STATE OF NEW MEXICO
ENVIRONMENT DEPARTMENT

IN THE MATTER OF:

THE UNITED STATES DEPARTMENT OF ENERGY AND THE UNIVERSITY OF CALIFORNIA	**)**	**ORDER**
	)	**PROCEEDING UNDER THE NEW MEXICO HAZARDOUS WASTE ACT §§ 74-4-10.1 and 74-4-13**
LOS ALAMOS NATIONAL LABORATORY) LOS ALAMOS COUNTY, NEW MEXICO,	**)**	
RESPONDENTS.	**)**	

LIST OF TABLES

LIST OF ACRONYMS

AOC	Area of Concern
ASTM	American Society for Testing and Materials
BGS	Below Ground Surface
BS/BSD	Blank Spike/Blank Spike Duplicate
cfs	Cubic Feet Per Second
C.F.R.	Code of Federal Regulations
CLP	Contract Laboratory Program
COPC	Contaminant of Potential Concern
DOE	Department of Energy
ECO-SSL	Ecological Soil Screening Level
EPA	Environmental Protection Agency
ER	Environmental Restoration
ESH	Environment, Safety, and Health
ESL	Ecological Screening Level
ft	Feet
HI	Hazard Index
HE	High Explosive
HHMSSL	Human Health Medium-Specific Screening Level
HMX	High Melting Explosive (cyclotetramethylenetetranitramine)
HQ	Hazard Quotient
HSWA	Hazardous and Solid Waste Amendments
HWA	New Mexico Hazardous Waste Act, NMSA 1978, §§74-4-1 et seq.
HWP	Hydrogelogic Workplan
IDW	Investigation-Derived Waste

IM	Interim Measures
K	Hydraulic Conductivity
K_d	Sorption Coefficient
kg	Kilogram
LANL	Los Alamos National Laboratory
m	Meter
MCL	Maximum Contaminant Level
MDA	Material Disposal Area
mg/kg	Milligrams per Kilogram
mg/L	Milligrams per Liter
MS/MSD	Matrix Spike/Matrix Spike Duplicate
MSL	Mean Sea Level
NMAC	New Mexico Administrative Code
NPDES	National Pollutant Discharge Elimination System
pCi/g	Picocuries per gram
pCi/l	Picocuries per liter
ppb	Parts per billion
ppm	Parts per million
ppmv	Parts per million of vapor
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation Recovery Act, 42 U.S.C. Section 6901 et seq.
RDX	Royal Demolition Explosive (cyclonitrite)
RFI	RCRA Facility Investigation
SAP	Sampling and Analysis Plan
SAR	SWMU Assessment Report

SOP	Standard Operating Procedure
SSL	Soil Screening Level
SVOC	Semivolatile Organic Compound
SWMU	Solid Waste Management Unit
TA	Technical Area
TAL	Target Analyte List
TW	Test Well
UCL	Upper Confidence Level
USGS	United States Geological Survey
UTL	Upper Tolerance Level
VCA	Voluntary Corrective Action
VCM	Voluntary Corrective Measure
VOC	Volatile Organic Compound
WQCC	Water Quality Control Commission
µg/kg	Micrograms per kilogram
µg/L	Micrograms per liter

I. INTRODUCTION

Pursuant to the New Mexico Hazardous Waste Act, NMSA 1978 §§ 74-4-10.1 and 74-4-13, the New Mexico Environment Department hereby **ORDERS** the Respondents, the United States Department of Energy and the University of California, to comply with the terms and conditions hereinafter set forth in this Order.

The New Mexico Environment Department (the Department) issues this Order to the Respondents, the United States Department of Energy (DOE) and the University of California, under the New Mexico Hazardous Waste Act (HWA), NMSA 1978 §§ 74-4-10.1 and 74-4-13, and the New Mexico Hazardous Waste Management Regulations 20.4 NMAC. This Order contains the investigation and cleanup, or corrective action requirements, for Los Alamos National Laboratory (the Facility), owned and operated by DOE and operated by the University of California.

This Order is divided into 13 Sections. Section II of this Order sets forth the Department's findings of fact and conclusions of law in support of this Order. Section III contains general provisions, such as purposes, definitions, offsite access, entry and inspection, availability of information, reservation of rights, and enforcement. Section IV sets forth the requirements for a detailed, comprehensive investigation of environmental contamination at the Facility. It is divided into three subsections, addressing general Facility-wide investigations, investigations of separate watersheds within the Facility, and investigations of individual technical areas (TAs) at the Facility. Section V provides for the investigation of units not otherwise addressed in Section IV and Section VI. Section VI provides for the completion of investigations that are currently underway for several waste management units at the Facility. Section VII provides for the identification of cleanup alternatives and the implementation of cleanup measures for the Facility. Section VIII establishes screening and cleanup levels for contaminants at the Facility. Section IX sets forth methods and procedures for investigation, sampling, and analysis. Section X establishes requirements for groundwater monitoring well construction. Section XI sets forth the requirements for various reports to be submitted to the Department. Finally, Section XII establishes the schedule for implementation of the Order. Section XIII establishes the effective date of this Order. Except as expressly provided herein, the requirements of this Order apply to all solid waste management units (SWMUs), "areas of concern" (AOCs), other sites named in this Order, and all other places at the Facility where contaminants have come to be located.

The requirements of this Order do not apply to any site for which the Respondents demonstrate to the satisfaction of the Department: 1) that such site is an active or inactive firing site or military range as defined under EPA's military munitions rule, 40 C.F.R. § 266.201 (incorporated by 20.4.1.700 NMAC); and 2) that the contaminants on such site are military munitions, within the meaning of 40 C.F.R. §§ 260.10 and 266.200 to 266.202 (incorporated by 20.4.1.100 and 20.4.1.700 NMAC), that are not solid wastes as defined in the HWA, NMSA 1978, § 74-4-3.O. However, the requirements of this Order apply to all contaminants that have landed or migrated off the site or

range, and to all contaminants that have been buried or otherwise disposed of on the site or range. In addition, the requirements of this Order apply to all firing sites and military ranges designated by the Facility as closed, surplussed, demolished, decommissioned, "decontaminated and decommissioned," slated for transfer or conveyance, transferred or conveyed, or otherwise abandoned, and to all contaminants located on or originating from such sites.

The cleanup requirements of this Order (not including monitoring and reporting requirements) do not apply to contaminants that the Respondents demonstrate to the satisfaction of the Department are solely source, special nuclear, or byproduct material as defined in the Atomic Energy Act of 1954. If a site contains both source, special nuclear, or byproduct material and other contaminants, the cleanup requirements of this Order apply to such other contaminants, which may incidentally result in cleanup of the contaminants that are source, special nuclear, or byproduct material, unless such other contaminants can be separated and cleaned up or otherwise addressed separately. The monitoring and reporting requirements of this Order apply to source, special nuclear, and byproduct material.

II. FINDINGS OF FACT AND CONCLUSIONS OF LAW

II.A FINDINGS OF FACT

Based on the Administrative Record, the Department makes the following findings of fact.

II.A.1 Complainant

1. Complainant is the Secretary of Environment, who is the head of the Environment Department, the department within the executive branch of the New Mexico State government charged with administration and enforcement of the HWA and the Hazardous Waste Regulations, 20.4.1 NMAC.

II.A.2 Respondent

2. The Respondent DOE is a department of the Federal government, and is the owner and a co-operator of the Facility. The Respondent Regents of University of California is the operating contractor for the Facility pursuant to a contract with DOE, and is a co-operator of the Facility.

II.A.3 Facility

3. The Los Alamos National Laboratory (the "Facility") is a federal facility currently comprising approximately 43 square miles (27,500 acres) located on the Pajarito Plateau in Los Alamos County in north central New Mexico, approximately 60 miles north-northeast of Albuquerque and 25 miles northwest of Santa Fe. During its history, the Facility has comprised up to roughly 71 square miles (45,666 acres). The Facility is surrounded by the Pueblo of San Ildefonso, Los Alamos County, Bandelier National Monument, Santa Fe National Forest, Santa Fe County and Bureau of Land Management lands. The Rio Grande River, Los Alamos County, Sandoval County and the tribal lands of the Pueblo of San Ildefonso border the Facility downgradient to the east (LANL 1998f and 2001c).

4. The Pajarito Plateau is dissected by nineteen major surface drainages, or canyons and their tributaries. The canyons run roughly west to east or southeast. From north to south, the most prominent canyons are Pueblo Canyon, Los Alamos Canyon, Sandia Canyon, Mortandad Canyon, Pajarito Canyon, Cañon de Valle and Water Canyon, Ancho Canyon, and Chaquehui Canyon (LANL 1997a).

5. Hydrogeologic investigations have identified four discrete hydrogeologic zones beneath the Pajarito Plateau on which the Facility is located: (1) canyon alluvial systems; (2) intermediate perched water in the volcanic rocks (Tschicoma Formation and the Tshirege Member of the Bandelier Tuff); (3) canyon-specific intermediate perched water within the Otowi Member of the Bandelier Tuff, Cerros del Rio basalt and sedimentary units of the Puye Formation; and (4) the regional aquifer (NMED 1996a and LANL 1998f).

6. Habitat for several federally threatened and endangered species, including the bald eagle, the southwestern flycatcher, and the Mexican spotted owl have been identified on Facility property. Other species of concern, such as the Jemez Mountains salamander, spotted bat, whooping crane and black-footed ferret, may occur on Facility lands. The Mexican spotted owl, southwestern flycatcher, bald eagle and Jemez Mountains salamander have been recorded on Facility and Los Alamos County lands (LANL 1998f).

II.A.4 Facility Operations

7. The Facility began operations in 1943 when the United States Army Manhattan Engineer District was established for the research and development of an atomic bomb. Current and historic operations have included nuclear weapons design and testing; high explosives research, development, fabrication, and testing; chemical and material science research; electrical research and development; laser design and development; and photographic processing (LANL 1998f).

8. The Facility is currently owned by the United States Department of Energy and operated by the Regents of University of California (University of California) [the "Facility Operators"].

9. The Facility has been divided into numerous Technical Areas, or "TAs." Currently, 49 TAs exist; however, many former TAs have ceased operations and have been abandoned, have been combined with other TAs, or were cancelled before becoming operational (CDCP 2002).

10. *TA-2*. TA-2 is located in Los Alamos Canyon near the western boundary of the Facility. It currently houses the Omega West Reactor but has historically housed water boiler reactors and "Clementine," a mercury cooled plutonium fast reactor. The Omega West Reactor is scheduled for decontamination and decommissioning in 2006. Cooling tower outfalls at TA-2 discharged to Los Alamos Canyon (DOE 1987; LANL 2001c; CDCP 2002).

11. *TA-3*. TA-3 is located at the western boundary of the Facility. It includes the Administration Complex and support facilities as well as chemical and materials science laboratories. The Chemical and Metallurgical Research building, a Van de Graaff Accelerator (Ion Beam Facility), technical shops, metal plating shops and cooling towers from a power plant are among the current and historic operations housed in this part of the Facility (DOE 1987; LANL 2001c).

12. *TA-10*. Former TA-10 is located north of the Facility in Bayo Canyon, adjacent to TA-74. The Facility operators conducted hydrodynamic tests using conventional explosives and radiochemical research at TA-10 from 1943 to 1961. In 1963, the TA structures were decontaminated and demolished. The land was then transferred to the County of Los Alamos, and is no longer part of the Facility (LANL 1992a). The SWMUs and AOCs associated with this former TA are included in the Facilities current HSWA module

13. *TA-16*. TA-16 is located on the southwestern side of the Facility. TA-16 includes high explosive, plastic and adhesive research, development, testing, and production facilities. The operations include pressing, casting and milling of high explosives, plastic operations,

photographic laboratories, cooling towers, surface disposal areas, and historic wastewater outfalls in addition to open burn and open detonation activities (LANL 1993, 1998b, 1998c, and 2001c).

14. *TA-21.* TA-21 is located on DP Mesa on the northern side of the Facility. TA-21 was the plutonium processing area where the Facility Operators produced metal and alloys of plutonium and other transuranic elements from nitrate solution feedstock, processed polonium, and actinium, and produced initiators (a weapons component) from 1945 until 1978. TA-21 also housed treatment facilities for industrial wastewater from the plutonium processing facility. Chlorinated and non-chlorinated solvents, metals such as beryllium, cadmium, chromium, lead, mercury, and nickel, as well as other constituents were used at TA-21 (LANL 1991 and 2001c).

15. *TA-45.* Former TA-45 housed an industrial wastewater treatment plant located within the Los Alamos townsite that discharged to a small tributary of Acid Canyon. The industrial treatment plant operated from 1951 to 1964. The treatment plant served TA-3, TA-21, TA-43, and TA-48, as well as former TA-1. Prior to 1951, untreated industrial wastewater was discharged slightly upgradient from former TA-45. Discharge to the untreated industrial wastewater outfall originated from the former main technical area, TA-1 (LANL 1981).

16. *TA-49.* TA-49, the Frijoles Mesa Site, is approximately 1280 acres located on the southwestern boundary of the Facility. Since the mid-1940's, TA-49 has been used as a buffer zone for activities at adjacent firing sites. Between 1959 and 1961, underground hydronuclear and related experiments were conducted at TA-49 (LANL 1987 and 1998a). TA-49 is currently described as restricted because of it's location near Bandelier National Monument and past use in high explosive and radioactive materials experiments. The Hazardous Devices Team Training Facility located there; therefore, it is no longer used as a buffer zone for adjacent firing sites (LANL 2001c).

17. *TA-50.* TA-50 is located in the center of the Facility, bounded by Mortandad Canyon to the north, Two Mile Canyon to the south, TA-55 to the west, and TA-63 to the east. TA-50 includes a waste reduction characterization facility, an industrial wastewater treatment plant, several container storage areas, and a 12-acre landfill comprised of pits and shafts. The industrial wastewater treatment plant has been in operation since 1963. The landfill was operated from 1948 until 1964 (LANL 1992b, 1997e, and 2001c).

18. *TA-54.* TA-54 is located at the eastern end of Mesita del Buey on the eastern side of the Facility. The Facility Operators have used TA-54 since the 1950s as the primary waste disposal area for the Facility. TA-54 includes a waste characterization area, container storage areas, a waste transfer facility, and numerous surface impoundments, pits, trenches, and shafts used for waste disposal (LANL 1992d, 2000a, and 2001c).

19. Inventories of selected organic solvents indicate that during a 16 year period from the early 1970s to middle 1980s the Facility used the following quantities of solvents each year: 40,260 to 86,460 pounds of trichloroethane; 858 to 44,880 pounds of trichloroethylene; 14,817 to 41,360 pounds of acetone; 18,040 to 70,840 pounds of freons; 4.4 to 20,020 pounds of perchloroethylene; 1,350 to 17,820 pounds of kerosene; 880 to 48,400 pounds of

methyl ethyl ketone; 132 to 7,260 pounds of toluene; 220 to 4,840 pounds of methylene chloride; 352 to 1,100 pounds of chloroform; 132 to 660 pounds of carbon tetrachloride; 26 to 398 pounds of benzene. Lesser amounts of hexane, xylene, tetrahydrofuran and dioxane were also utilized during this period although data is only available for a few years during this time frame. (CDCP 2002). Limited historic documented information is available regarding non-radiological contamination and waste at the Facility. Historically, it appears that the Facility did not always analyze samples for constituents other than radionuclides. Solvents used at the Facility were probably released to the air, discharged in industrial wastewater streams and disposed in absorption beds, pits, shafts and trenches. Solvents also were disposed of as solid waste; volatile organic compounds (VOCs) have been detected beneath the Facility (e.g. at material disposal areas C, G and L) (LANL 2000a and 2000e).

