs of the body. The basic dose limit (100 mrem) is used in establishing guideline concentrations of residual radioactive material in the soil. This basic dose limit is an annual limit for members of the public who are assumed to participate in worst-case exposure scenarios (residential rancher and farmer). Other exposure scenarios could include an industrial worker and/or a recreational user. This regulation requires an environmental pathway analysis using approved models such as RESRAD to derive acceptable levels of radionuclides in soils from all exposure pathways. Radiation dose is assessed for these exposure scenarios every year during a 1,000-year time frame.

Chapter II of DOE Order 5400.5 requires that the ALARA process be adopted in planning, monitoring, cleanup, and control of residual radioactive material (DOE, 1993). DOE Order 5400.5 states "ALARA requires judgement with respect to what is reasonably achievable. Factors that relate to societal, technological, economic, and other policy considerations shall be evaluated to the extent practicable in making such judgements." These factors include:

- The maximum dose to members of the public
- The collective dose to the population
- Alternative processes
- Doses for each alternative process
- Costs for each technological alternative
- Differential doses from various pathways

The ALARA analysis may be quantitative (i.e., cost-benefit analysis) or qualitative. However, in either case, the bases for judgement should be clearly stated. The ALARA process for DOE Order 5400.5 is summarized in greater detail in the draft document *Applying the ALARA Process for Radiation Protection of the Public and Environmental Compliance with 10 CFR Part 834 and DOE 400.5 ALARA Program Requirements* - Volumes I and II (DOE, 1997)."

Title 10 CFR Part 20

The 10 CFR Part 20 regulations (CFR, 2000) establish standards for protection against ionizing radiation resulting from activities conducted under licenses issued by the NRC. Subpart D of 10 CFR Part 20 states that operations should be conducted so "the total effective dose equivalent to individual members of the public from the licensed operation does not exceed 100 mrem in a year, exclusive of the dose contributions from background radiation, any medical administration the individual has received, voluntary participation in medical research programs, and the licensee's disposal of radioactive material into sanitary sewerage." Subpart E further states this criteria for license termination: "a site will be considered acceptable for unrestricted use if the residual radioactivity that is distinguishable from background radiation results in a total effective dose equivalent (TEDE) to an average member of the critical group that does not exceed 25 mrem per year, including that from groundwater sources of drinking water, and the residual radioactivity has been reduced to ALARA levels." Subpart E further states that, if the land use was restricted, the 25 mrem/year limit would still apply. Therefore, an unrestricted exposure scenario would still have to be considered. The radiation dose (if the land restrictions fail) shall not exceed 100 mrem/year. Therefore, any individual will not receive more than the ICRP recommended dose limit of 100 mrem/year under any land-use scenarios.

Title 10 CFR Part 20 states that to the extent practicable, procedures and engineering controls based upon sound radiation protection principles shall be used to achieve occupational doses and doses to members of the public that are ALARA.

Based on the available information and regulations, a dose criteria of 25 mrem/yr is the only promulgated dose criteria and is considered protective to human health. Therefore, 25 mrem/yr will be used for comparison purposes at the Gasbuggy Site. Note that DOE Order 5400.5 is currently being revised to include the 25 mrem/yr criteria. It is not known when the revised DOE Order will be issued.

D.3.2.2 Risk Criteria

The EPA classifies all radionuclides as Group A carcinogens. Ingestion and inhalation slope factors are central estimates in a linear model of the age-averaged, lifetime attributable radiation cancer incidence (fatal and nonfatal cancer) risk per unit of activity inhaled or ingested, expressed as risk/pCi. External exposure slope factors (SF) are central estimates of lifetime attributable radiation cancer incidence risk for each year of exposure to external radiation from photon-emitting radionuclides distributed uniformly in a thick layer of soil and are expressed as risk/yr per pCi/gram soil. When combined with site-specific media concentration data and appropriate exposure assumptions, SFs can be used to estimate lifetime cancer risks to members of the general population due to radionuclide exposures. In most cases, cancer risks are limiting, exceeding both mutagenic and teratogenic risks. The slope factor used in RESRAD Version 5.95 (ANL, 1999) is taken from the EPA Health Effects Assessment Summary Tables (EPA, 1995).

In evaluating the calculated exposure from potentially carcinogenic radionuclides, a reasonable level of risk must be selected. The EPA used an incremental lifetime cancer risk (ILCR) (also referred to as excess cancer risk) of one in one million (1×10^{-6}) as the lower bound of an acceptable range. The upper bound of an acceptable ILCR recommended by the EPA for drinking water is 1 in 10,000 (1×10^{-4}) (EPA, 1999). In addition, the EPA specifies a risk range of 10^{-6} to 10^{-4} associated with the consideration and selection of remedial alternatives for contaminated media in the National Contingency Plan (NCP) (CFR, 1999).

Based on the regulatory precedents cited above, a reasonable and appropriate ILCR range would be from 10^{-6} to 10^{-4}. As implemented under the NCP, pathway risks greater than 10^{-6} ILCR must receive risk management consideration (CFR, 1999). This quantitative risk screening is one of many factors that are considered in the decision-making process for the need for additional analytical data. Therefore, there is no single risk value that defines "acceptable" and "unacceptable" risk. The purpose of this risk screening is to present qualitative estimates of potential risk; thus, all sites greater than the cumulative upper bound of 10^{-4} will be examined further for the need for additional data.

Cumulative site radionuclide ILCRs were developed for surface and shallow subsurface soils. However, the risks for the individual media were not combined. These cumulative ILCRs included all media and pathways that were appropriate to combine. Combined pathways occur when there is potential for an individual to be exposed to multiple pathways at the same given instant in time. Where the cumulative ILCR site risk to an individual based on the RME for both current and future land use is less than 10^{-4}, action generally is not warranted unless there are adverse environmental impacts (EPA, 1991b).

D.3.2.3 Results of the Human Health Dose/Risk Characterization

The results for each potential receptor are as follows:

- Recreational User in Contact with Soil - the maximum dose was 7.7×10^{-4} mrem/yr at 23 years (i.e., 2023) and the cumulative ILCR was 1.4×10^{-8}
- Rancher User in Contact with Soil - the maximum dose was 1.7×10^{-3} mrem/yr at 23 years (i.e., 2023) and the cumulative ILCR was 2.8×10^{-8}
- Native American User in Contact with Soil - the maximum dose was 7.8×10^{-4} mrem/yr at 23 years (i.e., 2023) and the cumulative ILCR was 1.4×10^{-8}

The difference in the dose numbers for the recreational user and Native American user scenarios, although the ILCR numbers are the same, is due to rounding.

Based on the maximum detected tritium activity, all of the potential doses are significantly below the allowable dose of 25 mrem/yr, and the potential risks were significantly below the lower bound ILCR of 1.0×10^{-6}. The site does not pose a potential risk to human health based on exposure to tritium in soil. Based on the significant number of analytical samples (both historical and confirmatory), and the overall potential dose, no further soil sampling for tritium is necessary.