20. The Facility Operators have conducted dynamic testing at firing sites, which released a variety of high explosive compounds (HE), barium, beryllium, lead, mercury, and other compounds to the environment (DOE 1979 and 1995; CDCP 2002). Many of these firing sites have been closed, decommissioned, abandoned, surplussed, conveyed or transferred.

II.A.5 Waste Management

II.A.5.a General

21. As a result of the Facility operations, from approximately 1943 to the present, the Facility Operators have generated, treated, stored, disposed of, and otherwise handled solid wastes, inlcuding hazardous wastes, hazardous waste constituents, and hazardous wastes mixed with radioactive wastes at the Facility (DOE 1987 and 2001; LANL 1998b, 1998c, 1998e, and 2000a).

22. The Facility operators have disposed of hazardous and solid wastes, hazardous constituents, mixed wastes and radionuclides in septic systems, pits, surface impoundments, trenches, shafts, landfills, and waste piles throughout the Facility. The Facility Operators have also discharged industrial wastewater and other discharges from outfalls into many of the canyon systems at the Facility (Rogers 1977; DOE 1987 and 2001; LANL 1991, 1992b, 1992c, 1993, 1994, 1995c, and 1998f; CDCP 2002).

23. Hazardous wastes and hazardous constituents, other solid wastes, mixed wastes and radionuclides have been released into Los Alamos Canyon, Pueblo Canyon, Pajarito Canyon, Cañon de Valle, Water Canyon, and Sandia Canyon, as well as other canyons (Purtymun 1975; DOE 1987; LANL 1981, 1997a, 2000a, and 2001a; CDCP 2002).

24. As a result of the releases, the Facility has identified over 2100 solid waste management units (SWMUs) and "areas of concern" (AOCs) where hazardous wastes, hazardous constituents, solid wastes and mixed wastes and radionuclides have been disposed (LANL 1998f).

25. The Facility Operators have disposed of hazardous wastes, hazardous constituents, other solid wastes and mixed wastes at the Facility. These wastes include chlorinated and nonchlorinated solvents such as carbon tetrachloride, methylene chloride, trichloroethane,

trichloroethylene, tetrachlorethylene, benzene, toluene, acetone, chloroform, and methyl ethyl ketone ("MEK"); high explosive compounds such as trinitrotoluene (TNT), dinitrotoluene compounds, octahydro-1357-tetranitro-1357-tetrazocine (HMX), and cyclonite (RDX); corrosive and toxic gases; metals such as arsenic, barium, beryllium, cadmium, chromium (including chromium VI), copper, lead, mercury, molybdenum, silver, and zinc; cyanide; polychlorinated biphenyls (PCBs); pesticides such as 2,4-D; perchlorate; other inorganic contaminants such as nitrates, ammonia, and fluoride; various radionuclides such as tritium; and other wastes (e.g., DOE 1979, 1987 and 2001; LANL 1981, 1998c, 1998f, 2000a, and 2001a; CDCP 2002).

26. The Facility Operators have disposed of radioactive wastes, some of which are also solid wastes, at the Facility. In some cases, the radioactive wastes were mixed with hazardous wastes and in other cases they were disposed of separately. These radioactive wastes may include isotopes of plutonium and uranium as well as a variety of activation and mixed fission products including tritium, actinium-227, cobalt-60, strontium-90, cesium-137, technetium-99 and americium-241 (DOE 1979, 1987 and 2001; LANL 1998c and 2000a; CDCP 2002).

27. The CDCP reports that accelerator complexes within DOE have been found to release large quantities of solvents. Little operational data concerning the quantities and releases have been documented historically. Operational accelerators currently exist at TA-8, TA-15 (PHERMEX) and TA-53 (LANSCE). Previously, several accelerators were utilized by the LANL Facility. For example, TA-1 and TA-3 housed Van de Graaff accelerators, a cylcotron, a betatron, the Cockroft-Walton and the Short Tank accelerators and TA-18 also housed other accelerators (CDCP 2002; LANL 2001c).

28. Some of the various waste disposal units at the Facility have been categorized into "Material Disposal Areas" or "MDAs" within many of the Technical Areas (CDCP 2002).

II.A.5.b TA-21 Material Disposal Areas

MDA A

29. The Facility operators disposed of hazardous and solid wastes, hazardous constituents as well as mixed and radioactive wastes in MDA A from 1945 to 1949 and again from 1969 to 1977. Waste streams included laboratory equipment, building construction debris, chemicals, and other solid wastes. In addition, corroded and leaking 55-gallon drums were stored on the eastern portion of MDA A in the 1950s, resulting in releases of contaminants of unknown volumes and chemical content to the ground surface. The storage area was later paved over to "immobilize" contaminants (Rogers 1977; DOE 1987; LANL 1991).

30. On the western portion of MDA A, a liquid solution containing plutonium-239/240 and associated industrial waste materials was disposed in two subsurface 50,000-gallon steel tanks. Liquid was later removed from the tanks, but an unknown volume of radioactive sludge and liquid remain in the tank bottoms (Rogers 1977; DOE 1987; LANL 1991).

31. In 1969 a large pit was constructed in the center of MDA A. Contaminants placed into this pit include unspecified radionuclides as well as plutonium, uranium, and asphalt (Rogers 1977; DOE 1987; LANL 1991).

MDA B

32. The Facility Operators disposed of hazardous and solid wastes, hazardous constituents, mixed wastes and radionuclides in MDA B from 1945 until 1948. MDA B covers six acres and is comprised of at least five disposal pits. Wastes disposed in MDA B include organic chemicals, perchlorate, ethers, solvents, corrosive gases, and radionuclides. In addition, at least one truck contaminated with fission products from the Trinity test and other large pieces of debris were disposed in MDA B (Rogers 1977; DOE 1987 and 2001; LANL 1991).

33. Wastes were placed in four or five pits at MDA B, one of which has estimated dimensions of 15 feet wide, 300 feet long, and about 12 feet deep (Rogers 1977; DOE 1987 and 2001; LANL 1991 and 1998d).

MDA T

34. The Facility Operators disposed of solid, hazardous, and radioactive wastes containing hazardous constituents in MDA T from 1945 to 1983. MDA T covers approximately 2.21 acres containing four absorption beds used to dispose of industrial wastewater, a retrievable waste storage area, a series of disposal shafts, an acid holding tank and acid sump, a caisson built in 1959, and two surface spill areas of americium-241 paste (Rogers 1977; DOE 1987; LANL 1991).

35. The four absorption beds at MDA T measure 120 feet long, 20 feet wide, and 4 feet deep. Over 18 million gallons of industrial wastewater containing hazardous and radioactive constituents was discharged to the four absorption beds between 1945 and 1967 (Rogers 1977; DOE 1987 and LANL 1991).

36. Disposal shafts were installed and a retrievable waste storage area was constructed between the absorption beds. The shafts and retrievable storage area were utilized between 1968 and 1976 and between 1975 and 1983, respectively. There appear to be 101 shafts that range between 4 and 8 feet in diameter and from 15 to 80 feet in depth (Rogers 1977; DOE 1987 and LANL 1991).

37. Roughly 60 disposal shafts were installed and a retrievable waste storage area was constructed between the absorption beds at MDA T. The shafts measured roughly four to eight feet in diameter and ranged from 15 to 69 feet in depth; however, inconsistent information is provided regarding dimensions of absorption beds and shafts in various documents submitted by the Facility (Emelity 1996; LANL 1991 and 1996a). The shafts and retrievable storage area were used between 1968 and 1983. Liquid waste from the TA-21-257 industrial waste treatment plant was mixed with cement and pumped into the shafts or pumped into the corrugated metal pipes and placed in the retrievable storage area. The corrugated metal pipes were removed and sent to Area G at TA-54 between 1984 and 1986. Several radionuclides have been detected above their respective screening action levels, the

presence of RCRA constituents is suspected based on the process knowledge but has never been adequately assessed (LANL 1996b). Wastes disposed in MDA T shafts include mixed wastes, treatment sludge, industrial wastewater, and bathyspheres filled with plutonium-239/240. Liquid effluent and treatement sludges were mixed with cement prior to disposal, resulting in an estimated volume of 902,265 gallons, or 3,418 cubic meters, of waste disposed in the shafts (Rogers 1977; DOE 1987; LANL 1991).

MDA U

38. The Facility Operators disposed of wastewater and cooling tower effluent in MDA U from 1948 until sometime after 1976. MDA U is approximately 0.2 acres and consists of two absorption beds used for subsurface disposal of industrial wastewater and an associated sump located between the two beds. The primary known contaminants disposed of at MDA U include polonium-210, actinium-227, tritium, uranium, and plutonium (DOE 1987; LANL 1991).

MDA V

39. The Facility Operators discharged at least 40 million gallons of effluent into MDA V between 1945 and 1961. MDA V is approximately 0.88 acres and consists of three absorption beds and associated sumps used for the subsurface disposal of wastewater generated by a Facility laundry operation. Wastewater discharged to the pits contained barium and various radionuclides as well as other constituents. In addition, soil samples collected in 1982 contained elevated levels of tritium (DOE 1987; LANL 1991).

II.A.5.c TA-49 Material Disposal Areas

40. The Facility Operators detonated HE and conducted nuclear device safety and related tests in underground shafts at TA-49. TA-49 contains Areas 1, 2, 2A, 2B, 3, 4, 5, 6, 11 and 12. These operations used conventional explosives and small amounts of fissile material. The tests resulted in releases of HE, barium, uranium, plutonium-239, americium-241, cesium-137, tritium, lead, and beryllium in addition to other radioactive elements used and produced in the tests. The majority of the releases are in shafts at depths ranging from 31 to 108 feet below the ground surface although the available documents contain inconsistent information regarding the dimensions of the shafts. Estimates of some of the contaminants in the subsurface include 198,000 lbs (90,000 kg) of lead, 24 lbs (11 kg) of beryllium, 204 lbs (93 kg) of enriched uranium, 372 lbs (169 kg) of depleted uranium, and 88 lbs (40 kg) of plutonium (LANL 1987, 1992c, and 1998a).

41. Four accidental releases in Areas 2 and 2B resulted in contamination of the ground surface that resulted in closing and capping of Area 2 in 1961. Surface monitoring indicated surface contamination as high as 800,000 cpm. Surface monitoring station A3 (located in a drainage leading to Water Canyon directly adjacent to Areas 2, 2A and 2B) have shown Pu-239 ranging from 0.01 to 17 pCi/g in sediments leaving the site (LANL 1987). Lead and beryllium also have been detected in surface samples at concentrations greater than calculated background concentrations (LANL 1992c). The highest radionuclide concentration measured in a surface sample was approximately 1660 pCi/g of plutonium

239/240 for an individual sample at Area 2 (LANL 1992c). Beryllium was found in the drainage in the northeast side of Area 2 in 1987. Groundwater was periodically observed in monitoring well, CH-2 (now plugged and abandoned) located at Area 2. Groundwater found in CH-2 during 1977 and 1978 contained 1.7 to 3.1 pCi/l of Pu-239 and samples collected in 1979 and 1980 contained 0.1 and 5.5 pCi/l Pu-239. Pu-239 and uranium were also detected in samples obtained in 1991 indicating subsurface contaminant migration that was not anticipated by historic site hydrogeology studies (LANL 1998a).

42. The Facility Operators conducted radiochemical research and small-scale shot experiments using HE from 1959 to 1961 at Area 11 of TA-49. Area 11 consists of the former radiochemistry laboratory, associated leach field, and a small-scale shot area. The radiochemistry laboratory was demolished in 1971 (LANL 1992c).

43. The Facility Operators used Area 12 of TA-49 for confinement experiments in 1960 and 1961, and later to support operations at the Cable Test Pull Facility. The confinement experiments consisted of HE detonations in sealed metal "bottles" that were placed in a 30-foot shaft located within the Bottle House structure (LANL 1992c).

II.A.5.d TA-50 Material Disposal Areas

44. Only one material disposal area, MDA C, is located within TA-50. The Facility Operators disposed of a large volume of hazardous, solid, radioactive, and mixed waste as well as hazardous constituents in MDA C from 1948 until 1974. MDA C encompasses 11.8 acres and consists of seven disposal pits including a chemical disposal pit, and 108 shafts. High activities of radionuclides, including tritium, and high concentrations of volatile organic compounds have been released from MDA C to the vadose zone (Rogers 1977; LANL 1992b; DOE 2001). 1,1,1 trichloroethane (TCA) was detected at 11.4 ppmv at the 120-feet port and TCE was detected at 12.9 ppmv at the 200-feet port during 2000 quarterly sampling (LANL 2000e).

II.A.5.e TA-54 Material Dsiposal Areas

MDA G

45. The Facility Operators have used MDA G for the disposal of a variety of Facility wastes from 1957 to the present, and continue to use it for waste storage and disposal. Since 1957, MDA G has been the Facility's primary radioactive and mixed waste disposal site. From 1957 until at least 1990, the Facility Operators disposed of solid, hazardous, mixed, and radioactive wastes at MDA G. Since 1990, the Facility Operators have reported to use MDA G only for the disposal of radioactive wastes. Some of the radioactive wastes disposed at MDA G since 1990 are also solid wastes. MDA G consists of hazardous and radioactive waste container storage areas, 34 disposal pits, four disposal trenches, and 218 disposal shafts (Rogers 1977; DOE 1987; LANL 1992d and 2000a).

46. MDA G encompasses 100 acres of which 65 acres have been used for waste disposal. Hazardous, solid, mixed and radioactive wastes have been placed in unlined pits, trenches and shafts at MDA G since 1957. Records were not maintained for the chemicals contained

in the mixed waste until 1985. Classified mixed waste was reportedly disposed at MDA G until 1986. Until the mid-1990s, waste disposed of in pits was generally not containerized (Rogers 1977; DOE 1987; LANL 1992d and 2000a).

47. The pits at MDA G vary in size, but are typically 200 to 600 feet long, 60 to 100 feet wide, and 65 feet deep. When filled, roughly 4 feet of crushed volcanic tuff and 4 inches of topsoil are used to cover each pit. On average, 35% of each pit is estimated to be waste material and the rest is crushed volcanic tuff (Rogers 1977; LANL 1992d and 2000a).

48. The four trenches at MDA G are 200 to 300 feet long, 13 feet wide, and 8 feet deep. Waste disposed of in these trenches is retrievable transuranic (TRU) waste and was reportedly packaged in 30-gallon drums inside concrete casks (Rogers 1977; LANL 1992d and 2000a).

49. The shafts or "disposal wells" are typically 3 to 6 feet in diameter and 65 feet deep. Wastes disposed in the shafts required special packaging, special handling or segregation. Tritium, highly activated metals, PCB-contaminated waste, and hydrocarbon oil are among the wastes disposed in the shafts (Rogers 1977; LANL 1992d and 2000a).

MDA H

50. The Facility Operators disposed of classified solid wastes, hazardous and radioactive wastes including HE at MDA H from 1960 to 1986. MDA H contains nine cylindrical shafts with a diameter of 6 feet and depth of 60 feet. Tritium and VOCs have been detected in the subsurface beneath MDA H (LANL 1992d, 2000a and 2002b).

MDA L

51. The Facility Operators disposed of liquid hazardous and radioactive wastes at MDA L from 1959 to 1986. MDA L covers roughly 2.6 acres and consists of hazardous and radioactive waste container storage areas, one subsurface disposal pit, three inactive surface impoundments, and 34 inactive disposal shafts. The pits and impoundments are no longer receiving waste and are covered by an asphalt that is presently used for RCRA permitted waste storage and treatment and also for mixed-waste storage under interim status authority in the Facility's RCRA operating permit (LANL 1992d and 2000a).

52. The dimensions of the surface impoundments at MDA L vary but range from 35 to 75 feet long, 12 to 18 feet wide, and 10 feet deep. The impoundments were used at various times from 1972 to 1986. The primary function of two of the impoundments was to evaporate treated salt solutions and liquid electroplating wastes. One of these impoundments was filled to 25 percent of its 2000 cubic foot capacity. The third impoundment was used to neutralize lithium hydride, a reactive waste. This impoundment was also used as secondary containment for oil storage for an unknown duration (LANL 1992d and 2000a).

53. The dimensions of the 34 shafts or "disposal wells" at MDA L range from 3 to 8 feet in diameter and 15 to 65 feet deep. Most of the shafts are 60 feet in depth. Disposal in the shafts began in 1975 and lasted until 1985 (LANL 1992d and 2000a).

54. The disposal pit operated from 1964 to 1978. It is approximately 200 feet long, 15 feet wide, and 12 feet deep. The pit was used for the disposal and treatment of uncontained liquid waste and drums and is filled to an estimated 10% of its 28,800-cubic foot capacity. Ammonium bifluoride, acid and caustic solutions, cyanide solutions, and chromium wastes were treated and disposed of at the pit. In 1992, the Facility acknowledged that the batch treatment of liquid waste "may have facilitated the downward migration of liquid contaminants along fractures within the tuff." (LANL 1992d).

II.A.6 Releases of Contaminants

II.A.6.a General

55. These waste disposal and other waste management activities at the Facility have resulted in the release of solid and hazardous wastes, hazardous waste constituents, mixed wastes, and radioactive wastes to the environment (Purtymun 1975; DOE 1987 and 2001; LANL 1981, 2001a, and 2001c; CDCP 2002).

56. Contaminants that have been released into, and detected in, soils and sediments at the Facility include HE compounds; VOCs, SVOCs, metals such as arsenic, barium, beryllium, cadmium, chromium, copper, lead, mercury, molybdenum, silver, and zinc; PCBs; various radionuclides such as tritium; and other contaminants (DOE 1987 and 2001; LANL 1998b, 1998c, 2000a, 2001a, and 2001c; CDCP 2002).

57. Contaminants that have been released into, and detected in, groundwater beneath the Facility include HE compounds; volatile organic compounds such as trichloroethylene, dichloroethylene, and dichcloroethane; metals such as molybdenum, manganese, beryllium, lead, cadmium, and mercury; perchlorate; other inorganic contaminants such as perchlorate, ammonia, nitrate, and fluoride; radionuclides such as tritium; and other contaminants. Contaminants have been detected beneath the Facility in all four groundwater zones (Purtymun 1975; LANL 1981, 1998c, 2001a, 2001c, and 2002a; EPA 2001b; CDCP 2002).

58. HE compounds and metals have been detected in groundwater and springs beneath the Facility at levels in excess of health advisory levels set by the Environmental Protection Agency (EPA) under the Federal Safe Drinking Water Act, 42 U.S.C. §§ 300f to 300j-26 (EPA 2000; LANL 1981, 1998b, 1998c, and 2002; NMED 1996b).

59. Nitrate and molybdenum have been detected in groundwater beneath the Facility at levels in excess of numerical standards set by the New Mexico Water Quality Control Commission ("WQCC"), at 20.6.2.3103 NMAC (LANL 1981, 2001c and 2002e; NMED 1996b).

60. Perchlorate has been detected in groundwater beneath the Facility at levels in excess of EPA's 2002 proposed drinking water equivalent level of 1 µg/L and at concentrations greater than EPAs 1999 proposed drinking water equivalent level of 4 µg/L (LANL 2001c, 2002a and 2002e).

61. Perchlorate, which is a byproduct of the processing of plutonium and is also used in high explosives and rocket fuel, is very soluble, mobile, and persistent in the environment (LANL

1999b and 2001c). Perchlorate often precedes other less mobile contaminants in a contaminant plume.

62. Tritium, which is used in fusion reactors, weapons production and is generated in nuclear accelerators, is very soluble and mobile in the environment. It is useful as a conservative tracer for contaminant transport in groundwater. Tritium contamination in groundwater often precedes contamination by other, less mobile substances.

II.A.6.b Releases of Contaminants from TA-2

63. At various times, the Facility Operators operated nuclear reactors in TA-2. Chromium was released to Los Alamos Canyon from the cooling towers [SWMU 02-005; 02-008(a)]at the reactor complex. In addition, solvents, mercury and other metals, and radionuclides may also have been released to the environment at TA-2. Chromium, other metals, and perchlorate have been detected in the alluvial groundwater system downgradient of the TA-2 reactor complex (DOE 1987; LANL 1998g and 2002e; CDCP 2002).

64. Loss of chromium VI from the TA-2 Omega West Reactor cooling tower was reportedly 0.05 pounds per hour in the form of potassium dichromate (DOE 1987; CDCP 2002).

65. The chromium VI concentration in the discharge was reportedly 25 mg/L from the TA-2 Omega West Reactor (CDCP 2002).

66. The cooling tower for the Water Boiler Reactor at TA-2 reportedly "rained" chromium from the sky (CDCP 2002).

67. Mercury coolant was spilled from the Clementine Reactor at TA-2 in December 1948 (CDCP 2002).

II.A.6.c Releases of Contaminants from TA-3

68. From the 1950s to the 1970s, the Facility Operators operated a power plant at TA-3. The TA-3 power plant [SWMU 3-012(b)] discharged between 128,000 and 288,000 gallons per day of wastewater into Upper Sandia Canyon[SWMU 3-012(b)]. The power plant used roughly 36 pounds per day of chromate phosphate-zinc corrosion inhibitors. Chromium levels in the discharged wastewater averaged up to 34 ppm, and chromium VI was estimated to be half that average. Chromate in discharged wastewater collected four miles down stream averaged 10 to 15 ppm. Chromium VI has been detected in surface water approximately two miles down stream of the outfall (DOE 1987).

69. Cadmium, beryllium, lead, and mercury were detected in surface water samples obtained at two locations up to two miles downstream of the power plant cooling tower outfalls. Samples obtained from groundwater monitoring well (03-MW-1) located at TA-3 contained concentrations of hazardous constituents above EPA drinking water standards and tritium concentrations above background levels. The detected constituents included 1,1-dichloroethene at 510 μg/L (EPA drinking water standard is 7 μg/L); 1,2-dichloroethene at 120 μg/L (EPA drinking water standard for (cis) 1,2 dichloroethene is 7 μg/L);

trichloroethane at 22,000 µg/L (EPA drinking water standard for 1,1,1, trichloroethane is 200 µg/L); 1,2-dichloroethane at 200 µg/L (EPA drinking water standard is 5 µg/L); trichloroethene at 300 µg/L (EPA drinking water standard is 5 µg/L) (EPA 2001b).

II.A.6.d Releases of Contaminants from TA-9

70. Studies conducted at an outfall from a drain sump for a recovery and shipping building (TA-9-50) at TA-9 indicate that "soils from the outfall serving the building contain 2.6 percent acetone solubles, with less than 2.5% by weight total explosives." (DOE 1987).

71. "In 1973, the aluminum settling basin serving the sump for building [TA-9]-45 (a process laboratory) was observed to have been essentially destroyed by the acids dumped down the drain." A large variety of chemicals were used at TA-9, including sulfuric acid, nitric acid, and hydrazoic acid (DOE 1987). Acids alter the pH of soils and water and mobilize amphoteric metals.

II.A.6.e Releases of Contaminants from TA-15

72. In 1995, DOE estimated that average annual "releases" from the Pulsed High Energy Radiation Machine Emitting X-Rays Facility (PHERMEX), to the environment between 1963 and 1995, as a result of high explosive testing, were: depleted uranium-1,100 lbs (500 kg), beryllium-15 lbs (7 kg), lead-22 lbs (10 kg), copper-155 lbs (70 kg), other metals (aluminum, nickel, silver, tantalum, tin, etc.)-310 lbs (140 kg), tritium-2 curies, lithium hydride-155 lbs (70 kg), and HE-2,400 lbs (1,100 kg). In 1992 alone, the PHERMEX site released 244 kg of depleted uranium, 2 kg of beryllium, 48 kg of lead, 146 kg of HE, and 17 kg of lithium. An estimated 35,000 lbs (16,000 kg) of uranium was used at PHERMEX over a 30-year period (DOE 1995).

73. Soil contamination was detected at PHERMEX. Total uranium concentrations ranged from 0.8 to 13,398 ppm, total beryllium ranged from 0.2 to 218 ppm and lead ranged from 2.9 to 230 ppm. Analyses of two samples collected in drainage channels leading from the firing point indicate that uranium was also detected at 105 and 11.5 ppm. RCRA and heavy metals in the drainages were apparently detected below "EPA or background concentrations"; although, no details of the quality of the samples were provided, how the comparisons were completed, to what background and "EPA" the concentrations were compared, if the concentrations were averages and if the values were compared to ecological screening values (DOE 1995).

74. At E-F firing site, between 1943 and 1973, up to 150,000 lbs (66,500 kg) of uranium was used which was four times the inventory used at PHERMEX (DOE 1995). SWMU 15-008, located on the canyon edge, consists of debris from Firing "Point" E-F. (LANL 1990). Mean concentrations of uranium ranged from 4,650 ppm at the ground surface to 165 ppm at a horizontal distance of 660 ft indicating contamination has migrated laterally. No information is available on site cleanup or removal of beryllium and lead. Beryllium, lead and other contaminants released to the environment at the firing site, are assumed to be available for migration in hydrologic pathways (DOE 1995).

75. In 1976 LANL reported that "[m]ost of the uranium at E-F Site is apparently available for surface transport, mainly by storm runoff, and can move into the Potrillo Canyon drainage." Uranium concentrations in suspended sediment of 3900 μg/g were reportedly similar to "average" surface soil concentrations. In addition, it was reported that uranium had "a much greater solubility" than was expected due to dissolved uranium concentrations (87 to 282 mg/l) found in standing water (LASL 1977). This substantiates the correlation that other contaminants, such as lead, beryllium, copper, high explosives and other compounds associated with firing sites are likely migrating offsite as well as uranium. This correlation can be applied to all current and former firing sites.

76. LANL reported in 1990, that lead is present at E-F Site, near phototoxic levels while beryllium is present at slightly elevated levels (LANL 1990).

77. Although no concentrations were provided, LANL reports that sampling data from Firing Sites A, B, C, D, G, and H show concentrations of metals such as barium, beryllium, cadmium, lead, mercury, and uranium "at" or "above" detection limits (LANL 1990).

II.A.6.f Releases of Contaminants from TA-16

78. During the six month period from November 1970 to April 1971, the chemical inventory for Building 16-340 included 11 pounds of toluene; 750 pounds of methyl ethyl ketone; 72 pounds of methylene chloride; 110 pounds of methanol; 11 pounds of ethyl acetate; 55 pounds of 1,2-dichloroethane; 3 pounds of chloroform; 330 pounds of n-butyl acetate; 500 pounds of ammonium sulfate; and 700 pounds of acetone (LANL 1993). The final disposition of these compounds is unknown; however, this is an indication of the material used at Building 16-340 and likely reflects the composition of the disposed waste and wastewater discharged at the Facility.

79. From 1951 until 1988, untreated wastewater containing machine turnings and HE was discharged from Building 16-340 to the Building 16-340 outfall [SWMU 16-003(o)], a small tributary to Cañon de Valle. In the early 1980s, a 250-foot weir-type green plastic air-stripper (the Fish Ladder) was fitted to the outfall to allow some aeration of solvents before final discharge to the drainage. In 1989, a distiller was installed in Building 16-340 to help trap solvents before discharge to the Fish Ladder (LANL 1993).

80. Since operations began in 1951, the Facility Operators have used Building 16-260 in TA-16 to machine high explosives. Contaminants released from Building 16-260 include high explosive compounds (e.g., HMX, RDX, and TNT), solvents, barium and natural uranium (LASL 1971 and 1976; LANL 1993, 1998b and 1998c).

81. Data from 1994 indicate that 2.5 million gallons of wastewater was discharged from the Building 16-260 Outfall that year (LANL 1993).

82. Investigations conducted at the 16-260 Outfall [SWMU 16-021(c)] during the 1990s detected RDX, TNT, HMX, dinitrotoluene (DNT), amino-DNT compounds, trinitrobenzene (TNB), dinitrobenzene, pentaerythritol tetranitrate (PETN), barium nitrate, tetryl, nitroguadine, triaminotrinitrobenzene (TATB), ammonium nitrate, various plastic binders, acetone,

acetonitrile, chloromethane, dichloroethane, dichlorobenzene, isopropyltoluene, tetrachloroethene, trichloroethene, anthracene, bis(2-ethylhexyl)phthalate, diethylphthalate, butylbenzylphthalate, barium, beryllium, copper, cadmium, chromium, cobalt, lead, nickel, silver, vanadium, uranium, and zinc in addition to other constituents (DOE 1987; LANL 1993, 1998b, and 1998c; LASL 1971 and 1976).

83. The TA-16, Building 16-260 Outfall, pond, and drainage channel [SWMU 16-021(c)] were excavated in 2000, and the majority of the contaminated material was removed and disposed of. Prior to the excavation, soil in the area was contaminated with total HE at levels up to 27% by weight in the pond area, and with barium at levels up to 33,000 ppm. Following excavation, RDX levels detected in drainage channel soils remain as high as 1200 ppm, barium concentrations as high as 8,200 ppm (at 6 feet below the ground surface) and HMX was detected at concentrations up to 2000 ppm. Currently, RDX has been detected in surface water samples obtained in the canyon below the outfall at concentrations greater than 800 ppb. HE compounds, such as RDX, were detected in the intermediate zone groundwater, during the drilling of regional well R-25, at concentrations greater than EPA health advisories (LANL 1998b, 1998c and 2002c, NMED 2000, EPA 2000 and 2002c).

84. The EPA drinking water health advisory for RDX is 2 ppb, the NMED residential soil screening level for RDX is 44 ppm and the EPA residential screening level for barium is 5400 ppm in soil (EPA 2002c and 2002d; NMED 2000).

85. The Building 16-260 Outfall is a primary source of water contamination observed in SWSC Spring, Burning Ground Spring, Martin Spring, surface and alluvial waters of Cañon de Valle, and in perched groundwater (approximately 740 feet below ground surface) observed during drilling of regional aquifer well R-25 (LANL 1998b and 1998c).

II.A.6.g Releases of Contaminants from TA-21

86. From 1945 until 1978, the Facility Operators produced metal and alloys of plutonium and other transuranic elements at TA-21. TA-21 also housed treatment facilities for industrial wastewater from the plutonium processing facility. Chlorinated and non-chlorinated solvents and metals such as beryllium, cadmium, chromium, lead, mercury, and nickel were used at TA-21 (LASL 1974, LANL 1990 and 1991).

87. From 1945 to 1952, industrial wastewater effluents from TA-21 were disposed into the absorption beds at MDA T. In 1952, a wastewater treatment facility at Building 21-35 began operation and discharged to the SWMU 21-011(k) outfall. Sludge and remaining wastes from the treatment process were reportedly disposed of in shafts at MDA T and other MDAs, presumably MDAs C and G. Treated wastewater from the plant was discharged to DP Canyon. The treatment facility at building 21-35 was replaced in 1967 by a larger capacity treatment facility, Building 21-257 (Rogers 1977; LANL 1981, 1990 and 1991).