D.4.0 References

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Appendix E

New Mexico Environment Department
Document Review Sheets

DOCUMENT REVIEW SHEET

1. Document Title/Number Site Characterization Work Plan for Gasbuggy, New Mexico DOE/NV–690
2. Document Date February, 2001
3. Revision Number Revision 0
4. Originator/Organization ITLV
5. Responsible Manager Monica Sanchez
6. Date Comments Due September 10, 2001
7. Review Criteria
8. Reviewer/Organization/Phone No. New Mexico Environment Department
9. Reviewer's Signature

10. Comment Number/ Location	11. Type[a]	12. Comment	13. Comment Response	14. Accept
General Comments				
General Comment #1		Notification to Native American Tribe - A primary concern is associated with DOE Order 0451.1B.5 (Responsibilities) d (10) (c), whereby DOE must notify any sovereign Indian Tribe neighboring any environmental restoration site of any intent for activity. Because DOE/NV is contemplating closure of the Gasbuggy Site, and because the Jicarilla Apache Reservation borders the site, it appears necessary that the tribe receive a copy of the Work Plan. The tribe was not listed or mentioned on the distribution list of the Work Plan. NMED also believes it would be appropriate for DOE/NV to solicit comments from the Jicarilla Apache Tribe on the Work Plan.	The Jicarilla Apache Tribe has been and will continue to be kept informed as to environmental restoration activities conducted by the U.S. Department of Energy, National Nuclear Security Administration Nevada Operations Office (NNSA/NV). An initial meeting was held on March 6, 2000, with representatives of the Jicrailla Apache Tribe. Since that meeting, NNSA/NV has corresponded with the Jicarilla Apache Tribe on several occasions, including notifying the Tribe of all NNSA/NV-sponsored activities at the Gasbuggy Site. A copy of the final Work Plan will be provided to the Jicarilla Apache Tribe for informational purposes.	
General Comment #2		Notification to the Public - A secondary concern is that of a more severe posting of contamination than the Work Plan indicates is currently being implemented. At present, significant gas and oil exploration is occurring near the Gasbuggy Site. The Work Plan has apparent deficiencies for warning of subsurface drilling. For example, a trifoil warning on the existing plaque may be considered prudent. DOE posts trifoil symbols at all contaminated laboratory sites and should consider consistency in this practice.	There are no radioactive materials at the Gasbuggy Site surface or near-subsurface that would require the area be posted as a radiological area and/or radioactive material area as defined in 10 CFR. Administrative controls (e.g., subsurface intrusion restrictions) are in place to ensure appropriate radiological controls are established before excavating, penetrating, or otherwise disturbing the underground radioactive materials still in the subsurface cavity. The subsurface intrusion restrictions, potential posting, and potential monitoring requirements for those restrictions will be examined as part of the subsurface closure process (see Figure 5-1 on page 67 and page 28 of the DQO document).	

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Specific Comments				
1. Sect. 1.3, 4th paragraph, 1st sentence, pg. 8		A plaque at Surface Ground Zero (SGZ) states the current subsurface intrusion (drilling) restrictions as: no intrusion is allowed from surface to 1,500 ft total vertical depth (TVD) within a 100-ft radius, and no intrusion is allowed from 1,500 to 4,500 ft TVD within 1,600-ft radius (DOE/NV, 1978). NMED believes the plaque should indicate the reason for restricted intrusion. The plaque should indicate the potential of radioactive contamination existing within the intrusion restrictions and possibly include a trifoil. The plaque should be inspected periodically (e.g., annually) for the integrity of the material from which it is composed.	The full text of the plaque was not quoted in the Work Plan. Including on the plaque is an explanation of the significance of the site. The full text of the plaque is as follows: "Project Gasbuggy Nuclear Explosive Emplacement/Reentry Well (GB-ER) Site of the first United States underground nuclear experiment for the stimulation of low productivity natural gas reservoir. A 29-kiloton nuclear explosive was detonated at a depth of 4,227 feet below this surface location on December 10, 1967. No excavation, drilling, and/or removal of subsurface materials to a true vertical depth of 1,500 feet is permitted within a radius of 100 feet of this surface location, nor any similar excavation, drilling, and/or removal of subsurface materials between the true vertical depths of 1,500 feet and 4,500 feet is permitted within a 600 foot radius of this surface location in the SE quarter of the SW quarter of Section 36, T 29 N, R 4 W, New Mexico Principal Meridian, Rio Arriba County, New Mexico, without U.S. Government permission. United States Department of Energy November 1978" The full text of the plaque has been inserted in the document. As indicated in the response to General Comment #2, the subsurface intrusion restrictions, posting requirements, and monitoring requirements will be examined as part of the subsurface closure process.	

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2. Sect. 2.1.3, 2nd sentence, pg. 9		Four artificially created seasonal ponds: Are any radioactive species present in ponds or their sediment? NMED suggests sampling of pond sediment and analysis for radionuclides (plutonium, uranium, fission products [specifically ^{137}Cs and ^{90}Sr], and tritium). All results should indicate levels of radioactive contamination as 'releasable to the public', as indicated in DOE Order 5480.11. DOE/NV should also declare a 'releasable to public' limit for tritium as several of the DOE national laboratories have designated a limit of 1,000 dpm for tritium.	A literature review has been performed on the extensive sampling and analysis of chimney gases, particulates, ground surface, and soil. Tritium has been identified as the only radionuclide of concern. See Attachment A to this document review sheet for a summary of the review. Based on the result of the review of the literature review, direct sampling of the ponds is not warranted and will not be conducted.	
3. Sect. 2.2, 3rd paragraph, 3rd sentence, pg. 10		Short-lived radioactive gases and tritium; If "process knowledge" stated that there were radiological releases at the site surface and these consisted of short-lived radioactive gases and tritium, it follows that there may well have been other non-gaseous radionuclides released at the surface simply by mechanical entrainment with the "short-lived radioactive gases and tritium." There are references in Appendix A (Page A-1 of A-24), but there are no comments relating to the laboratory methodology and Quality Assurance documentation. The Eberline Instrument Corporation 1979 Report, *Project Gasbuggy Radiation Contamination Clearance Report*, PNE-G-89, was cited as containing the information dealing with the non-existence or no-detectability of radionuclides other than "short-lived radioactive gases and tritium." Because the PNE-G-89 Report did not report items such as limit of detection for those radionuclides other than tritium; it is of limited value. Appropriate action would be to take soil samples at the Gasbuggy Site and have them analyzed for the isotopes of concern and use MARSSIM criteria for clearance and sampling, where appropriate.	Based on the historical documentation, tritium is the only radionuclide of concern for the Gasbuggy Site surface (see response to Comment #2). Based on the conclusions presented in Appendix D, tritium does not present a health risk at the Gasbuggy Site surface/near-surface; therefore, no additional sampling and analysis for tritium in soil at the site surface/near-surface will be conducted.	
4. Sect. 2.2.1, 13th paragraph, 5th sentence, pg. 21		This process contaminated the soil in the SQZ area with low-levels of tritium. If there was contamination by tritium from the water that was injected into the gas flare, there was certainly the opportunity for the contamination of this soil by other radionuclides. Analyze for the presence of radionuclides in the soil near the SQZ.	Based on the historical documentation, tritium is the only radionuclide of concern for the Gasbuggy Site surface (see response to Comment #2). No additional soil sampling and analyses for radionuclides is planned for the Gasbuggy Site surface/near-surface.	

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5. Sect. 2.2.1, 17th paragraph, 2nd sentence, pg. 21		Septic Tank B has no documentation of actually existing. If it did exist and was not located, it could be a matter of concern. A site survey with Ground-Penetrating Radar (GPR) may be of use in determining whether or not this tank was present and also may identify the presence of other underground items at the site.	A geophysical survey was conducted over the entire Surface Ground Zero area with an EM-31 instrument (see Section C.3.0). Two of the objectives of this survey were to locate and delineate the septic tanks and locate and delineate undocumented subsurface features (e.g., underground storage tanks). In addition to the EM-31 survey, the suspected locations of the septic tanks were surveyed with EM-61 and ground-penetrating radar instruments. These surveys did not definitively identify the locations of any of the septic tanks. See Appendix C for details on these surveys. Information on these surveys has been added to Section 2.2.1 of the document so that the reader is aware of this information when the septic tanks are first discussed. Additional investigation of the septic tanks is planned as described in Section 4.2.3.1, paragraphs 13 and 14 of the main document.	
6. Sect. 2.2.3, 1st paragraph, 2nd sentence, pg. 24		Septic tank or underground storage tank existence is of concern. The absence of these tanks is based solely upon "historical documents." If the actual site construction is different than as-built drawings, there may be a case for the presence of septic tanks and/or underground storage tanks. A site survey with GPR may be of use in determining whether or not tanks are present and also may identify the presence of other underground items at the site.	A geophysical survey was conducted in order to identify the presence of septic tanks and/or underground storage tanks (see response to Comment #5).	
7. Sect. 2.3, Table 2-1, pg. 30		The table has a reference to the determination of ^{137}Cs, but not ^{90}Sr. If ^{137}Cs is present there should have been a report on the presence of ^{90}Sr. The fact that it was present in 1990-1994, and not present after 1994 is not consistent with its half-life of 30 years. Does this mean that any ^{137}Cs originally present has been swept into surrounding aquifers? There should be a determination of both ^{137}Cs and ^{90}Sr in surrounding aquifers and groundwater.	The lack of reference to ^{90}Sr reflects its non-detection in the well. The erratic analytical results from EPNG 10-36 are discussed in Sections 3.2.2 and 5.1.4, and have been elaborated on in response to Comment #9, below. The level of detail presented in the table commented on here is obviously confusing at this point in the document, so the table has been revised and simplified to describe the activities, but not necessarily the results. As described in Section 5.6, samples will be collected from Well EPNG 10-36 to be analyzed for gamma spectroscpy (e.g., ^{137}Cs) and ^{90}Sr.	

[a] Com[illegible]Type[illegible] = Ma[illegible]ry, S[illegible]Sugge[illegible]

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8. Sect. 2.3, Table 2-1, pg. 31		A beta/gamma survey was also conducted (DOE/NV, 1983): NMED needs to review this document to determine exactly how the survey was performed in order to determine its sensitivity. Were MARSSIM criteria followed? If the document cannot be located, gamma flyovers could be conducted. Los Alamos National Laboratory, ESH-17, regularly conducts such surveys.	The beta/gamma survey cited is the same survey conducted as described in the *Project Gasbuggy Radiation Contamination Clearance Report* (Eberline, 1979). The reference for the statement in the table has been changed to include the Eberline report. The Eberline (1979) report was transmitted to Bob Weeks of the NMED DOE Oversight Bureau on July 19, 2001, and to James Bearzi of the NMED Hazardous & Radioactive Materials Bureau on March 29, 2000. The beta/gamma survey was conducted after all site activity was completed with the exception of the reseeding effort. The survey was conducted with a portable thin window (< 7 mg/cm^2) pancake geiger counter PRM-5-3 (EIC HP-210 probe), SN 1987, calibrated 8/10/78. A 30-second count was made at each of the soil sampling locations, by holding the counter just a few centimeters above the ground. All readings were < 0.05 mrad/hr for beta/gamma. The average probe background away from the site was approximately 0.036 mrad/hr. MARRSIM criteria are not applicable for this survey since MARSSIM was not adopted until December 1997. In addition to portable radiological instrument surveys soil, vegetation, and water samples were collected. The radioanalysis of the samples demonstrates that there was no radiological contamination of soil or surface waters which exceeded the DOE site restoration criteria applicable at that time, 300 pCi/mL of tritium in surface water, 30,000 pCi/mL of tritium in soil moisture, and 0.05mrad/hr beta/gamma including worldwide fallout measured at 1 cm (page 30 of Eberline, 1979). An aerial radiological survey was conducted of the Gasbuggy Site on October 27, 1994 (EG&G, Energy Measurements, 1995). This survey was able to ascertain man-made gamma emitting radionuclides (i.e., Cs-137) in concentrations that would produce an exposure rate at 1 meter greater than 1 mR/hr. The conclusion of this survey is that no man-made radionuclides were detected at concentrations that would exceed an exposure rate of 1 mR/hr.	

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9. Sect. 3.2.2, 3rd paragraph, 3rd sentence, pg. 42		^{137}Cs at concentrations up to 16 pCi/L: In the monitoring of Well EPNG 10-36, why was only ^{137}Cs analyzed and reported and not ^{90}Sr, another fission product of potential concern to human health? There should be a review of Boehlecke, 2001, to determine if the ^{90}Sr was an analyte in these studies.	^{90}Sr is occasionally analyzed for in water collected from Well EPNG 10-36 as part of the Long-Term Hydrological Monitoring Program (LTHMP). ^{137}Cs has been analyzed more frequently because it has been found above the detection limit. The record of ^{137}Cs in Well EPNG 10-36 is very erratic and led to question whether it was representative of anything in the formation (this is discussed in Section 5.1.4 on p. 75). This in turn led to the development of the investigative work in EPNG 10-36 described in Section 5.2.2. The sample with the initial ^{137}Cs record in 1988 has a collection comment saying "Accidently contaminated with Cs-137-resampled 10-25-88". A clearer record of the sampling history of Well EPNG 10-36 has been added to the report in Section 5.1.4 along with a discussion of the apparent sample contamination issue. Also, Figure 5-5 has been changed to reflect the data as presented in a printout from the LTHMP data base. A printout of data from the LTHMP (Boehlecke, 2001) will be provided to NMED under separate cover.	
10. Sect. 4.2.3.2, 2nd paragraph, 2nd sentence, pg. 60		The anomaly warrants further investigation: In Table 4-4, the Contaminants of Potential Concern do not include any radiological species. At the very least, screen the samples with survey meters for alpha and beta/gamma and include these results in the report. If these examinations give positive results, proceed with laboratory determination of suspect radionuclides.	Well GB-D was used for instrument placement and is located approximately 1,500 ft southeast of the surface ground zero area. Radiological contamination is not suspected in the Well GB-D Area (see Section 2.2.2). As discussed in the response to Comment #2, there is no reason to suspect radiological contamination at the Gasbuggy Site other than potential tritium contamination. As stated in the Work Plan, additional soil sampling for tritium is not planned based on the results of previous samples and the results of the dose/risk assessment presented in Appendix D. Screening soil for radiological contamination to aid or guide site characterization activities is not planned. However, due to internal protocol and procedures all soil samples are screened for alpha and beta/gamma for health and safety reasons. This screening is detailed in the Health and Safety Plan which will be made available to NMED prior to initiation of field activities.	

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11. Sect. 4.2.3.4, 1st paragraph, 1st sentence, pg. 62		Search for the septic tank with exploratory excavation: Samples should be made of any contents. Would it not be more productive to search with GPR than via exploratory excavation? Evaluate GPR capabilities and employ this technique if appropriate. If found, the sampling could be simple survey meter for alpha and beta/gamma screening. Note: Later in this report, GPR was employed and a statement was made that future work will include a more extensive search for the missing septic tank.	A geophysical survey was conducted over the entire surface area of the Control Point with an EM-31 instrument (see Section C.3.0). Two of the objectives of this survey were to locate and delineate the septic tank and locate and delineate undocumented subsurface features (e.g., underground storage tanks). In addition to the EM-31 survey, the suspected location of the septic tank was surveyed with ground-penetrating radar. These surveys did not positively identify the location of the septic tank. See Appendix C for details on these surveys. Information on these surveys has been added to Section 2.2.4 of the document so that the reader is aware of this information when the septic tank is first discussed. The septic tank at the Control Point (CP), if found, will be investigated in the same manner as those at the SGZ area. This will include making observations on the condition of the tank (e.g., filled, empty) and sampling of contents, if applicable. The process by which the septic tanks will be investigated is explained in the thirteenth and fourteenth paragraphs of Section 4.2.3.1 as cited in the subject paragraph. See response to Comment #10 regarding radiological screening. Tritium has been added as a COPC for the septic tanks in the event the tanks have not yet been closed and material is available for sampling.	