88. From 1945 through 1952 an estimated 12.6 to 14 million gallons of untreated wastewater from Building TA-21-35 was discharged to the absorption beds (DOE 1987; LANL 1991).

89. After the Building 21-35 industrial treatment facility became operational in 1952, an additional estimated 4.3 to 5.7 million gallons of wastewater was discharged to the absorption beds at MDA T (Rogers 1977; LANL 1991).

90. From 1952 to 1975, an estimated 65 million gallons of treated industrial wastewater was discharged to outfall 21-011(k). In addition, an unknown volume of untreated industrial wastewater was discharged directly to the 21-011(k) outfall **(**LANL 1981 and 1991).

91. In 1973, flow rates from the 21-011(k) outfall were 143,000 gallons per month (DOE 1987).

92. In 1973, samples collected from the treated wastewater from the Building TA-21-257 treatment facility contained cadmium at levels from 1 to 500 µg/L (MCL is 5 µg/L; chromium VI at levels up to 7 µg/L; total chromium at levels up to 380 µg/L (MCL is 100 µg/L); copper at levels up to 1500 µg/L (MCLG is 1,300 µg/L and SDWR is 1,000 µg/L); mercury at levels from as high as 25 µg/L (MCL is 2 µg/L); lead at concentrations up to 1300 µg/L (MCL is 15 µg/L); zinc at levels up to 1120 µg/L (SDWR is 5,000 µg/L); nitrate at levels from 31 to 1087 mg/L (MCL standard is 10 mg/L); and fluoride at levels from 3 to 149 mg/L (NMWQCC standard is 1.6 mg/L, SDWR is 2 mg/L) (LASL 1974).

93. In 1976, the treated wastewater from the Building 21-257 treatment facility contained cadmium, chromium (including chromium VI), copper, lead, mercury, zinc, nitrates, fluoride, and ammonia (DOE 1979).

94. In 1971 and 1972, surface water in DP Canyon contained average cadmium at concentrations of 6.9 µg/L in solution and 0.43 µg/L in particulates; beryllium concentrations of 0.3 µg/L in solution; lead concentrations of 1.8 µg/L in solution and 2.8 µg/L in particulates; and mercury concentrations of 0.09 µg/L in solution (DOE 1987; LANL 1981).

95. Cadmium, copper, lead, nickel, silver, and zinc exceed background concentrations in shallow (<18 inches below the ground surface) soil samples. TCE, silver, chromium, cyanide and other contaminants have been detected in the subsurface and radionuclides have been detected to depths of 100 feet below the ground surface at MDA T which is the furthest extent of investigation thus far. Data is available for radionuclides only at 100 feet below the ground surface. Since the site received waste streams containing plutonium-processing waste, organic extracts, and metals, it is likely that contaminants other than radionuclides are present at depth (DOE 2001; LANL 1991, 1995a, and 1996a).

96. At MDA V, radionuclides (only contaminants investigated) were detected at a depth of 58 feet below ground surface, the furthest extent of investigation, indicating that more mobile contaminants may have migrated to greater depths. Investigations conducted in 1996 detected radionuclides, metals and organics at MDA V. Antimony, cadmium, copper, lead, mercury and radionuclides were detected at concentrations greater than the respective screening action levels (LANL 1991, 1995a, and 1996e).

97. Several metals and radionuclides have been detected at concentrations greater than background in surface samples obtained at TA-21. Some of the metals and radionuclides were detected above their respective screening action levels [e. g. chromium at 1000 ppm,

and tritium at 2300 pCi/ml at SWMU 21-027(a); lead at 2300 ppm, chromium at 415 ppm and tritium at 7100 pCi/ml at SWMU 21-024(c)] (LANL 1995a).

98. The outfalls at the Facility, including those at TA-21, discharged contaminants to the environment. The Facility proposed sampling of these outfalls. "The reason for sampling these outfalls, even though they are permitted discharges, is that prior to being permitted, they may have discharged contaminants." (LANL 1991).

II.A.6.h Releases of Contaminants from TA-45

99. Untreated industrial wastewater generated as a result of nuclear materials research at the original main Technical Area (TA-1) during the early years of the Facility was discharged to a small tributary of Acid Canyon between 1943 and 1951. Roughly 30 million gallons of untreated industrial wastewater was discharged between 1943 and 1951 (LANL 1981).

100. The Facility Operators built an industrial wastewater treatment plant located at former TA-45, which went into operation in 1951. The plant operated until 1964, shortly after a new facility at TA-50 was built (LANL 1981 and 1995c).

101. The volume of treated wastewater effluent from the treatment plant at former TA-45 was 5.8 million gallons in 1951, and increased to 17 million gallons in 1962 (LANL 1981).

102. The estimated total volume of wastewater discharged from former TA-45 and the outfall is approximately 166 million gallons, 30 million of which was not treated (LANL 1981).

103. Cadmium, lead, mercury, nitrates, fluoride, tritium, strontium-90, and plutonium (a strongly sorbing constituent) and others contaminants, were detected in surface water, alluvial groundwater, perched groundwater and springs in Pueblo and lower Los Alamos Canyons between 1946 and 2000 (Purtymun 1975; LANL 1981 and 2001a).

104. During a recent investigation of the sediments found in the South Fork of Acid Canyon, the hazardous constituents detected include mercury, lead, silver, cadmium, chromium, as well as polychlorinated biphenyls (PCBs). Additionally, isotopic plutonium, strontium-90, cesium-137, and americium-241 were detected, indicating that hazardous constituents were discharged concurrently with radionuclides (LANL 1981, 2000c, and 2001a). Process knowledge from similar activities at TA-21 and TA-50 indicates the presence of similar waste streams and contaminants as do the contaminants detected in surface water, sediments and groundwater downgradient of former TA-45 (e.g., DOE 1987; LANL 1981, 1991, 1992b, 1995c, and 2001a; LASL 1974).

II.A.6.i Releases of Contaminants from TA-50

105. In 1963, the Facility Operators moved the wastewater treatment operation from former TA-45 to TA-50, although discharges continued at TA-45 for one additional year. TA-50 houses the Radioactive Wastewater Treatment Facility (formerly known as Central Waste Treatment Plant) that collects and treats industrial wastewater from throughout the Facility (DOE 1987; LANL 1981).

106. Facility operations that generated wastewater sent to TA-50 include handling of heavy metals and beryllium, analytical chemistry laboratories, target preparation facilities, research facilities, metal plating and other facilities. Solvents and other organics (e.g., scintillation cocktails that contain benzene, toluene, and xylene) as well as heavy metals enter the treatment plant and remain in residual treatment sludge and in treated effluent (DOE 1987).

107. From 1963 to 1995, the volume of treated effluent from the wastewater treatment plant at TA-50 was roughly 341 million gallons (DOE 1979 and 1987; LANL 1992b and 1997d).

108. Sampling data collected over the past ten years at and downstream of the outfall show elevated levels of trace metals and organic compounds. Historic data from treated liquid effluent released to Mortandad Canyon [via outfall SWMU 50-006(d) "effluent discharge"] and provided by the LANL Facility indicate that, beginning in 1973 and with no reporting in 1974 through 1977, the inorganic constituents cadmium, chromium (including chromium VI), copper, mercury, lead, zinc, cyanide, nitrate, ammonia, and fluoride were detected in the treated effluent (DOE 1979 and 1987; LANL 1992b and 1997d).

109. From 1963 to 1989, cadmium, chromium, cyanide, mercury, lead, and zinc were monitored in the effluent from the wastewater treatment plant at TA-50. Reported average concentrations of these contaminants indicate that the concentrations were often above drinking water standards (LANL 1992b and 1997d; Purtymun 1975).

110. In 1973, the treated wastewater from the industrial wastewater treatment plant at TA-50 contained cadmium at concentrations up to 560 µg/L (MCL is 5 µg/L); chromium VI at levels up to 65 µg/L; total chromium at concentrations as high as 220 µg/L (MCL is 100 µg/L); copper at levels up to 5280 µg/L (MCLG is 1,300 µg/L and SDWR is 1,000 µg/L); mercury concentrations ranging from 1 to 149 µg/L (MCL is 2 µg/L); lead at levels up to 2600 µg/L (MCL is 15 µg/L); zinc at concentrations up to 260 µg/L (SDWR is 5,000 µg/L); and nitrate at concentrations ranging from 27 to 2093 mg/L (MCL is 10 mg/L) (LASL 1974).

111. Between 1963 and 1972, the annual average concentration of nitrogen as nitrate in treated wastewater from the wastewater treatment plant at TA-50 was 217 mg/L, with a maximum of 766 mg/L (MCL is 10 mg/L) in 1972 (Purtymun 1975).

112. In 2001, monthly composite samples from the wastewater treatment plant at TA-50 contained perchlorate at levels from 3 to 950 µg/L (1 µg/L is the EPA proposed drinking water equivalent level) (EPA 2002b; LANL 2002a).

113. Analytical results from 1971, 1972, and 1997 indicate cadmium, beryllium, lead, and mercury were detected in alluvial wells down gradient (2844 m) of the TA-50 outfall (LANL 1997d and 2001c; Purtymun 1975).

114. Plutonium, a strongly sorbing element, was detected in shallow alluvial aquifer well MCO-7.5 (2844 m down gradient of the outfall), the contamination may be attributable to releases from TA-35 from 1956 to1963 possibly associated with the LAMPRE I, a molten plutonium reactor located at TA-35 (Purtymun 1975; Emelity 1996; LANL 1997d and 2001c).

115. Available documentation indicates that perchlorate analyses were first performed on alluvial groundwater samples obtained from Mortandad Canyon in 1999 and, since then, levels have been detected as high as 440 µg/L (LANL 2002). Perchlorate has also been detected at 4.19 µg/L in regional aquifer well R-15 downgradient of the outfall, which is greater than the 2002 EPA provisional drinking water equivalent level of 1 µg/L, (LANL 2002a). Perchlorate, nitrate, and tritium have been detected at concentrations ranging from 12 to 145 µg/L (perchlorate) in intermediate groundwater zones beneath Mortandad Canyon at MCOBT-4.4 and R-15 (LANL 2002a).

116. The waste disposed at MDA C [SWMU 50-009] at TA-50 includes arsenic, antimony, barium, beryllium, cerium, cesium, copper, cyanide, lead, mercury, silver, thallium, tantalum, zinc, pyrophoric metals, compressed gas cylinders, and acid solutions. In addition, acetone, benzene, HE (e.g., TNT), trichloroethylene and other solvents, waste oil, and radioactive organic solutions have been disposed of at this site. Plutonium contaminated sodium loops from a reactor were also disposed at MDA C. Mercury coolant from the TA-2 Clementine reactor was disposed at MDA C. Sludge, which was contaminated with hazardous constituents and radionuclides, from various treatment plants located at the Facility were also disposed at MDA C during its operation (Rogers 1977; DOE 1987; LANL 1991 and 1992b).

117. A variety of chemicals such as pyrophoric metals, hydrides, compressed gases, nickel carbonyl cylinders (lecture bottles about 1 pound), and carboys of di- or triethylbenzene were disposed of at Pit 7, the chemical disposal pit at MDA C (DOE 1987).

II.A.6.j Releases of Contaminants from TA-54

118. The Facility Operators have used TA-54 since the 1950s as the primary waste disposal area for the Facility. TA-54 includes a waste characterization area, container storage areas, a waste transfer facility, and numerous surface impoundments, pits, trenches, and shafts used for waste disposal (LANL 1992d, 2000a, and 2001c).

119. More than 6500 cubic feet (approximately 48,000 gallons) of organic liquid waste, 1680 cubic feet (approximately 12,500 gallons) of inorganic liquid waste, and at least 53 cubic feet (approximately 396 gallons) of 1,1,1 trichloroethane were disposed of at MDA L in TA-54. In addition, at least another 9500 cubic feet (approximately 71,000 gallons) of unspecified waste was disposed of at MDA L, but not classifiable due to incomplete description in logbook entries (LANL 1992d).

120. At least 114.68 cubic feet (approximately 858 gallons) of 1,1,1-trichloroethane, in addition to other wastes, was disposed of in Shafts 17, 24, and 33at MDA L (LANL 1992d).

121. A plume of organic contaminant vapor has been identified from MDA L, although not fully characterized. Monitoring of subsurface pore gas concentrations in 1999 detected trichloroethane, trichloroethylene, trichlorotrifluoroethane, methylene chloride, chloroform, toluene, 1,1-dichloroethane, and 1,1-dichloroethene, among other solvents (LANL 2000a).

122. A plume of organic vapor and a plume of tritium vapor have been identified beneath MDA G at TA-54 (LANL 2000a).

II.A.6.k Other Releases of Contaminants

123. Dynamic testing at firing sites in 1976 released an estimated 57 lbs (26 kg) of beryllium, 42 lbs (19 kg) of lead, 79 lbs (36 kg) of mercury, and 2244 lbs (1020 kg) of depleted uranium. As reported in 1979, an estimate of the total amount of depleted and natural uranium used in dynamic testing was 220,000 lbs (100,000 kg) (DOE 1979). In 1972, the Facility reports that 18,700 lbs (8500 kg) of high explosives; 57 lbs (26 kg) of beryllium; 286 lbs (130 kg) of lead and; 220 lbs (100 kg) of mercury were used and dispersed to the environment at Dynamic Testing and Weapons Engineering firing sites (LASL 1973).

124. Fractures and higher permeability units (e.g., surge beds and the "Cerro Toledo interval") facilitate contaminant migration in the subsurface at the Facility (Rogers 1977; LANL 1991, 1998a, 1998d and 2001b).

125. Detected concentrations of HE compounds in alluvial groundwater upgradient of TA-18 were used to develop what DOE termed "site-specific background value[s]" at TA-18. Concentrations of 4-amino-2,6-dinitrotoluene, 2-amino-4,6-dinitrotoluene, 2-butanone, 1,3-dinitrobenzene, 2,4-dinitrotoluene, HMX, nitrobenzene, o-nitrotoluene, p-nitrotoluene, RDX, tetryl, 1,3,5-trinitrobenzene, and 2,4,6-trinitrotoluene were used to determine the background values (LANL 1995b). High explosive compounds are not naturally occurring therefore calculation of "background values" for HE compounds in groundwater indicates a pervasive problem at the Facility with regard to HE-related contamination in a potential drinking water source.

II.A.7 Firing Sites

126. There are several active, inactive, closed conveyed or transferred, and decommissioned firing sites at the Facility. Currently TAs -14, -15, -36, -39 and -40 have active firing sites. L-Site (TA-12) was constructed in 1945 for explosive testing and abandoned in the 1950s. Soil tests done in 1993 detected RDX, TNT and picric acid at the site. Q-Site (TA-14) has been used for development and testing of explosives since 1944. HMX and metals have been detected in soils at Q-Site. Between 1944 and 1948 eight firing sites were established at TA-15, these sites are not in use today and most structures associated with these firing sites have been decommissioned and dismantled. Site E-F was most heavily used and reportedly contains the largest quantities of hazardous waste. TA-15 is home of PHERMEX and DARHT. Uranium and other metals such as lead, beryllium, aluminum and cadmium have been released to the environment as a result of test shots conducted at the Facility since 1940s. The firing sites have introduced potential inorganic, organic, and radionuclide contamination to the some of the canyons during the past 50 years. TA-10 was used from 1943 to 1961 as a firing site to conduct experiments that used high explosives, radionuclides in addition to other chemicals. It was decommissioned in 1963 and the land was transferred to Los Alamos County in 1967 (LANL 2001d; CDCP 2002).