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12. Sect. 4.3.1, 2nd paragraph, 3rd sentence, pg. 63		Discussion with NMED: Which bureau or bureaus will this involve? There are three entities that could be contacted. The Hazardous Waste Bureau (HWB), Ground Water Bureau (GWB), and the DOE Oversight Bureau (DOE-OB) should be involved with this study prior to the wells are drilled.	Based on the results of the preliminary field work conducted in 2000 (see Appendix C), it appears unlikely that shallow groundwater will be encountered and require sampling. Shallow groundwater was not found in the areas investigated. The maximum depth of investigation was 36 ft below ground surface. The deepest contamination (i.e., TPH) detected was at 9-11 ft below ground surface. This information has been added to Section 4.3.1. Shallow groundwater will only be investigated if it is found within 10 ft of contamination (see Figure 4-1 on page 45). NNSA/NV established the DQOs in consultation with the HWB and will continue to use the NMED/HWB as the primary point of contact for all matters regarding characterization and closure activities at the Gasbuggy Site. The NNSA/NV is relying on NMED HWD to consult with other appropriate organizations as necessary.	
13. Sect. 5.1.1, 3rd paragraph, 7th sentence, pg. 71		Although randomly oriented joints present throughout the San Juan basin may influence some groundwater flow, pore flow is believed to dominate in the Ojo Alamo. However, the migration of radionuclides via groundwater flow through these "randomly oriented joints: is possible. There should be a determination of the presence of radionuclides as measured by appropriate monitoring wells.	*Both porous medium flow and fracture flow have been* considered in evaluations of the site (e.g., Chapman et al., 1996). The EPA has been annually sampling the only monitoring well at the site, Well EPNG 10-36. The final decision point in the DQOs describes the assessment of long-term monitoring needs (see page 78 of the DQO document).	

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14. Sect. 5.1.2, 5th paragraph, 3rd sentence, pg. 73		4.5×10^4 Curies of tritium: What about tritiated sandstone? Hydroxyls in rock should become tritiated. What about "higher hydrocarbon fractions"? How was this determined? Was there anything like a Soxhlet extraction performed on the rock samples? Conduct chemical extractions of samples of rock/rubble that are suspect, and follow with liquid scintillation determination of tritium. Ascertain that the statement "4.5×10^4 Curies of tritium" is correct in order of magnitude.	Tritiated sandstone would not be mobile and therefore is not of concern regarding contaminant migration. A substantial amount of radioactivity remains in the nuclear cavity, and as described at the beginning of the subsurface work plan (Section 5.0, page 66), there is no technology to remediate underground nuclear cavities. The approach is to ensure that drilling restrictions are adequate. Regarding the estimate of tritium mass: radionuclide production from nuclear tests is predicted based upon the physics of the device and the surrounding rock and fluid properties. These predictions are verified by post-shot samples. Accurate assessment of production is of importance to evaluating device performance and thus has been a priority in the nuclear weapons testing program. The classified data will be used as the source mass during transport calculations performed for the characterization effort. Unclassified data are used in the work plan, and elsewhere, to allow unclassified audiences the ability to understand the approach and general results.	
15. Sect. 5.1.4, 1st paragraph, 2nd sentence, pg. 74		Evidence for a connection between the Ojo Alamo and the Gasbuggy cavity: If there is a connection, then there is a potential for longer lived radionuclides to ultimately find their way into the Ojo Alamo and even though its water would not be used for drinking, perhaps there would be a pathway for these to get into a groundwater source used for human or animal consumption. Hydrological testing for radionuclides should be conducted if there is a reasonable location for such sampling.	Well EPNG 10-36 presents the only opportunity for sampling the Ojo Alamo and is part of the annual LTHMP network. No long-lived radionuclides from Gasbuggy have been detected there. There is no exposure scenario for the Ojo Alamo aquifer in the Gasbuggy area because its great depth and poor water quality preclude it from use.	

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16. Sect.5.1.4, 4th paragraph, 1st sentence, pg. 75		Water uncharacteristic of the Ojo Alamo: If not Ojo Alamo, then what is the source of the water? Could these also be pathways for radionuclides to migrate? A more extensive investigation, which gives the ultimate determination of the source of the "uncharacteristic" water, should be conducted.	This concern will be addressed during purging and sampling of the well, presented in Sections 5.2.2 and 5.6 of the Work Plan. It is possible the non-Ojo Alamo water was introduced from the top of the well. Down-hole geophysical logging of Well EPNG 10-36 in 1994 and 1999 did not positively identify any holes in the casing. The purging and sampling will identify any sources of water into the well other than the bottom perforations and identify entry of contaminants.	
17. Sect. 5.3, 2nd paragraph, 1st sentence, pg. 80		Fracture permeability in the subsurface: Radionuclide migration through fractures and faults could be occurring. Employ those geophysical tools/methods which best determine whatever state-of-the-art will allow for determining the nature of fractures throughout the subsurface.	The investigation presented in this part of the work plan will use existing subsurface data, not collect new data. There are several inter-related reasons for this. There are no open boreholes at the site that penetrate the Pictured Cliffs Formation, so data collection would necessitate deep well drilling that introduces the potential for creating new migration pathways, as well as requiring great expense. In addition, the type of data discussed here (fracture permeability distribution) is very difficult to collect. Though fractures in a single borehole can usually be identified with ATV and radar logs, their lateral extent and continuity to other fractures is extremely difficult to discern and necessarily spatially limited. Thus a field program is not likely to contribute to reducing this uncertainty; therefore, no additional deep groundwater monitoring wells are planned.	
18. Sect. 5.6, 3rd paragraph, 4th sentence, pg. 84		A C-14 and Carbon-13 (C-13) sample will also be collected: Will fission product ^{13}C or ^{14}C obscure these age results? Particularly, would this be the case if there were the same uncertainty regarding their source or origin, as was the case for tritium and ^{137}Cs as detected in Well EPNG 10-36 and as mentioned on page 77 of 97 of this report? If not classified information, examine the technical literature to determine the presence of ^{13}C and ^{14}C resulting from nuclear detonations.	Device-related C-14 will be very obvious, if present in a sample. ^{14}C was produced by the Gasbuggy test. Thus this analyte provides both a check for contamination, or if absent, a sense of groundwater age.	
19. Sect. 6.0, 1st paragraph, 1st sentence, pg. 86		The schedule is not current and should be revised.	The schedule has been revised.	

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20. App. A, A.2.2, 2nd paragraph, 2nd bullet, pg. A-1		No radionuclides other than tritium and naturally occurring radioisotopes were found in the soil samples collected during 1978 Gasbuggy restoration effort. Analytical methodology employed in the analysis of these soil samples could be conducted. There should be an examination of the reference EIC, 1979, to assure the veracity of the above statement.	The collected soil samples were analyzed off site at Eberline Instrument Corporation (EIC) facilities for Pu-238, Pu-239, and Sr-90. Gamma-emitting radionuclides were analyzed for using a GeLi detector. Based on the past history of samples taken from the Gasbuggy Surface Ground Zero area, the numerous samples analyzed for beta and gamma emitters during the clearance operation, the beta-gamma survey of the site itself, and additional samples collected and sent to other laboratories confirms that tritium is the only radioactive isotope other than naturally occurring radioactive isotopes and worldwide fallout present in the Gasbuggy soil. See response to Comment #2.	
21. App. A, A.2.2, 2nd paragraph, 3rd sentence, pg. A-4		The mean plus or minus one standard deviation for the pre- and post-detonation TLD sets were 0.37 +/- 0.47: The values of the standard deviation appear to be large relative to the mean. An examination of these numbers and a determination of the standard deviations appear warranted. Also, deploy TLDs at appropriate locations near and at some distances from SGZ and exchange them on a quarterly basis. Continue this for several years. Compare the results from the TLDs around the site with other TLDs placed some distance away and which would serve as background dosimeters. This would be a cost effective method to obtain valuable information.	The values given for the standard deviation were incorrect. The correct values are 0.047 (not 0.47) for the predetonation TLDs and 0.055 (not 0.55) for the postdetonation TLDs. The text has been revised to reflect the correct values. Since tritium is the only radioisotope of concern potentially present in soils at the Gasbuggy Site, additional TLD monitoring is not warranted.	
22. App. A, A.2.5, 1st paragraph, 2nd sentence, pg. A-4		None of the gas samples collected during the posttest contained radioactive material except for the noble gases of xenon and krypton: What about the presence of tritium? There should be an examination of the reference AEC, 1971, to assure the veracity of the above statement.	The statement is not accurate. The reviewer is referred to the sixth paragraph of Section 5.1.2 for a more accurate description of the composition of the chimney gas. The reviewer is also referred to the response to Comment #2. Specifically to the literature review of the paper *Project Gasbuggy Gas Quality Analysis and Evaluation Program Tabulation of Radiochemical and Chemical Analytical Results*, April 19, 1971, Lawrence Radiation Laboratory (UCRL-50635). Section A.2.5 has been revised to more accurately reflect the available data.	