127. At TA-9, MDA M, several metals were detected in soils samples at concentrations that exceeded their respective soil screening action levels: antimony (22.2 ppm), arsenic (113 ppm), barium (2,130 ppm), cadmium (24.4 ppm), copper (4,770 ppm), cobalt (24.9 ppm), lead (11,600 ppm), mercury (1.4 ppm), manganese (1,240 ppm), nickel (85.9 ppm), silver (109 ppm), and zinc (4,550 ppm). Several SVOCs also were detected in soil samples: benzo(a)anthracene (160,000 ppb), benzo(b)fluoranthene (200,000 ppb), benzo(k)fluoranthene (77,000 ppb), benzo(a)pyrene (130,000 ppb), ideno(1,2,3-cd)pyrene (80,000 ppb), chrysene (190,000 ppb), benzo(g,h,i)perylene (64,000 ppb), fluoranthene (310,000 ppb), phenanthrene (150,000 ppb), pyrene (280,000 ppb), and dibenzo(a,h)anthracene (23,000 ppb) (LANL 1995d).

128. TA-10 was used from 1943 to 1961 as a firing site to conduct experiments that used high explosives, metals and radionuclides in addition to other chemicals. It was decommissioned in 1963 and the land was transferred to Los Alamos County in 1967 (LANL 1990, 1992a, 1995e, and 2001d).

129. Beryllium (approximately 4 ppm), silver (13.3 ppm), cadmium (approximately 12.5 ppm), copper (approximately 260 ppm), mercury (approximately 0.65 ppm), and zinc (approximately 91 ppm) were found in the soils at SWMU 10-007. Explosives were detected at TA-10 at concentrations of 2,4-dinitrotoluene (200 ppb), 2,6-dinitrotoluene (200 ppb), HMX (1,480 ppb), and m-nitrotoluene (790 ppb). Other contaminants detected at the site were SVOCs including: naphthalene (130 ppb), 1,3,5-trimethylbenzene (14 ppb), 1,2,4-trimethylbenzene (39 ppb), 1,1-dichloroethene (7 ppb), diethylphthalate (15,000 ppb), and bis(2-ethylhexyl)phthalate (2,400 ppb) (LANL 1996c and 2001d).

130. At SWMU 10-001(a-d), the investigation of the residual contamination detected heavy metals like copper (50.8 ppm), nickel (101 ppm), thallium (10 ppm), zinc (668 ppm), and mercury (0.52 ppm). High explosives were detected on both side of Bayo Canyon, on the mesa top, the slopes, and in the channel of the canyon and included: 2,6-dinitrotoluene (789 ppb), 4-amino-2,6-dinitrotoluene (157 ppb), HMX (1,560 ppb), nitrobenzene (154 ppb), m-nitrotoluene (435 ppb), o-nitrotoluene (210 ppb), and p-nitrotoluene (469 ppb) (LANL 1995e and 2001d).

131. At SWMU 14-002(a) copper (30.7 ppm), nickel (32.9 ppm), and total uranium (2,010 ppm) were detected in soils. At SWMU 14-010 metals including cobalt (62.2 ppm), copper (158 ppm), nickel (128 ppm), selenium (3.2 ppm), and total uranium (1,370 ppm) were detected. The surface soil and the soil around the drain line of SWMU 14-010 contained high concentrations of HMX (including concentrations of 40,800 ppb and 14,500 ppb) (LANL 1997c).

132. At SWMU 14-003, metals exceeding soil screening action levels were detected that included: antimony (27.6 ppm), barium (10,300 ppm), cadmium (69 ppm), copper (46,200 ppm), lead (13,100 ppm), manganese (3,910 ppm), nickel (33.7 ppm), silver (167 ppm), zinc (8,040 ppm), and total uranium (64.2 ppm). High explosive compounds were detected at concentrations exceeding soil screening action levels including 2-amino-4,6-dinitrotoluene (2,720 ppb), 4-amino-2,6-dinitrotoluene (2,900 ppb), and RDX (2,680,000 ppb) (LANL 1996f).

133. At SWMU 14-006, lead (46.5 ppm), cobalt (52.6 ppm), copper (74.9 ppm), thallium (3.4 ppm), and zinc (394 ppm) were detected in soils samples obtained from the site. Several SVOCs were also detected at concentrations exceeding soil screening action levels and included: benzo(a)anthracene (118,000 ppb), benzo(b)fluoranthene (120,000 ppb), benzo(k)fluoranthene (71,900 ppb), benzo(a)pyrene (5,000 ppb), ideno(1,2,3-cd)pyrene (50,900 ppb), anthracene (59,300 ppb), chrysene (152,000 ppb), benzo(g,h,i)perylene (44,100 ppb), fluoranthene (282,000 ppb), phenanthrene (200,000 ppb), and pyrene (248,000 ppb). High explosives including HMX (800 ppb) and RDX (230 ppb) were detected in surface samples obtained from SWMU 14-006 and 50 feet downgradient of the SWMU 14-006 outfall, 2,4,6-TNT (4,750 ppb), 4-amino-2,6-dinitrotoluene (270 ppb), and HMX (540 ppb) also were detected in surface samples (LANL 1996a).

134. Between 1944 and 1948, eight individual firing sites were established at TA-15. These sites are not in use today and most structures associated with these firing sites have been decontaminated and decommissioned. Although the other sites are of concern, E-F Site [15-004(f) and 15-008(a)] was most heavily used and reportedly contains the largest quantities of solid and hazardous wastes as well as hazardous constituents. TA-15 is home to PHERMEX and DARHT. Uranium and other metals such as lead, beryllium, aluminum and cadmium have been released to the environment as a result of test shots conducted at the Facility since 1940s. The Facility reports that initial sampling indicates that beryllium, lead and uranium (as a "toxic metal") are elevated, lead at levels bordering phototoxic levels and uranium at "several thousand" ppm at the surface. In addition, the firing sites have introduced potential inorganic, organic, and radionuclide contamination to the some of the canyons during the past 50 years (CDCP 2000; LANL 1990).

135. At TA-15, former firing points, A, B, C and D, originally thought to have left no residues, were sampled after they were "inactivated." Barium, beryllium, cadmium, lead, mercury, uranium and HE were detected in during investigations (LANL 1990).

136. At TA-9, MDA M, several metals were detected in soils samples at concentrations that exceeded their respective soil screening action levels: antimony (22.2 ppm), arsenic (113 ppm), barium (2,130 ppm), cadmium (24.4 ppm), copper (4,770 ppm), cobalt (24.9 ppm), lead (11,600 ppm), mercury (1.4 ppm), manganese (1,240 ppm), nickel (85.9 ppm), silver (109 ppm), and zinc (4,550 ppm). Several SVOCs also were detected in soil samples: benzo(a)anthracene (160,000 ppb), benzo(b)fluoranthene (200,000 ppb), benzo(k)fluoranthene (77,000 ppb), benzo(a)pyrene (130,000 ppb), ideno(1,2,3-cd)pyrene (80,000 ppb), chrysene (190,000 ppb), benzo(g,h,i)perylene (64,000 ppb), fluoranthene (310,000 ppb), phenanthrene (150,000 ppb), pyrene (280,000 ppb), and dibenzo(a,h)anthracene (23,000 ppb) (LANL 1995d).

137. At SWMU 36-001, MDA AA, there were detections of metals in soils that included: antimony (16.6 ppm), cobalt (556 ppm), copper (21,300 ppm), lead (1,850 ppm), nickel (450 ppm), silver (250 ppm), thallium (2.24 ppm), mercury (0.39 ppm), zinc (998 ppm), total uranium (136 ppm), and chromium (62.9 ppm). Detected SVOCs included: anthracene (2.03 ppm), 3,3-dichlorobenzidine (32.9 ppm), bis(2-ethylhexyl)phthalate (3.95 ppm), and benzoic

acid (1.07 ppm). High explosives were also detected in soil samples obtained from the vicinity of MDA AA and included: RDX (2.24 ppm) and HMX (0.8 ppm) (LANL 1996d).

138. Inorganic and organic contamination was detected at SWMU 39-001(a). The pits in this landfill were used for disposal of materials consisting of debris from firing sites, empty chemical containers, and office waste. The contamination found in the soil included cyanide (0.74 ppm), mercury (1.3 ppb), zinc (140 ppm), copper (32.5 ppm), nickel (22 ppm), beryllium (3.4 ppm), total uranium (17.6 ppm), and lead (57.1 ppm). Bis(2-ethylhexyl)phthalate (1.8 ppm) and m-nitrotoluene (420 ppb) also were detected at several locations outside of the identified landfill trenches (LANL 1997b).

139. At SWMU 39-001(b), MDA Y, contaminants detected in soils included antimony (8.9 ppm), beryllium (3.7 ppm), cadmium (11.6 ppm), copper (383 ppm), cyanide (2.9 ppm), manganese (1,780 ppm), total uranium (67.9 ppm), zinc (153 ppm), mercury (4.5 ppm), nickel (17.5 ppm), and silver (11 ppm). Several SVOCs detected in soil samples obtained from MDA Y exceeded soil screening action levels including: benzo(a)anthracene (122 ppm), benzo(b)fluoranthene (153 ppm), benzo(k)fluoranthene (158 ppm), benzo(a)pyrene (116 ppm), ideno(1,2,3-cd)pyrene (79.3 ppm), chrysene (125 ppm), benzo(g,h,i)perylene (76.7 ppm), fluoranthene (362 ppm), phenanthrene (407 ppm), pyrene (354 ppm), dibenzo(a,h)anthracene (19.7 ppm), naphthalene (44.6 ppm), and bis(2-ethylhexyl)phthalate (13.2 ppm). High explosive compounds were also detected within the MDA Y disposal trenches and included: 2-amino-4,6-dinitrotoluene (300 ppb), 2,6-dinitrotoluene (200 ppb), 2,4,6-TNT (300 ppb), and HMX (4,100 ppb) (LANL 1997b).

140. Composite soil samples obtained at SWMU 18-002(a), a closed firing site indicated presence of 2,4-dinitrotoluene (600 ppb), 2,6-dinitrotoluene (600 ppb), and nitrobenzene (7,060 ppb) in soils (LANL 1995g).

141. At SWMU 18-002(b), a closed firing site, HE compounds were detected in the subsurface samples including: 4-amino-2,6-dinitrotoluene (101 ppb), RDX (856 ppb), and 2,4,6-TNT (867 ppb) and HE compounds including: 4-amino-2,6-dinitrotoluene (101 ppb), RDX (856 ppb), and 2,4,6-TNT (867 ppb) were detected in subsurface samples (LANL 1995g).

142. At SWMU 27-002, a decommissioned firing site, metals were detected in subsurface soil samples including: chromium (104 ppm), copper (40 ppm), lead (322 ppm), and nickel (53.1 ppm). HE compounds were detected in surface and subsurface soil samples. HE compounds were detected in surface samples at concentrations up to 136 ppb for 4-amino-2,6-dinitrotoluene, 184 ppb for 2-amino-4,6-dinitrotoluene, 84 ppb for HMX, and 3,690 ppb for RDX. HE compounds were detected in subsurface samples at concentrations up to 677 ppb for 4-amino-2,6-dinitrotoluene, 468 ppb for 2-amino-4,6-dinitrotoluene, 1,870 ppb for HMX, 30,300 ppb for RDX, and 6,650 ppb for 2,4,6-TNT (LANL 1995g).

II.A.8 Potential for Exposure to Contaminants

143. Los Alamos County operates seven public water supply wells within the Facility boundary and an additional five public water supply wells within three miles to the north of the Facility. The wells draw water from the regional aquifer. Contamination has been detected

in two of the County wells north of the Facility, wells G-1 and G-1A. The contaminant detected is strontium-90 (LANL 2001c).

144. The public water supply well for the City of White Rock, PM-1, is located on the east (downgradient) side of the Facility in Sandia Canyon. The well draws water from the regional aquifer (Purtymun and Stoker 1988).

145. The database of the New Mexico Office of the State Engineer (SEO) for registered wells in Los Alamos County lists six shallow domestic wells, one irrigation well, and four non-domestic wells in the county, excluding the U.S. Atomic Energy Commission wells. The listed depths to water in the domestic wells (when drilled) range from 6 feet to 52 feet; total well depths range from 45 feet to 150 feet. Although the exact locations or status of these wells are not known, their shallow depths indicate that they are designed to utilize alluvial groundwater (SEO 2002).

146. Tritium, nitrate, and perchlorate have been detected in Los Alamos County water supply wells (LANL 2001c, LANL 2002e). Strontium-90 contamination has been detected in two of the County wells north of the Facility, wells G-1 and G-1A. The Facility reports that Well G-1 over the course of 2 years, between March 1997 and March 1999, had three intermittent detections of Sr-90 between 1.2 and 6.8 pCi/L (MCL 8 pCi/L) (LANL 2001c and 2002e). The nature and extent of the tritium and other anthropogenic contamination is unknown because of inadequate groundwater characterization.

147. Water supply wells are located on Pueblo of San Ildefonso to the east and downgradient of the Facility. The wells draw water from the regional and alluvial aquifers (LANL 1995h and 1996g).

148. Perchlorate has been detected in a municipal water supply well (Otowi-1) for Los Alamos County and located in Pueblo Canyon, approximately 5 miles downgradient of the South Fork of Acid Canyon. Detected concentrations greater than the 2002 EPA proposed drinking water equivalent of 1 µg/L and the 1999 EPA proposed drinking water equivalent level of 4 µg/L (LANL 2001c, 2002a and 2002e).

149. Based on limited testing, perchlorate has been detected above the 2002 EPA proposed drinking water equivalent level of 1 µg/L in groundwater at several locations beneath and surrounding the Facility. Perchlorate was detected in Pueblo Canyon in regional aquifer wells TW-1 (1.37 µg/L) and Otowi-1 (1.12 to 5.85 µg/L) and intermediate groundwater in monitoring well POI-4 (1.73 µg/L); in Mortandad Canyon in regional aquifer well TW-8 (3.26 µg/L) and alluvial wells MCO-3 (33 to 280 µg/L), MCO-4B (157 µg/L), MCO-5 (156 to 252 µg/L), MCO-6 (83.2 to 400 µg/L), MCO-7 (69 to 282 µg/L), MCO-7.5 (252 µg/L), and CDBO-6 (2.38 µg/L); in Los Alamos Canyon in regional aquifer well Otowi-4 (1.43 to 3.6 µg/L) and alluvial well LAO-3A (1.17 to 1.28 µg/L); in the Pajarito well field at wells PM-1 (1.3 to 2.12 µg/L), PM-2 (1.54 µg/L), PM-3 (1.01 to 3.96 µg/L), PM-4 (1.71 µg/L), and PM-5 (1.05 to 2.42 µg/L); in the Guaje well field at wells G-1A (2.9 µg/L), G-2A (2.63 µg/L), G-3A (2.64 µg/L), G-4A (2.69 µg/L), and G-5A (1.28 to 2.65 µg/L); and in Springs 4 (2.35 to 8.49 µg/L), 4A (12 µg/L), 4AA (1.57 µg/L), 4B (1 to 6.62 µg/L), 4C (2.5 to 2.63

µg/L), 5 (1.29 µg/L), Basalt Spring (1.3 µg/L), and Sacred Spring (1.95 µg/L) (LANL 2002e).

150. Tritium, a conservative contaminant tracer, has been detected in the Otowi-1 municipal water supply well at 38 pCi/L. The reported tritium activity of 38 pCi/L underestimates the activity of tritium in the groundwater zone(s) entering the supply well since Otowi-1 is screened over 1460 feet. Due to the limited groundwater characterization in the vicinity and upgradient of the well, the nature and extent of the tritium and other anthropogenic contamination is unknown. This data indicates that communication between effluent discharges and the deep regional aquifer has occurred during the last 59 years and may continue to be occurring (Purtymun 1995, LANL 2001c).

151. Volatile organic compounds such as 1,1-dichloroethylene, trichloroethylene, and 1,1,1-trichloroethane have been detected above EPA MCLs in alluvial groundwater at SWMU 3-010(a) (LANL 2000d and EPA 2002e).

152. Inorganic chemicals such as arsenic, barium and lead have been detected in alluvial groundwater and seeps at concentrations greater than EPA MCLs in Cañon de Valle below the Building 16-260 outfall. High explosive compounds such as 4-amino-2,6-dinitrotoluene, RDX, and 2,4,6-trinitrotoluene have been detected in alluvial groundwater or seeps at levels greater than EPA health advisories and MCLs in the same area (LANL 1998c).

153. The soil samples obtained from the vicinity of and downgradient of the TA-16-303 outfall, and HE storage building [SWMUs 16-026(d) and 16-029(c)] detected zinc (134 ppm), chromium (72.7 ppm), lead (79.8 ppm), benzo(a)anthracene (310 ppb), benzo(a)pyrene (260 ppb), diethylphthalate (800 ppb), and di-n-butylphthalate (170 ppb). High explosive compounds were detected in soils at the outfall and 25 feet below the outfall at the following concentrations: 2,4,6-TNT (240 ppb) and 4-amino-2,6-dinitrotoluene (168 ppb). RDX was detected at 50 feet below the outfall at a concentration of 2,420 ppb (LANL 1997f).

154. At SWMU 16-026(v) heavy metals were detected at concentrations greater than background levels including barium (317 ppm), beryllium (2 ppm), chromium (160 ppm), copper (412 ppm), lead (103 ppm), mercury (9.2 ppm), nickel (26.1 ppm), and zinc (321 ppm). SVOCs also were detected in soil samples at concentrations that exceeded soil screening action levels including: benzo(a)anthracene (4.9 ppm), dibenz(ah)anthracene (610 ppb), benzo(a)pyrene (4.4 ppm), pyrene (9.7 ppm), naphthalene (1.2 ppm), benzo(b)fluoranthene (6.5 ppm), Ideno(1,2,3-cd)pyrene (2.7 ppm), bis(2-ethylhexyl)phthalate (2.9 ppm), and fluoranthene (13 ppm). The rare high explosive triaminotrinitrobenzene (11.1 ppm) and tetryl (122 ppb) were detected in soil samples at SWMU 16-026(v) outfall and also were detected at decreasing concentrations downgradient from the outfall (LANL 1997f).

155. At SWMU 16-030(g), historical data obtained during the 1970s and 1980s from the wastewater effluent and the soils beneath the outfall indicated presence of the HE compounds HMX, RDX, and TNT. Heavy metals such as barium (391 ppm), copper (62.4 ppm), lead (434 ppm), and zinc (107 ppm) also were detected in soils. SVOCs were detected at concentrations that exceeded soil screening action levels including: benzo(a)anthracene (3.3 ppm), dibenz(ah)anthracene (410 ppb), benzo(b)fluoranthene (4.8 ppm),

benzo(k)fluoranthene (2.5 ppm), naphthalene (860 ppb), benzo(a)pyrene (3.2 ppm), indeno(1,2,3-cd)pyrene (1.4 ppm), and di-n-butylphthalate (2.2 ppm). Several high explosives compounds were detected in soils samples obtained downgradient from the SWMU 16-030(g) outfall including: 2,4,6-TNT (478 ppb), 2,4-dinitrotoluene (114 ppb), 2-amino-4,6-dinitrotoluene (109 ppb), 4-amino-2,6-dinitrotoluene (218 ppb), HMX (1.72 ppm), and triaminotrinitrobenzene (3.34 ppm). One of these explosive compounds, TNT, was detected 200 feet downgradient from the outfall (LANL 1997f).

156. Samples of surface water run-off collected from MDA M [SWMU 9-013] contained concentrations of antimony (94.8 ppb), barium (2,740 ppb), beryllium (19.3 ppb), cadmium (40.2 ppb), chromium (144 ppb), lead (147 ppb), manganese (2,770 ppb), and methylene chloride (6 ppb). Surface water samples collected from the three springs located in the vicinity of MDA M contained concentrations of the following high explosives: 2,4-dinitrotoluene (1.52 ppb) and HMX (found in two springs at levels 1.99 ppb and 1.48 ppb) (LANL 1995d). The source of the HE compounds in the springs has not been characterized, but MDA M is a potential source.

157. A sludge sample obtained from the tank at SWMU 36-003(b) contained RDX at a concentration of 128 ppb. Surface soil samples obtained from the drainage channel downstream of SWMU 36-003(b) contained concentrations of antimony (6.3 ppm), copper (318 ppm), total uranium (84.5 ppm), and RDX (510 ppb) at a distance of 90 feet below the outfall (LANL 1995f).

158. High explosives [RDX (244 ppb), HMX (954 ppb), and tetryl (626 ppb)] were detected in water samples obtained from the wetland/pond that received effluent discharges from the sanitary lagoons at SWMU 18-001(a,b) (LANL 1995b).

159. High explosive compounds such as 2-amino-4,6-dinitrotoluene and RDX were detected in regional groundwater during the drilling of regional monitoring well R-31 located at TA-39 (LANL 2000b).

160. High explosive compounds such as RDX, TNT, HMX, and amino-DNTs were detected in a perched saturated zone and in regional groundwater in monitoring well R-25. Well R-25 is located east of Building TA-16-260 and has a total depth of 1942 feet. RDX concentrations ranged up to greater than 75 µg/L. The two highest HE concentrations were detected in samples obtained from the middle of the intermediate perched zone and near the regional aquifer water table (LANL 1999a).

161. Strontium-90 has been detected in several alluvial groundwater wells in Los Alamos and Mortandad Canyons. The detections are above the EPA Primary Drinking Water Standard of 8 pCi/L, and range from 8.1 to 226 pCi/L. Strotium-90 has also been detected in DP Spring above the EPA Primary Drinking Water Standard of 8 pCi/L, and ranges from 40.7 to 115 pCi/L (LANL 2002e).

162. Several high explosive compounds have been detected in Los Alamos County water supply well PM-5 above their respective health advisories. These include 2,6-dinitrotoluene, 2,4-dinitrotoluene, 4-amino-2,6- dinitrotoluene, and RDX. PM-5 is located in the Pajarito Well

Field, withdraws from the regional aquifer, is over 3000 feet deep and is screened over a 1,600-foot interval. The depth to water is approximately 1200 feet (NMED 1996a; LANL 2002e; Purtymun 1995).

163. Organic compounds have been detected in samples obtained from regional aquifer test wells at TA-49 (DT-5A, DT-10, DT-9). The largest contaminant detection was pentachlorophenol, detected in a sample obtained, from test well DT-9 at a concentration of 110 ppb which is greater than the EPA MCL of 1 ppb. Plutonium-239 was also detected in CH-2, a 500 foot monitoring well, located in Area 2 of MDA AB (DOE 1996; LANL 1987).

164. High explosives, VOCs, and nitrates were found in samples collected from recently discovered springs discharging alluvial and perched water in the Pajarito Canyon watershed. Tetrachloromethane was detected at 15 µg/L, and the HE compounds Hexahydron-1,3,5-trinitron-1,3,5-triazine (RDX) and 2-amino-[2,4]-6-dinitrotoluene were detected at 100 µg/L, and 3.31 µg/L, respectively. The potential exists for contaminants to migrate from alluvial groundwater bodies through the rock matrix below to the main aquifer (DOE 1999).

165. The presence of tritium in the regional aquifer was first reported in LANL's 1992 Environmental Surveillance Report. Although the exact recharge mechanism(s) is not known, possible transport pathways could be: 1) contaminants infiltrating along well shafts or boreholes, 2) contaminants moving through the unsaturated zone, and 3) contamination infiltrating areas of high fault or fracture density (DOE 1999).

166. Beryllium was detected in groundwater above the EPA MCL of 4 µg/L at the following locations: alluvial wells LAO-0.7, LAO-3A, LAO-6A, and MCO-7A, Indian Spring, the Bureau of Indian Affairs Wellpoint 1, and the New Community Well. The detections range from 5.3 to 30 µg/L (LANL 2002e).

167. Several metals including barium, beryllium, chromium, lead, and manganese, and also nitrate have historically been detected at or above state and/or federal standards in PCO-Series alluvial wells and TW-Series wells located in Pajarito Canyon (NMED 1996a and 1996b).

168. The potential for ecological risk exists at many sites at the Facility. Ecological risk evaluation was not performed for most of the sites that underwent remediation in the past. It is difficult to assess ecological risk for the Facility because of incomplete investigations. For an ecological risk evaluation, concentrations at a site are compared to a benchmark (a concentration in soil that is estimated to provide the given species with a dose considered to be unlikely to cause harmful effects when the size of the animal and amount of material ingested in soil or food are considered). The potential for ecological risk is given as a hazard quotient (HQ=(level at site)/(benchmark level)) therefore an HQ>1 indicates potential for risk to specific ecological receptors. The benchmarks used to generate HQs are not based on linear functions, so an HQ of 100 is not necessarily ten times worse than an HQ of 10. Conversely an HQ of 100 may be more than ten times worse than an HQ of 10. A HQ is generated using a point estimate of exposure and a point estimate of toxicity. Because the quotient does not include any information on the mathematical relationships used to generate each of these point estimates, we cannot say that the relationship between them is linear. Therefore, a hazard quotient greater than one indicates the potential for adverse effects to the

receptor species, but not the magnitude of that potential. Because the HQ system can only determine the potential for effects, HQs greater than one must be investigated using more sophisticated risk assessment techniques that examine the exposures and toxic effects in-depth. The potential for ecological risk is best described by presenting the number of HQs substantially above one for all the receptors that have those high HQs: sites with more high HQs for more receptors are more likely to present actual risk to ecological receptors. For example, the robin is screened with 3 different diets (herbivore, omnivore, insectivore) to be a surrogate for 3 different species of small birds; therefore, each diet type represents a different receptor. LANL has not completed detailed ecological risk assessments at most individual SWMUs and AOCs.

169. At SWMU 16-021(c)-99, 19 HQs had values greater than one (indicating a potential ecological risk). The HQs for barium were five (omnivore robin), 8.2 (herbivore robin), and 19 (red fox). The HQs for HMX were 46 (deer mouse), 39 (cottontail), 7.7 (shrew), and 4 (earthworm). The HQs for RDX were 130 (deer mouse), 109 (cottontail), 36 (shrew), and 2.4 (earthworm). The HQs for 2,4,6-trinitrotoluene were 471 (earthworm), 2.75 (kestrel 50-50 diet), 60 (herbivore robin), 19 (insectivore robin), 39.75 (omnivore robin), 6 (deer mouse) 4.3 (cottontail), and 3.3 (shrew) (LANL 2002c).

170. At SWMU 21-024(i), nine HQs had values greater than one. Antimony had an HQ of 2.7 (red fox), lead had an HQ of 1.4 (shrew), and 3.2 (kestrel 50-50 diet). Mercury (inorganic) had HQs of 10.5 (herbivore robin), 24 (insectivore robin), and 17 (omnivore robin). Zinc had HQs of 3.25 (insectivore robin), 1.5 (herbivore robin), and 2.4 (omnivore robin) (LANL 2002d).

171. At the airport landfill (PRSs 73-001(a-d) and 73-004(d)), six HQs had values greater than one. Copper had HQs of 11 (herbivore robin), 7.5 (insectivore robin), and 9.4 (omnivore robin). Zinc had HQs of 4.7 (omnivore robin), 2.9 (herbivore robin), and 6.3 (insectivore robin) (LANL 1998e).

172. In Cañon de Valle (canyon bottom), 16 HQs were above one. Barium had HQs of 690 (insectivore robin), 420 (omnivore robin), 160 (herbivore robin), 93 (kestrel 50-50 diet), 3.7 (kestrel all flesh diet), 120 (cottontail), 890 (deer mouse), 1600 (shrew), and 10 (red fox). Copper had an HQ of 1.4 for deer mouse. Silver had HQs of 5 (insectivore robin), 11 (omnivore robin), and 17 (herbivore robin). HMX had HQs of 260 (cottontail), 290 (deer mouse), and 29 (shrew) (Tardiff 2001).

173. In DP Canyon, eight HQs were above one. Antimony had an HQ of 1.46 for red fox. Copper had HQs of 2 (herbivore robin) and 1.8 (omnivore robin). Lead had HQs of 2 (shrew), and 1.4 (insectivore robin). Manganese had an HQ of 1.5 for deer mouse. Zinc had an HQ of 1.7 for omnivore robin and naphthalene had an HQ of 16 for kestrel (50-50 diet) (LANL 2002f).

174. In Los Alamos Canyon, seven HQs were above one. Manganese had an HQ of 2.9 for deer mouse. Copper had an HQ of 1.4 (herbivore robin). Cyanide had HQs of 25 (herbivore robin), 25 (insectivore robin), and 25 (omnivore robin). Zinc had an HQ of 4 for omnivore robin and naphthalene had an HQ of 13 for kestrel (50-50 diet) (LANL 2002f).

175. In Pueblo Canyon, eight HQs were above one. Cyanide had HQs of 5.5 (insectivore robin), 5.5 (herbivore robin), and 5.5 (omnivore robin). Copper had HQs of 1.8 (herbivore robin), and 1.6 (omnivore robin). Manganese had an HQ of 2 for deer mouse, zinc had an HQ of 2.3 for omnivore robin and naphthalene had an HQ of 2.8 for kestrel (50-50 diet) (LANL 2002f).

176. Wildlife and livestock access habitat on and downgradient from the Facility. Wildlife and livestock also make use of contaminated surface water flowing in the canyons as well as contaminated seeps and springs that discharge to the surface (LANL 1998f).

177. Concurrent with TA-21 industrial wastewater treatment plant releases, the Facility reports that in 1971, kidneys from rodents living in DP Canyon were analyzed for mercury. Mercury concentrations ranged from 0.1 to 0.7 micrograms per gram (µg/g) for wet tissue, compared to 0.02 to 0.1 µg/g for wet tissue at a control site. Activities for plutonium and tritium in rodents were reported to have had a similar correlation (DOE 1987).

178. Firing site-related contaminants have been detected at concentrations greater than LANLs Ecological Screening Levels at the following firing site SWMUs and AOCs: 6-003(a), 6-007(g), 7-001(b), 10-003(a-o), 10-001(a-d), 12-001(b), 16-003(k), 16-006(c), 16-010(a), 16-021(a), 16-026(v), 16-028(a), 14-002(a), 14-010, 14-003, 14-004(c), 14-006, TA-14 firing pad drainange, 15-002, 15-004, 15-008(a), 15-008(b), 15-010(a), 15-011(b), 15-012(b), 15-014(b), 9-013, 36-001, 36-003 and 39,001(a). Not all firing sites have been adequately characterized at the Facility (LANL 1995d, 1995e, 1995g, 1996b, 1996c, 1996d, 1996f, 1997b, 1997d, and 2001d)

II.A.9 Summary

179. The Facility has conducted weapons and other research and development operations since 1943. These operations have generated wastes that include VOCs, SVOCs, metals, HE, perchlorate, PCBs, petroleum compounds, radionuclides and associated degradation products. Examples of Facility operations and the types of materials used, disposed or discharged are provided in Findings 7 through 20.