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23. App. A, A. 3.0, 7th paragraph, 2nd sentence, pg. A-7		Have condensed and infiltrated the soil would have dissipated due to evapotranspiration: Tritium certainly could have associated with the sandstone of the reservoir and therefore not dissipated. Perform a sampling of the sandstone rubble from around the cavity and conduct analysis for tritium.	The Ojo Alamo reservoir is over 3,000 ft below ground and the cavity produced by the nuclear explosion is over 3,500 ft below ground. The tritium contamination this paragraph is referring to is tritium contamination within the surface and shallow subsurface soil. Based on the dose/risk assessment documented in Appendix D, tritium at the Gasbuggy Site surface does not present an increased risk to human health, and further sampling for tritium at the site surface is not warranted. For a discussion of the potential for tritium to have associated with the sandstone of the Ojo Alamo aquifer see the response to Comment #14.	
24. App. A, A.5.1, 1st paragraph, 3rd sentence, pg. A-21		The total gamma-ray flux was measured with a portable pressurized ion chamber system for comparison with the *in situ* spectrometry results: Is this comparison appropriate and relevant? There should be an examination of EPA, 1995, to determine the validity of the quote from the text.	*In situ* gamma ray spectrum were collected in the field. The activity of identified radionuclides were converted to exposure rates. These exposure rates were then summed and compared directly to the exposure rates as measured by the pressurized ion chamber (PIC). The comparison of the calculated dose rates to the actual dose rates is appropriate.	
25. App. B, B.5.1.3, 1st paragraph, 2nd sentence, pg. B-25		Contractors and other agency participants shall have a system in place for the storage and retrieval of quality records that is consistent with environmental regulations and DOE Order 200.1 (DOE, 1996a): Some of the citations associated with these comments mentioned herein have not been readily available for review. Compile a list of those documents cited and which are necessary for review and provide NMED copies of them so they can be evaluated. If the documents are available electronically, transmit electronic copies. Otherwise, provide hard copies.	Each document from which specific information was used is referenced in the text. There is a list of references at the end of the main document and each of the Appendices. It would be cost prohibitive to copy all of these documents. If there are specific documents NMED would like for their file, please indicate these and we will provide those documents. Several of the most highly referenced documents were provided to NMED in March of 2000. See cover letter entitled "Highlights of March 7-8, 2000, Meeting" from Runore C. Wycoff to James Bearzi, dated March 29, 2000. A copy of this letter is provided in Attachment B.	

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Reviewer/Organization Monica Sanchez

10. Comment Number/ Location	11. Type[a]	12. Comment	13. Comment Response	14. Accept
26. App. B, B.6.2, 1st paragraph, 3rd sentence, pg. B-26		To the extent possible, contractors and project participants' hardware and software should be compatible with that of DOE/NV Environmental Restoration Program: Has appropriate action been taken such that information from this project will be easily retrievable in the future? The information technology specialists concerned with this project must address this concern. There certainly are numerous examples of data collected in the past not being retrievable because of hardware or software problems or incompatibilities.	Contractors maintain regular and close contact with the requirements and operations of the NNSA/NV ER program to ensure compatibility of hardware, software, and prepared materials supplied to DOE. A formal process is followed to ensure that proposed equipment additions and upgrades fall into the existing and proposed information architecture. Data stored by the NNSA/NV contractor (including items maintained and supported for NNSA) are copied daily and archived monthly into an industry standard 8mm tape backup system for quick and easy retrieval. This system is reviewed annually in conjunction equipment addition and upgrade process to ensure that it meets generally accepted industry standards currently in affect. In addition, hard copies of documents, correspondence, quality records, health and safety records, and field records relating to the environmental investigation and restoration of the Gasbuggy Site are kept as part of a comprehensive central filing system. This system is consistent with NNSA orders and includes provisions for the storage and retrieval of quality records.	
27. App B, B.6.3.4.1, 1st paragraph, 3rd sentence, pg. B-35		Pre-Analysis Storage/Data reduction, Verification, and Validation shall be documented: There is a need to address specific storage vessel compositions in the context desired analytes (i.e., radiologicals, metals, organics, etc.). The reason is that there is some tendency for various analytes to chemisorb to the surface of the storage vessel. If this happens, low analytical results will occur for the analyte under consideration. An example of this is the loss of polonium during storage in certain container types awaiting analysis. There must be documentation of storage vessel type showing that the vessel is satisfactory for the analyte of concern and that it will not be "lost" during storage.	Attachment 2, Laboratory Chemical, Toxicity Characteristic Leaching Procedure, and Radiochemistry Analytical Requirements for New Mexico sites have been revised to include sample container composition requirements which are compatible with preserving the analysis of concern.	

[a] Comment Types: M = Mandatory, S = Suggested.

DOCUMENT REVIEW SHEET

Document Title/Number Site Characterization Work Plan for Gasbuggy, New Mexico Revision Number 0
Reviewer/Organization Monica Sanchez

10. Comment Number/ Location	11. Type[a]	12. Comment	13. Comment Response	14. Accept
28. App. B, B.6.4.3, 2nd paragraph, 2nd sentence, pg. B-37		Data Reduction, Verification and Validation: This section does not refer to the need for independent audits of the laboratories performing the analytical work. An independent audit should be performed for those laboratories analyzing samples under the present program. The person(s) performing the audit must know what they are doing. There have been instances in which "auditors" were essentially clueless regarding the work they were supposed to be auditing. The concept of audit either may or may not be addressed in B.11.0, Criteria 10-Independent Assessments.	As indicated in Section B.11.0, "Independent Assessments," "assessments shall be conducted to measure item and service quality." This statement is written so as to include audits of outside laboratories. All laboratories used by NNSA contractors to perform analytical work are considered services and are audited on an annual basis in compliance with the DOE Environmental Management Consolidated Audit Program (EMCAP). This program coordinates auditors from various DOE sites into a comprehensive audit team. Auditors must meet stringent qualification criteria in order to be accepted within this program. The audits examine six areas to include: quality systems; organic, inorganic, and radiological analysis; waste management; and information management systems.	
29. App C, C.1.1, 3rd paragraph, 5th sentence, pg. C-2		The septic tank was not located. See above Section 4.0 reference to septic tank.	See response to Comment #5	
30. App. C, C.4.3, 1st paragraph, 3rd sentence, pg. C-17		"The core was screened for alpha and beta contamination with....and gamma...": there was no apparent reporting of the levels of either background or elevated reading alpha, beta, or gamma radiation. An examination of the field notes to obtain this information. Then include in another report. A simple statement that was no evidence of radiation above background would be informative if this were the case.	This section of the work plan discusses the processes that took place during sample collection. Radiological screening of the core was conducted to ensure worker safety and not to guide the investigation. At no time did radiological screening results meet or exceed radiological hold points as listed in the site-specific health and safety plan. The Work Plan has been edited to more accurately reflect the use of the screening.	
31. App C, C.6.2 1st paragraph, 1st sentence, pg. C-64		The problem with the existence and location of the septic tank as mentioned above.	See response to Comment #5.	

[a] Comment Types: M = Mandatory, S = Suggested

DOCUMENT REVIEW SHEET

Document Title/Number Site Characterization Work Plan for Gasbuggy, New Mexico Revision Number 0

Reviewer/Organization Monica Sanchez

10. Comment Number/ Location	11. Type[a]	12. Comment	13. Comment Response	14. Accept
32. App D, D.3.2.3, 3rd paragraph, 2nd sentence, pg. D-19		The site does not pose a potential risk to human health based on exposure to tritium in the soil: Radioisotopes other than tritium man be of concern. Their absence based solely on the Eberline document (EIC, 1979) may be problematic as mentioned above. It may be worthwhile to include radioisotopes other than tritium in this statement, and this would make the statement a bit more clear.	The statement is based on the results of the dose/risk assessment which was conducted only for tritium. Radiological contamination other than tritium is not of concern for the surface and shallow subsurface of the Gasbuggy Site. See response to Comment #2.	

[a] Comment Types: M = Mandatory, S = Suggested.

<u>Attachment A</u>
to Document Review Sheet for
Site Characterization Work Plan for Gasbuggy, New Mexico, Rev. 0

Literature review for potential radiological contamination at the Gasbuggy site surface

(4 pages)

Literature review for potential radiological contamination at the Gasbuggy site surface

The following information is provided as a response to Comment #2 received from the New Mexico Environment Department on Revision 0 of the Site Characterization Work Plan for Gasbuggy, New Mexico.

The following reports were reviewed for information on potential radiological contamination at the Gasbuggy Site surface and near surface.

Nongaseous Radioisotopes - Project Gasbuggy Chimney Gas, April 7, 1969, Lawrence Radiation Laboratory (Document No. UCRL-50634).

This report discusses the experimental determination of the upper limits (i.e., detection limits) for nongaseous radionuclide concentrations in the Gasbuggy chimney gas. The probable upper limit concentrations for Cs-137 and Sr-90 were determined to be 0.03 x 10^{-15} curies per cubic centimeter (cc) (equivalent to 3 x 10^{-11} microcuries per milliliter [μCi/mL]) of chimney gas. These upper limit values indicate that the possible presence of these semivolatile nuclides can be excluded in the chimney gas of the Gasbuggy experiment (LRL, 1969).

Project Gasbuggy Gas Quality Analysis and Evaluation Program Tabulation of Radiochemical and Chemical Analytical Results, April 19, 1971, Lawrence Radiation Laboratory (Document No. UCRL-50635).

This report indicates that during high-rate production tests of the Gasbuggy chimney, filter papers were exposed to collect any particulate debris that might be entrained in the chimney gas. Subsequently these filters were analyzed for Sr-90 and Cs-137 by radiochemical separation and low-level beta counting. The detection limit for this analysis was listed as twice the standard deviation of the background (0.3 counts/min). Four sets of filters were combined and analyzed with the following results: Sr-90 at 1.32 +/- 0.15 cpm with a background of 1.36 +/- 0.16 cpm, and Cs-137 at 0.91 +/- 0.15 cpm with a background of 1.08 +/- 0.15 cpm. Additional attempts to detect the presence of gamma emitting radionuclides on these filters demonstrated Cs-137 and Sr-90 did not exceed the minimum detectable activity (LRL, 1971).

Surface Radioactivity at the Plowshare Gas-Stimulation Test Sites: Gasbuggy, Rulison, Rio Blanco, January 1995, United States Environmental Protection Agency (Document No. EPA 600/R-95/002).

This report identifies that gamma ray spectra were obtained in the field at nine locations using a high purity germanium (HPGe) diode detector. The identified radionuclide surface activities were then converted to exposure rates based on cited methods. The Cs-137 exposure rate was highest at off-site locations near Gasbuggy. These locations had extensive forest litter, which is known to accumulate fallout radiocesium. The locations also do not lie in areas of drainage. The exposure rates measured at the nine field locations are consistent with those observed at other locations in the United States with similar amounts of precipitation (i.e., fallout Cs-137 was only detected) (EPA, 1995).

Literature review for potential radiological contamination at the Gasbuggy site surface
(Attachment A - Page 2 of 3)

An Aerial Radiological Survey of Project Gasbuggy and Surrounding Area, October 27, 1994, EG&G Energy Measurements Remote Sensing Laboratory (Document No. EGG 11265-1129).

This report identified that a 16 square mile, 150 foot altitude survey was conducted over the Gasbuggy site. This survey had a sensitivity to detect any man-made gamma emitting isotope at concentrations resulting in an exposure rate of greater than 1 mR/h at 1 meter above the ground surface. The conclusion is that no man-made gamma emitting radionuclides were detected (EG&G EM, 1995).

Project Gasbuggy Radiation Contamination Clearance Report, June 27, 1979, Eberline Instrument Corporation, (Document No. PNE-G-89).

This report identified that the samples were analyzed for the following radionuclides; tritium, Pu-239, Pu-238, Sr-90, and gamma emitters. Of these radionuclides, tritium was the only one to be detected above the analysis specific detection limit. The highest soil moisture tritium concentration was reported as 1,303 picocuries per milliliter (pCi/mL) as of September 19, 1978. The soil clearance criteria used at the time was 30,000 pCi/mL. The reference to DOE Order 5480.11 Radiation Protection for Occupational Workers in comment number two is not clear. DOE Order 5480.11 was canceled under DOE N 441.1 Radiological Protection for DOE Activities. Additionally, the reference to 1,000 disintegrations per minute (dpm) for a tritium release limit is confusing. Title 10 CFR 835 states that the removable tritium posting limit is 10,000 dpm/100 square centimeters (cm^2), and the allowable total residual surface contamination value for tritium per DOE Order 5400.5 is 10,000 dpm/100 cm^2 (EIC, 1979).

References

Eberline Instrument Corporation. 1979. *Project Gasbuggy Radiation Contamination Clearance Report*, PNE-G-89. Sante Fe, NM.

EPA, see U.S. Environmental Protection Agency.

EG&G EM, see EG&G Energy Measurements.

EG&G Energy Measurements. 1995. *An Aerial Radiological Survey of Project Gasbuggy and Surrounding Area, Rio Arriba County, NM, Date of Survey October 27, 1994*, EGG 11265-1129. Las Vegas, NV.

EIC, see Eberline Instrument Corporation.

LRL, see Lawrence Radiation Laboratory.

Lawrence Radiation Laboratory. 1969. *Nongaseous Radioisotopes - Project Gasbuggy Chimney Gas*, UCRL-50634. Prepared by C.F. Smith. Livermore, CA.

[a] Comment Types: M = Mandatory, S = Suggested.

Literature review for potential radiological contamination at the Gasbuggy site surface

(Attachment A - Page 3 of 3)

Lawrence Radiation Laboratory. 1971. *Project Gasbuggy Gas Quality Analysis and Evaluation Program Tabulation of Radiochemical Analytical Results*, UCRL-50635. Prepared by C.F. Smith. Livermore, CA.

U.S. Environmental Protection Agency. 1995. *Surface Radioactivity at the Plowshare Gas-Stimulation Test Sites: Gasbuggy, Rulison, Rio Blanco*, EPA-600/R-95/002. Prepared by S.H. Faller. Washington, DC.

[a] Comment Types: M = Mandatory, S = Suggested.

Attachment B
to Document Review Sheet for
Site Characterization Work Plan for Gasbuggy, New Mexico, Rev. 0

Copy of Letter "Highlights of March 7-8, 2000 Meeting" from
Runore C. Wycoff to James Bearzi dated March 29, 2000

(10 Pages)

Department of Energy
Nevada Field Office
P.O. Box 98518
Las Vegas, NV 89193-8518

MAR 29 2000

James P. Bearzi, Chief
New Mexico Environment Department
Hazardous & Radioactive Materials Bureau
2044 A Galisteo, P.O. Box 26110
Sante Fe, NM 87502

HIGHLIGHTS OF MARCH 7-8, 2000 MEETING

On behalf of this office, I would like to thank you for allowing your staff to meet with my staff on March 7-8, 2000. The Gasbuggy site visit and discussions were very beneficial to all parties and served as our kick-off meeting for the Gasbuggy and Gnome Coach sites. Enclosure 1 contains highlights of this meeting. Enclosure 2 is a listing of documents provided to you as well as those enclosed with this letter.