180. Sludge, liquid-phase and solid-phase wastes have been discharged or otherwise disposed at various locations across the Facility in landfills, pits, trenches, shafts, absorption beds, septic systems, sumps, leach fields, as surface discharge and through treatment systems designed to remove specific constituents. Contaminants also were released to the environment during testing activities, through air emissions, and via leaks and spills from Facility activities, process units, ancillary equipment and unpermitted discharges. Examples of waste disposal and contaminant releases are provided in Findings 21 through 54.

181. Facility activities have resulted in the release of solid and hazardous wastes as well as mixed and radioactive wastes to the environment. As a result, Los Alamos National Laboratory has identified over 2100 areas of concern (AOCs) and solid waste management units (SWMUs) (LANL 1998f). LANL has documented evidence of numerous releases of contaminants to the environment at the Facility. Examples of releases of contaminants to the environment are provided in Findings 55 through 125.

182. Facility activities at firing sites have resulted in the release of explosives-related contamination including metals, HE compounds and SVOCs at numerous current and decommissioned firing sites. Explosives-related contamination was detected in surface and subsurface soils associated with current, decommissioned, abandoned, surplussed, conveyed and transferred ranges, landfills and burial sites, and in groundwater. Examples of releases of explosive-related contamination in soils as buried waste or at transferred or decommissioned firing sites are provided in Findings 126 through 142.

183. Water supply wells at the Facility, in Los Alamos County and on San Ildefonso Pueblo property withdraw water from the regional aquifer beneath the Pajarito Plateau as well as the alluvial aquifer. Springs discharge groundwater to the surface from the alluvial groundwater system and from intermediate zone perched groundwater (Findings 143,144, 145, 147 and 162).

184. Contamination has been reported in groundwater samples obtained from water supply wells located within the Facility boundaries and downgradient from the Facility. Examples of detections in water supply wells are provided in Findings 146, 148, 150, and 162.

185. Contamination has been reported in the alluvial, intermediate perched, and regional aquifers often at concentrations greater than established drinking water standards, cleanup, screening or health advisory levels and action levels for a variety of contaminants. Examples of detections in groundwater are provided in Findings 149, 151, 152, 160, 161, 162, 163, 166, and 167.

186. Facility records report that solid, hazardous, mixed hazardous and radioactive, and radionuclide contamination has been detected at numerous locations across the Laboratory. The contamination is present in surface and subsurface soils, as subsurface vapor-phase contamination and in surface water and groundwater. The potential for human and ecological exposure to soil contamination at the ground surface or in the subsurface through construction activities, animal burrowing activities or through plant uptake exists at areas where soil contamination is present. Examples of the presence of soils contamination are provided in Findings 55 through 142, 153, 154, 155, and 157.

187. Contamination from firing sites has been documented in sediments, soils, surface water and groundwater. Examples of firing site contamination are provided in Findings 73 through 76, 126 through 142, 157, 158, 159, 162, 164, and 178.

188. Contamination has been detected in surface water within the canyons and as spring-supplied discharge that includes metals and HE-related contamination. Examples of surface water contamination are provided in Findings 149, 152, 156, 158, 161, and 164.

189. The potential for ecological risk exists at many Facility sites. Ecological assessments were generally not performed for sites where remedial actions were conducted in the past. Documented ecological risk (potential risk defined as having a HQ value greater than 1) exists for numerous ecological receptors at several sites. Examples of the documented risk are included in Findings 168 through 178. Site-specific ecological assessments have not been performed at most Laboratory AOCs and SWMUs.

190. Findings 3 through 177 above are examples of known releases and detections in various media. The sources of contamination have not been adequately identified or characterized at many of the over 2,100 SWMUs and AOCs and watersheds at the Laboratory. The sources and extent of surface soil and water and subsurface soil, groundwater and vapor-phase contamination at the Laboratory have not been adequately characterized and are likely more extensive than the NMED Administrative Record indicates.

II.A.10 Toxicity of Contaminants

191. *Barium.* Subchronic and chronic studies on rats and mice have shown kidney damage in response to oral doses of barium. Hypertension has been observed in humans who ingested high doses of barium under occupational exposure conditions. Ingestion of high levels of barium compounds over the short term has resulted in difficulties in breathing, increased blood pressure, changes in heart rhythm, stomach irritation, brain swelling, muscle weakness, damage to the liver, kidney, heart, and spleen (EPA 2002a, ATSDR 2002).

192. *Benz (a) anthracene.* Animal studies showed an increased incidence of pulmonary adenoma and hepatoma as well as increased incidence of liver adenomas or carcinomas in animals exposed to this chemical. This chemical is a known animal carcinogen and has been classified by EPA as a probable human carcinogen. U.S. Environmental Protection Agency (EPA) Office of Research and Development, National Center for Environmental Assessment Integrated Risk Information (IRIS) database (www.epa.gov/iris). This chemical also caused gene mutations in laboratory animals. In the presence of activators, this chemical caused gene mutations in tissue cultures (ATSDR 1995d).

193. *Benzo (a) pyrene.* This chemical is a known animal carcinogen and has been classified by EPA as a probable human carcinogen. U.S. Environmental Protection Agency (EPA) Office of Research and Development, National Center for Environmental Assessment Integrated Risk Information (IRIS) database (www.epa.gov/iris) Mice exposed to this chemical showed decreased survival time due to bone marrow depression. Other hematopoietic effects ultimately leading to death were also seen in mice exposed to this chemical. This chemical damaged DNA in a number of species. In laboratory animals benzo (a) pyrene bound with DNA, caused gene mutations, and caused chromosomal aberrations. This chemical caused DNA damage and gene mutations in cells in tissue cultures. Reduced lung function and abnormal lung structure in chest x-rays have been documented in humans exposed to benzo (a) pyrene in the workplace (ATSDR 1995d).

194. *Benzo (b) fluoranthene.* This chemical is known to cause cancer in animals and has been classified by EPA as a probable human carcinogen. U.S. Environmental Protection Agency (EPA) Office of Research and Development, National Center for Environmental Assessment Integrated Risk Information (IRIS) database (www.epa.gov/iris) In the presence of activators, this chemical caused gene mutations and DNA damage in tissue cultures (ATSDR 1995d).

195. *Benzo (k) fluoranthene*. This chemical is known to cause liver and lung cancer in animals and has been classified by EPA as a probable human carcinogen. In the presence of activators, this chemical also caused gene mutations in cell cultures. U.S. Environmental

Protection Agency (EPA) Office of Research and Development, National Center for Environmental Assessment Integrated Risk Information (IRIS) database (www.epa.gov/iris) This chemical bound directly to DNA in the skin of laboratory mice (ATSDR 1995d).

196. *Beryllium*. Inhalation of beryllium can cause chronic beryllium disease, an inflammatory reaction to low levels of beryllium, and it may cause lung cancer. Ingestion of beryllium has not been reported to cause effects in humans because very little beryllium can move from the stomach and intestines into the bloodstream. Beryllium contact with scraped or cut skin can cause rashes or ulcers (EPA 1998a; ATSDR 2002).

197. *Cadmium*. Cadmium can cause kidney damage through both ingestion and inhalation exposures. Cadmium has been linked with damage to the intestinal tract through ingestion and with damage to the lungs through inhalation. Cadmium is also considered to be a probable (class B) human carcinogen. Long-term exposure to lower levels of cadmium in air, food, or water leads to a buildup of cadmium in the kidneys and possible kidney disease. Other long-term effects are lung damage and fragile bones (EPA 2002a; ATSDR 2002).

198. *Chrysene*. Chrysene is a known animal carcinogen, producing liver, lung and skin tumors as well as malignant lymphoma in mice. Chrysene also produced chromosomal abnormalities in hamsters, and changes to cell cultures in several types of assays. Chrysene is a component of mixtures (coal tar, coke oven emissions, soot) that have been associated with human cancer. U.S. Environmental Protection Agency (EPA) Office of Research and Development, National Center for Environmental Assessment Integrated Risk Information (IRIS) database (www.epa.gov/iris) In the presence of activators, this chemical caused gene mutations in tissue cultures. Chrysene has been classified by EPA as a probable human carcinogen (ATSDR 1995d; EPA 2002a).

199. *Chromium (III)*. Chromium III has a much lower bioavailability than chromium (VI) and is therefore much less toxic than chromium (VI). Chromium (III) caused reduced liver and spleen weights in animals and allergic contact dermatitis in exposed workers (EPA 1998b).

200. *Chromium (VI)*. Inhaled chromium (VI) is a carcinogen that acts as a mutagen on DNA. Breathing high levels of chromium (VI) can cause irritation to the nose, such as nosebleeds, and ulcers and holes in the nasal septum. Ingesting large amounts of chromium (VI) can cause stomach upsets and ulcers, convulsions, kidney and liver damage, and even death. Skin contact with certain chromium (VI) compounds can cause skin ulcers (EPA 1998c; ATSDR 2002).

201. *Copper*. Exposure to copper in drinking water may cause vomiting, diarrhea and stomach cramps. This type of exposure may also cause liver damage in infants. Animals exposed to copper in drinking water or food showed liver and kidney damage (ATSDR 1990).

202. *Cyanide*. Oral ingestion of cyanide salts (sodium cyanide and potassium cyanide) is linked in animal studies with weight loss, thyroid effects, and myelin degeneration. Exposure to lower levels of cyanide for a long time may result in breathing difficulties, heart pains, vomiting, blood changes, headaches, and enlargement of the thyroid gland. People with high blood cyanide levels have also shown harmful effects such as weakness of the fingers and

toes, difficulty walking, dimness of vision, deafness, and decreased thyroid gland function. Skin contact with cyanide can produce irritation and sores (EPA 2002a; ATSDR 2002).

203. *Dibenz (a,h) anthracene*. This chemical is a known animal carcinogen and has been classified by EPA as a probable human carcinogen. U.S. Environmental Protection Agency (EPA) Office of Research and Development, National Center for Environmental Assessment Integrated Risk Information (IRIS) database (www.epa.gov/iris). This chemical caused chromosomal aberrations in the bone marrow cells of laboratory test animals. This chemical caused gene mutations and DNA damage in tissue cultures (ATSDR 1995d).

204. *Dichloroethylene.* Inhalation of high concentrations of dichloroethylene resulted in deaths of laboratory animals; the concentration resulting in death varied widely from one test species to the next (ATSDR 1994a). Both ingestion and inhalation of this chemical resulted in liver and kidney damage in laboratory animals (EPA 2002a).

205. *1,3-Dinitrobenzene*. Exposure to this chemical can reduce the ability of blood to carry oxygen and lead to a reduction in the number of red blood cells (anemia) in humans. Similar adverse effects were seen in test animals. These animals also showed behavioral changes, spleen damage, reduced sperm production, and male reproductive damage (ATSDR 1995a).

206. *2,4-Dinitrotoluene*. Workers exposed to this chemical in air had a higher likelihood of dying from ischemic heart disease as well as higher rates of incidence of congestive heart failure, cardiac arrest, and arteriosclerosis. In animal studies this chemical caused liver damage, kidney damage, weight loss, reproductive tract lesions, as well as kidney and liver cancer. Laboratory animals ingesting this chemical also developed cyanosis, ataxia, anemia, and methemoglobinemia. Severe damage to the nervous system was seen in laboratory animals fed lower doses of this chemical over a longer period of time (ATSDR 1998).

207. *2,6-Dinitrotoluene*. Workers exposed to this chemical in air had a higher likelihood of dying from ischemic heart disease as well as higher rates of incidence of congestive heart failure, cardiac arrest, and arteriosclerosis. In animal studies ingestion of this chemical caused liver damage, kidney damage, weight loss, anemia, nervous system damage, methemoglobinemia, and increased mortality compared to control animals. Animals in other studies showed decreased spermatogenesis and testicular degeneration. Animals in one study developed liver cancer after ingesting this chemical (ATSDR 1998)

208. *High Melting Explosive (HMX)*. HMX, or Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine, causes lesions in the liver, primarily in males (EPA 2002a).

209. *Lead*. Lead has been shown to adversely affect children's neurobehavioral development by affecting the central nervous system. Lead also damages kidneys and the reproductive system. The effects are the same whether it is breathed or swallowed. At high levels, lead may decrease reaction time, cause weakness in fingers, wrists, or ankles, and possibly affect the memory. Lead may cause anemia, a disorder of the blood. It can also damage the male reproductive system (EPA 2002a; ATSDR 2002).

210. *Manganese.* Inhalation of high concentrations of manganese cause profound neurological dysfunction in humans; exposure to lower levels of manganese may decrease neurological performance, such as eye-hand coordination. Inhalation of manganese particulates can lead to lung inflammation that may cause coughing, bronchitis, pneumonia, or decreased lung function. Decreased fertility, impotence, and abnormal sperm have also been observed in male humans exposed to manganese particulates. Neuronal degeneration and altered brain enzyme function were seen in test animals exposed to manganese. Ataxia in test animals after exposure to manganese was reported in several studies (ATSDR 2000).

211. *Mercury*. Inorganic and methylated mercury adversely affects primarily the nervous system. Methylmercury and metallic mercury vapors are more harmful than other forms, because more mercury in these forms reaches the brain. Exposure to high levels of metallic, inorganic, or organic mercury can permanently damage the brain, kidneys, and developing fetus (EPA 2002a; ATSDR 2002).

212. *Methyl Ethyl Ketone (MEK)*. MEK, or 2-butanone, caused decreased fetal birth weight in animals through both the ingestion and inhalation pathways. Inhalation of MEK can cause irritation of the nose, throat, skin, and eyes. If MEK is inhaled along with other chemicals that damage health, it can increase the amount of damage that occurs. Exposure of animals to high levels of MEK resulted in birth defects, loss of consciousness, and death (EPA 2002a; ATSDR 2002).

213. *Naphthalene.* Ingestion of this chemical caused weight loss, diarrhea and lethargy in rats even though the animals ate normal amounts of food. U.S. Environmental Protection Agency (EPA) Office of Research and Development, National Center for Environmental Assessment Integrated Risk Information (IRIS) database (www.epa.gov/iris). Mice that inhaled naphthalene showed inflammatory lesions in the lung; the inflammation increased with larger doses. Exposure of humans to naphthalene vapors caused nausea, vomiting, and abdominal pain. Hemolytic anemia has been repeatedly documented in humans, particularly infants, exposed to naphthalene vapors and through naphthalene ingestion. Laboratory mice that inhaled naphthalene had significantly more pulmonary tumors. Ingestion of high concentrations of naphthalene has resulted in death in humans and laboratory animals. Ingestion of lower doses in humans commonly results in nausea, vomiting, diarrhea and abdominal pain. Ingestion by humans resulting in toxic effects to the kidney has also been reported (ATSDR 1995c).

214. *Nickel*. Exposure of animals to soluble nickel salts results in decreased body weight gain, increased heart-to-body weight ratios and decreased liver-to-body weight ratios. Once a person is sensitized to nickel, further contact with it will produce a reaction. The most common reaction is a skin rash at the site of contact. Ingestion and inhalation of nickel has been reported to cause lung disease in dogs and rats and to affect the stomach, blood, liver, kidneys, immune system, and reproduction and development in rats and mice (EPA 2002a; ATSDR 2002).

215. *Nitrate*. Exposure to nitrate has been shown to cause methemoglobinemia resulting in cyanosis ("blue baby syndrome") in infants under 3 months of age (EPA 2002a; ATSDR 2002).