Based on these meetings, we are proceeding forward with developing a strategy for characterizing both of these sites. Our initial step requires identification and approval of data quality objectives associated with these efforts. We expect to submit a draft copy for your review and comment by July 2000. Resolution of comments your staff had on the preliminary draft left at the March 8, 2000, meeting will be incorporated into the draft document.

There are several documents or references which will be very helpful in developing our characterization and remediation strategy. These documents may be used as the basis of decisions and comments made by your staff. We are interested in getting a copy or identifying a source for the following references.

- State of New Mexico voluntary closure regulatory drivers and guidelines
- State of New Mexico risk assessment regulatory drivers and guidelines
- State of New Mexico preliminary action levels and preliminary remediation goals
- State of New Mexico water control regulatory drivers and guidelines
- State of New Mexico data quality regulatory drivers and guidelines
- Aerial photo of Waste Isolation Pilot Plant (WIPP) facility which includes Gnome Coach site

Enclosure 2 are references which we feel may be beneficial to your organization in understanding both of these sites. However, if your staff is interested in getting other references from the lists provided at our meetings, please let us know.

Our next Gasbuggy site visit is tentatively scheduled for the week of June 12, 2000. Our next Gnome Coach site visit is scheduled for the following week, June 19, 2000. During these weeks, U.S. Environmental Protection Agency representatives will be collecting samples for our annual

Highlights of March 7-8, 2000, Kick-Off Meeting With State of New Mexico Representatives

Attendees:

Monica Sanchez (DOE/NV)
Scotty Afong (DOE/NV)
Paul Gretsky (IT)
Dawn Arnold (IT)
John Young (NMED)
Don James (EPA)
Jenny Chapman (DRI)
Robert Boehlecke (IT)
John Kieling (NMED)

March 7, 2000

DOE/NV and New Mexico Environmental Department (NMED) representatives drove in two vehicles to the Gasbuggy site. During this trip, each group talked about Gasbuggy and Gnome Coach sites. The site's kick-off meeting presentation outline was used as the basis for discussions by the DOE/NV team and copies of these presentations were given to NMED representatives. There were discussions on general issues and concerns related to these sites.

DOE/NV representatives explained that our primary purpose of visiting New Mexico was to initiate meetings with state of New Mexico representatives concerning corrective action investigations at Gasbuggy and Gnome Coach sites. They emphasized that DOE/NV has the opportunity to accelerate remediation work at these sites and were interested in initiating dialogue with cognizant stakeholders.

DOE/NV representatives further explained that DOE/HQ has assigned responsibilities for all underground test areas, which includes the New Mexico sites, to DOE/NV. These sites have been the responsibility of DOE/NV Environmental Management for approximately 8 years. Since there is no on-site DOE presence, DOE/HQ is interested in closing out liability associated with these sites. They also explained that changes in priorities and availability of funds would allow the DOE/NV office to expedite investigation efforts at these sites.

The site visit consisted of identifying the markers present at the site including the ground zero plaque, concrete pads, and well markers for EPNG 10-36, GB-1, GB-2, GB-3, and GB-D. The general locations of past facilities including septic tanks, mudpits, and trailers were also identified. The group discussed general issues and concerns related to items identified.

March 8, 2000

General:

DOE/NV and NMED representatives had an opportunity to discuss issues related to each site. Monica Sanchez indicated that DOE/NV does not intend to prepare a Gasbuggy Preliminary Risk Assessment. Using U.S. Environmental Protection Agency (EPA) risk assessment guidance for Superfund sites, risk screening was performed on Gasbuggy and used to generate the Data

Quality Objective (DQO) Conceptual Site Model (CSM) and to identify data gaps. The Gnome Coach Preliminary Risk Assessment was used to generate this site's DQO CSM and to identify data gaps. However, this document will only be used as a reference source.

Robert Boehlecke and Dawn Arnold gave a DQO presentation for each site. NMED were provided a copy of each site preliminary DQO package and asked to provide any comments on this document. DOE/NV plans are to incorporate any state comments into its draft document and will submit it to the state by July 2000.

DOE/NV representatives gave a brief overview of the project schedule. They explained that historical information would be gathered and compiled this fiscal year. Surface sampling would probably take place next year once the state of New Mexico staff reviewed our DQOs and corrective action investigation plan. Although the DQOs would be submitted to the state during the same time frame, Gasbuggy fieldwork will take place ahead of Gnome Coach due to funding and higher project priorities. DOE/NV intends to streamline the surface closure process. Desert Research Institute (DRI) would complete the subsurface modeling within the next several years.

The current baseline schedule reflects 30-day review cycles. The NMED representatives agreed this was a reasonable schedule. They understood the interconnection of these schedules and funding and would like to enhance the process by allocating the necessary resources to meet baseline time frames.

The status of mud pit regulations was discussed. John Young stated that if the drilling mud pits were closed under gas and oil industry standards, then he does not have a concern as long as there is no potential contamination from the nuclear test.

NMED representatives would like to see both dose and risk data from any Residual Radiation (RESRAD) analysis. Ms. Sanchez indicated DOE/NV's desires to identify and agree on RESRAD parameters before doing any calculations. Ms. Sanchez indicated that land use scenarios would have to be agreed upon as part of the RESRAD calculation process. DOE/NV will have to coordinate land use and housekeeping issues with other federal entities (i.e., Bureau of Land Management, Forest Park Services, etc.).

Mr. Young stated that any assumptions proposed by DOE/NV should be reasonable and defensible. Mr. Young did not see any problems with combining surface and subsurface work plan for each site. However, surface and subsurface work related to each site's work plan will progress as independent activities.

Preliminary action levels were discussed. NMED stated that EPA Region 3 Preliminary Remediation Goals (PRG) are typically used as guidelines and that Region 6 has some radiological PRG levels that the state may follow. DOE/NV requested that these and other (i.e. risk assessment) guidelines and references used as a basis for NMED decisions be provided or its resource identified.

Paul Gretsky mentioned that necessary background samples would be collected for different mediums (i.e., water, soil, etc). Regional data may be required. Mr. Gretsky asked about the state data quality requirements and guidelines. He mentioned that other current DOE/NV remediation projects use complete Tier II validation of all data. Mr. Young stated they typically require complete Contract Laboratory Program packages for Resource Conservation and Recovery Act sites. However, NMED did not object to DOE/NV proposing quality levels with its rationalization for its use. The data quality level will be addressed in the DQO document. DOE/NV requested that any regulations or guidelines related to the data quality issue is provided or its resource identified.

Mr. Gretsky mentioned that DOE/NV is considering using on-site laboratories due to the remoteness of these sites. He asked if NMED had any issues with this approach. Mr. Young stated that as long as EPA guidelines were followed he did not foresee any problems.

Ms. Sanchez indicated that DOE/NV has had significant characterization experience. She recommended that NMED representatives consider contacting Donna Stoner, Colorado Department of Public Health and Environment. She is currently working with DOE/NV on the Colorado Rio Blanco investigation.

A list of references from a draft preliminary assessment done at each site was provided to NMED representatives. They will review this list and identify any documents, which they would like to get. DOE/NV will continue to keep stakeholders (i.e., NMED, Jicarilla Apache Tribe, Bureau of Land Management, etc.) informed on issues and upcoming events.

Gasbuggy

Parties discussed the "if-then" statements in the DQO packages. In particular, this issue focused on potential shallow groundwater investigations at Gasbuggy. These statements will determine the path to proceed on this investigation.

NMED voiced concern over tritium levels detected in soil moisture near the flare stack during the 1978 Gasbuggy sampling event. Mr. Young asked how much historical information was available for the on-site laboratories. Mr. Boehlecke indicated that little information exists but he is still researching the subject.

Mr. Young asked about the migration pathways of natural gas and if any scenarios and assumptions have been established. Jenny Chapman stated there is a lot of uncertainty in model parameters, and that this uncertainty will be incorporated in the modeling process. Potential contaminant migration will be evaluated both under current conditions and under stressed (gas development) conditions, in order to evaluate the effectiveness of the existing drilling restrictions. Ms. Chapman pointed out that there is no known remediation for underground nuclear cavities and that the goal of the subsurface investigation is to ensure protection of human health and the environment through adequate drilling restrictions.

Mr. Young recommended that DOE/NV check with the Jicarilla Apache for human health scenarios and to investigate such things as subsistence gathering from the Gasbuggy area. He indicated that the state could provide information on New Mexico water control regulations. DOE/NV would specifically look at ion levels to establish whether groundwater in the areas of this site and Gnome Coach are potable. Ms. Chapman described previous investigations of the Ojo Alamo aquifer in well 10-36 and why groundwater is not the primary pathway of concern.

There was a brief discussion on the Contaminant of Potential Concern list. Ms. Chapman stated that most of the radiological contaminants from the test would be tied up in the melt glass within the cavity. All parties agreed that this list was sufficient based on available information.

Gnome

In her DQO presentation, Ms. Arnold pointed out the areas of concern on aerial photos and differences between these DQO and the Gasbuggy site. She pointed out that there is no evidence of mud pit use at the site. Mr. Young stated that the rationale for eliminating the need for mud pit follow-up work must be documented. DOE/NV will incorporate its rationale in its DQO document. Mr. Gretsky pointed out that DOE/NV techniques used to investigate soil-contaminated sites might be used to characterize the vent plume.

Site surface erosion factors require that surface transport mechanisms be addressed at these historically contaminated areas. Mr. Young stated that contamination may reside inches below the surface due to downward migration and/or wind deposition and that surface radiological surveys may no longer adequately measure potential contamination. The loose sandy soil is conducive to downward percolation of contaminants.

Since DRI has the lead subsurface work associated with the cavities, drifts, and shaft, Ms. Chapman discussed subsurface and groundwater issues. Any potential leakage from the shot cavity, shaft, and drift complex would be due to a combination of salt creep and hypothesized borehole plugging failure as a release mechanism. She suggested that monitoring the situation might be more appropriate than characterization of subsurface contamination due to the possibility of creating migration pathways during characterization and to the hypothetical nature of the release scenario.

The group discussed tracer test and groundwater contamination issues associated with the Culebra aquifer. Ms. Chapman touched on the fact that there are no monitoring well downgradient of the tracer test wells. She mentioned that there was abundant and good data on the Culebra aquifer near the Waste Isolation Pilot Plant and Gnome area but nothing for the area downgradient between Gnome and the Pecos River. The risk from the tracer test would be due to migration outside the controlled area (i.e., current subsurface restrictions are in place for section 34). She mentioned that the issue has been evaluated in previous modeling work, available for NMED review, and that this would probably form the basis for a cost-benefit analysis regarding the wisdom of additional subsurface data collection.

Summary

The past two days provided both parties an opportunity to discuss issues associated with Gasbuggy and Gnome Coach sites. DOE/NV considers this a kick-off meeting and NMED representatives did not have a problem with this. Ms. Sanchez and John Kieling will serve as the lead for programmatic issues (i.e., agreement in principle funding, public participation requirements, funding, etc.). Scotty Afong and Mr. Young will serve as the lead on technical issues.

General Documents
for
The State of New Mexico Environmental Department

1. New Mexico kickoff briefing (hard copy of slides)

2. DQO briefing package for Gasbuggy

3. DQO briefing package for Gnome Coach

4. Reference list for Gasbuggy site (developed during the preparation of the draft preliminary assessment)

5. Reference list for Gnome Coach site (developed during the preparation of the preliminary assessment)

6. General DOE/NV Environmental Restoration Corrective Action Investigation Plan outline

7. Draft outline of the Colorado Rio Blanco Work Plan

8. Copy of old Agreement in Principle

9. Copy of the Gasbuggy Life-cycle Baseline Schedule

10. Copy of the Gnome Coach Life-cycle Baseline Schedule

11. Operational Area Monitoring Plan Long-Term Hydrological Monitoring Plan, 2000-2001, November 3, 1999

12. Annual Water Sampling and Analysis Calendar Year 1996, EPA-402-R-97-010, June 1997 (only sections for Gasbuggy and Gnome Test Site Areas)

13. Annual Water Sampling and Analysis Calendar Year 1997, EPA-402-R-98-005, June 1998 (only sections for Gasbuggy and Gnome Test Site Areas)

14. Annual Water Sampling and Analysis Calendar Year 1998, EPA-402-R-98-014, January 1999 (only sections for Gasbuggy and Gnome Test Site Areas)

15. Annual Water Sampling and Analysis Calendar Year 1999, EPA-402-R-99-012, December 1999 (only sections for Gasbuggy and Gnome Test Site Areas)

16. Project Gasbuggy and Gnome Coach Sampling Locations, Rev. Jan. 2000

NOTE: Documents 1-10 on this list were provided at the March 8, 2000, meeting.

Enclosure 2

Gasbuggy Site Specific Documents
for
The State of New Mexico Environmental Department

1. Project Gasbuggy Manager's Report, PNE-G-79, NVO-37, November 1971
2. Project Gasbuggy Site Restoration Final Report, PNE-G-90, NVO-211, July 1983
3. Project Gasbuggy Radiation Contamination Clearance Report, PNE-G-89, June 27, 1979
4. Surface Radioactivity at the Plowshare Gas-Stimulation Test Sites: Gasbuggy, Rulison, Rio Blanco, EPA 600/R-95/002, January 1995
5. An Aerial Radiological Survey of Project Gasbuggy and Surrounding Area, EGG 11265-1129, August 1995
6. Tritium Migration at the Gasbuggy Site, DOE/NV/11508-12, Publication # 45144, September 1996
7. Assessment of Hydrologic Transport of Radionuclides from the Gasbuggy Underground Nuclear Test Site, DOE/NV/11508-16, Publication No. 45148, September 1996
8. Tritium Results from Long-Term Monitoring Program at Gasbuggy Site (1972-1987)
9. Gasbuggy Sampling Results (1988 - 1991)
10. Video *The Resourceful Atom: Project Gasbuggy*

Enclosure 2

Gnome Coach Site Specific Documents
for
The State of New Mexico Environmental Department

1. Project Manager's Report, Project Gnome, Plowshare Program, October 1962
2. Project Gnome Final Report, On-Site Radiological Safety Report, December 10, 1961, PNE-133F, May 22, 1962
3. Site Disposal Report, Carlsbad (Gnome/Coach) Nuclear Test Site, Eddy County, New Mexico, NVO-41, June 1969
4. On-Site Radiological Safety Report, Carlsbad Roll-Up Program, NVO-410-2, July 1969
5. Carlsbad Reconnaissance 1972 (Gnome Site), 39220, January 15, 1973.
6. Gnome Site Decontamination and Decommissioning - Phase I Radiological Survey and Operations Report, Carlsbad, New Mexico, NVO/0410-48, December 1978
7. Gnome Site Decontamination and Decommissioning Project, Radiation Contamination Clearance Report, March 28, 1979 - September 23, 1979, DOE/NV/00410-59, August 1981
8. Residual Soil Radioactivity at the Gnome Test Site in Eddy County, New Mexico, EPA 600/R-94/117, July 1994
9. Evaluation of the Radionuclide Tracer Test Conducted at the Project Gnome Underground Nuclear Test Site, New Mexico, DOE/NV/11508-08, Publication # 45141, August 1996
10. Scoping Calculations for Groundwater Transport of Tritium from the Gnome Site, New Mexico, DOE/NV/10845-46, Publication # 45126, August 1994
11. Assessment of Hydrologic Transport of Radionuclides from the Gnome Underground Nuclear Test Site, New Mexico, DOE/NV/11508-11, Publication # 45143, September 1996
12. Project Gnome Area, Long-Term Hydrological Monitoring Program Analytical Results (1980-1995)
13. Video - *Project Gnome*

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