216. *Nitrobenzene.* Animals exposed to nitrobenzene showed increased incidence and severity of liver and kidney lesions as well as increased incidence of hemolytic anemia. Some workers exposed to this chemical developed headaches, vertigo, and methemoglobinemia U.S. Environmental Protection Agency (EPA) Office of Research and Development, National Center for Environmental Assessment Integrated Risk Information (IRIS) database (www.epa.gov/iris) (EPA 2002a).

217. *Pentachlorophenol.* Mice exposed to pentachlorophenol showed statistically significant increases in the incidences of multiple biologically significant tumor types and a high incidence of two uncommon tumors. U.S. Environmental Protection Agency (EPA) Office of Research and Development, National Center for Environmental Assessment Integrated Risk Information (IRIS) database (www.epa.gov/iris) (EPA 2002a).

218. *Perchlorate*. Perchlorate interferes with iodide uptake into the thyroid gland. Because iodide is an essential component of thyroid hormones, perchlorate disrupts the function of the thyroid. Changes in thyroid hormone levels may also result in thyroid gland tumors. Impairment of thyroid function in expectant mothers may impact the fetus and newborn and result in effects including changes in behavior, delayed development and decreased learning capability (EPA 2002b).

219. *Polychlorinated Biphenyls (PCBs)*. PCB mixtures consist of a number of different Aroclor compounds. These aroclors can cause liver cancer. Aroclor 154 affects eye and immune system function. Aroclor 1216 reduces birth weights and affects reproduction in primates. Animals that ingested PCBs over several weeks or months developed various kinds of health effects, including anemia; acne-like skin conditions; and liver, stomach, and thyroid gland injuries. Other effects of PCBs in animals include changes in the immune system, behavioral alterations, and impaired reproduction (EPA 2002a; ATSDR 2002).

220. *Radionuclides*. Radionuclides are considered carcinogens based on their property of emitting ionizing radiation and on the extensive weight of evidence provided by epidemiological studies of radiogenic cancers in humans. All radionuclides are classified as known (Class A) human carcinogens by the EPA (EPA 2001a).

221. *Royal Detonating Explosive (RDX)*. RDX, also known as Cyclonite or Hexahydro-1,3,5-trinitro-1,3,5-triazine, causes inflammation of the prostate. Dosing with RDX also resulted in toxicity to and increased organ weight in kidneys. Exposure to large amounts of RDX can cause seizures (EPA 2002a; ATSDR 2002).

222. *Silver.* Humans ingesting silver may develop argyria, a medically benign but permanent bluish-gray discoloration of the skin. Toxic effects of exposure to high levels of silver have been reported primarily for the cardiovascular system and liver. U.S. Environmental Protection Agency (EPA) Office of Research and Development, National Center for Environmental Assessment Integrated Risk Information (IRIS) database (www.epa.gov/iris) (EPA 2002a).

223. *Tetrachloroethylene (perchloroethylene or PCE)*. Tetrachloroethylene is toxic to the liver and kidney by both oral and inhalation exposure, and the central nervous system by

inhalation exposure. Chronic exposure causes respiratory tract irritation, headache, nausea, sleeplessness, abdominal pains, constipation, cirrhosis of the liver, hepatitis, and nephritis in humans; and microscopic changes in renal tubular cells, squamous metaplasia of the nasal epithelium, necrosis of the liver, and congestion of the lungs in animals. The oral reference dose level set by EPA is based on toxic effects on the liver (EPA 2002a; ATSDR 2002).

224. *Tetryl.* Inhalation of tetryl by workers has lead to respiratory irritation, including asthma-like reactions in some workers. Test animals exposed orally to this compound showed liver and kidney damage; there is also some indication of liver damage in workers exposed to this substance. Mild to severe dermatitis was also seen in many workers exposed to tetryl dust (ATSDR 1995b).

225. *1,1,1-Trichloroethane*. Inhalation of 1,1,1-trichloroethane at high concentrations causes respiratory and nervous system effects that could lead to death at very high levels of exposure. Animals inhaling high concentrations of 1,1,1-trichloroethane showed effects to both the nervous system and the liver (ATSDR 1995e).

226. *Trichloroethylene (TCE)*. Human and animal data indicate that exposure to TCE can result in toxic effects on a number of organs and systems, including the liver, kidney, blood, skin, immune system, reproductive system, nervous system, and cardiovascular system. Inhalation may cause headaches, lung irritation, dizziness, poor coordination, and difficulty concentrating. Inhalation for long periods may cause nerve, kidney, and liver damage (EPA 2002a; ATSDR 2002).

227. *1,3,5-Trinitrobenzene.* Exposure to this chemical can reduce the ability of blood to carry oxygen and lead to a reduction in the number of red blood cells (anemia) in humans. Similar adverse effects were seen in test animals. These animals also showed behavioral changes, damaged sperm production, and male reproductive damage (ATSDR 1995a).

228. *2,4,6-trinitrotoluene (TNT)*. TNT has been shown to cause liver damage as a result of ingestion. TNT is a possible (class C) human carcinogen (EPA 2002a).

229. *Toluene*. Toluene adversely affects liver and kidney function through the ingestion pathway by causing significant increases in the weights of these organs. Inhalation of toluene results in adverse neurological effects in humans. Exposure to low to moderate levels can cause tiredness, confusion, weakness, drunken-type actions, memory loss, nausea, loss of appetite, and hearing and color vision loss. Toluene has been linked to birth defects in children of exposed mothers (EPA 2002a; ATSDR 2002).

230. *Tritium*. Tritium is considered a carcinogen based on its property of emitting ionizing radiation. Tritium is classified as a known (Class A) human carcinogen by the EPA (EPA 2001a).

231. *Zinc.* The short term effects of ingestion of zinc include stomach cramps, nausea and vomiting. Long-term exposure may cause anemia, damage to the pancreas, and may decrease levels of high-density lipoprotein (HDL) cholesterol. Animals given high doses

of zinc developed anemia, injury to the pancreas and kidney, and intestinal hemorrhaging (ATSDR 1994b).

II.A.11 Regulation of the Facility

232. On August 13, 1980, the Respondents submitted to EPA a "Notification of Hazardous Waste Activity" as required by Section 3010(a) of the Resource Conservation and Recovery Act (RCRA), 42 U.S.C. § 6930(a).

233. By letter dated November 19, 1980, the Respondents submitted to EPA a Part A RCRA permit application for the Facility. The Respondents also sent a copy of the Part A application to the Environmental Improvement Division of the New Mexico Department of Health and Environment, the predecessor to the Environment Department. The application covered hazardous waste treatment, storage, and disposal activities at TA-54, and included some 129 hazardous waste streams. It did not include mixed wastes. The Respondents have revised the Part A permit application several times since it was submitted, the last date being July 2000.

234. On January 25, 1985, the State of New Mexico received from EPA authorization to implement its hazardous waste program under the HWA in lieu of the Federal program [50 Fed. Reg. 1515 (Jan. 11, 1985)]. Subsequent program revision applications were approved effective on April 10, 1990, July 25, 1990, December 4, 1992, August 23, 1994, December 21, 1994, July 10, 1995, January 2, 1996, March 10, 1997, and June 13, 1998 (40 C.F.R. § 272.1601)

235. On May 1, 1985, the Respondents submitted to the Department and to EPA a Part B permit application for the Facility. The application included closure plans for Areas G and L at TA-54. The Respondents revised and supplemented the Part B permit application on March 27, 1986, November 13, 1986, November 25, 1987, and November 8, 1988.

236. By letter dated August 26, 1985, the Department notified the Respondents that the closure plans for MDA G and L at TA-54, submitted with the Part B application, were deficient.

237. On September 27, 1985, the Respondents submitted to the Department revised closure and post-closure plans for MDAs G and L at TA-54.

238. On July 26, 1984, the Respondents requested a waiver from the groundwater monitoring requirements under the Hazardous Waste Regulations incorporating 40 C.F.R. § 265.90(c) for MDAs G and L of TA-54. On May 7, 1985, the Department issued a compliance order to the Respondents requiring vadose zone monitoring to substantiate the waiver at MDAs G and L at TA-54.

239. By letter dated December 15, 1987, the Respondents requested a waiver from the groundwater monitoring requirements under the Hazardous Waste Regulations incorporating 40 C.F.R. § 265.90(c) for the area surrounding the landfill (MDA P) and surface impoundment at the TA-16 burning ground, stating that no free-flowing groundwater had been detected within the upper 200 ft below these units.

240. On March 22, 1989, the Respondents requested a waiver from the groundwater monitoring requirements under the Hazardous Waste Regulations incorporating 40 C.F.R. § 265.90(c) for the Ten Site Canyon Laboratory surface impoundments TSL-85 and TSL-125 in TA-35, asserting there was a low potential for migration of hazardous constituents from these surface impoundments to groundwater.

241. On November 8, 1989, the Department issued to the Respondents a permit to operate a hazardous waste treatment and storage facility at the Los Alamos National Laboratory (LANL) Facility pursuant to Section 74-4-4.2 of the HWA. The permit covered hazardous waste container storage areas at TA-16, TA-50, and TA-54, hazardous waste storage and treatment tanks at TA-54, and hazardous waste incinerators at TA-16 and TA-50. The permit did not address the requests for waivers from the groundwater monitoring requirements.

242. On April 1, 1992, the Respondents requested a waiver from the groundwater monitoring requirements under the Hazardous Waste Regulations incorporating 40 C.F.R. § 265.90(c) for the 166 Northeast, 166 Northwest, and 166 South surface impoundments in TA-53, asserting there was a low potential for migration of hazardous constituents from these surface impoundments to groundwater.

243. On April 19, 1994, EPA issued to the Respondents the Hazardous and Solid Waste Amendments (HSWA) Module portion of the permit covering those requirements of RCRA added by the HSWA of 1984. The EPA portion of the permit required corrective action for continuing releases of hazardous waste constituents at and from the Facility pursuant to Section 3004(u) and (v) of RCRA, 42 U.S.C. § 6924(u) and (v). The EPA portion of the permit also required investigation and reporting of radionuclides.

244. On March 6, 1995, the Respondents submitted to the Department a draft Groundwater Protection Management Program Plan "to monitor and protect the main aquifer underlying the Pajarito Plateau from contamination or other adverse impacts resulting from Laboratory operations."

245. By letter dated May 30, 1995, the Department formally denied the Respondents' request for a groundwater monitoring waiver for Areas G and L at TA-54; the area surrounding the landfill (MDA P) and surface impoundment at the TA-16 burning ground; the TSL-85 and TSL-125 surface impoundments in TA-35; and the 166 Northeast, 166 Northwest, and 166 South surface impoundments in TA-53.

246. In the May 30, 1995 letter, the Department also requested that the Respondents develop a comprehensive groundwater monitoring program plan, which addresses both site-specific, and Facility-wide groundwater monitoring objectives.

247. By letter dated August 17, 1995, the Department sent the Respondents comments on the groundwater protection program, describing several problems with the program and stating that a site-wide hydrogeologic workplan should be developed under RCRA.

248. On October 25, 1995, the Respondents submitted to the Department a revised draft Groundwater Protection Management Program Plan.

249. On January 2, 1996, the State of New Mexico received from the U.S. EPA final authorization to implement its corrective action program under the Hazardous Waste Act.

250. On March 1998, the Respondents submitted to the Department revised closure plans for MDAs H and L at TA-54.

251. On May 22, 1998, in response to the Department's August 1995 request, the Respondents submitted to the Department a Hydrogeologic Workplan (HWP), which set forth a proposal to characterize the subsurface hydrogeology at the Facility. The HWP was approved by the Department on March 25, 1998.

252. In May 1998, the Respondents proposed to install 32 groundwater characterization wells at the Facility under the HWP.

253. Pursuant to the HWP, the Respondents have installed 11 groundwater characterization wells, each completed in the regional aquifer beneath the Facility. These wells are R-5, R-7, R-8A, R-9, R-12, R-13, R-15, R-19, R-22, R-25, and R-31.

254. On January 15, 1999, the Respondents submitted a Part B application for a permit renewal for TA-54 at the Facility. The application covers hazardous waste container storage areas at TA-3 and TA-16, and at TA-54's MDA G, MDA L, and TA-54 west; hazardous waste treatment by solidification, cementation, and vitrification at TA-55; and hazardous waste treatment by burning and detonation at TA-14 and burning at TA-16. It includes general statements that corrective action will be conducted for releases of hazardous wastes and hazardous constituents at these areas. The Respondents have submitted several requests for application revision subsequent to the permit renewal request submittal.

255. By letter dated December 21, 2001, the Department notified the Respondents that the closure plans for MDA G, MDA H, and MDA L of TA-54, submitted in September 1985 and November 1986 and revised in March 1998, did not comply with the requirements of the Hazardous Waste Regulations 20.4.1.500 NMAC.

256. On May 2, 2002, the Department determined, pursuant to Section 74-4-13.A of the HWA, that the Respondents' past and current handling, storage, treatment, and disposal of solid waste and hazardous waste at the LANL Facility may present an imminent and substantial endangerment to human health or the environment.

257. On May 2, 2002, the Department determined, pursuant to Section 74-4-10.1.A of the HWA, that the presence of hazardous wastes at the LANL Facility may present a substantial hazard to human health or the environment.

258. On May 2, 2002, the Department made a draft copy of this Order available to the public, including the Respondents, for review and comment. The Department placed a public notice of the availability of the draft order in the local news outlets, and mailed copies of the notice

to all interested parties included on the Department's Hazardous Waste Bureau's mailing list, including the Respondents.

259. The Department provided the public with a 90-day period to comment on the draft copy of the Order. The comment period ended on July 31, 2002. During this period, the Department held four public meetings to provide the public with information on the draft Order.

II.B CONCLUSIONS OF LAW

Based on the Administrative Record, the Department makes the following conclusions of law:

1. Each of the Respondents, DOE and the University of California, is a "person" within the meaning of Section 74-4-3.K of the HWA, and the Hazardous Waste Regulations at 4.1.100 NMAC (incorporating 40 C.F.R. § 260.10).

2. The Los Alamos National Laboratory ("LANL") is a "facility" within the meaning of the Hazardous Waste Regulations at 4.1.100 NMAC (incorporating 40 C.F.R. § 260.10).

3. The Respondent DOE is an "owner" and an "operator" of the Facility with the meaning of the Hazardous Waste Regulations at 4.1.100 NMAC (incorporating 40 C.F.R. § 260.10).

4. The Respondent University of California is an "operator" of the Facility with the meaning of the Hazardous Waste Regulations at 4.1.100 NMAC (incorporating 40 C.F.R. § 260.10).

5. The Respondents have engaged in, and are currently engaging in, the "storage," "treatment," and "disposal" of "solid waste" and "hazardous waste" at the LANL Facility within the meaning of Section 74-4-3.P, T, E, O, and I of the HWA, and the Hazardous Waste Regulations at 4.1.100 NMAC (incorporating 40 C.F.R. § 260.10).

6. The contaminants, as defined herein, at or migrating from the Facility, except sourse, special nuclear, and byproduct material, are "solid wastes" within the meaning of Sections 74-4-3.(O) and 74-4-13 of the HWA.

7. The Secretary is in receipt of information that as a result of the Respondents' storage, treatment, and disposal of hazardous and solid wastes at the Facility, hazardous wastes, hazardous waste constituents, and other solid wastes have been "release[d]" from the Facility into the environment within the meaning of Section 74-4-10.1.A of the HWA.

8. The Secretary is in receipt of information that the presence of hazardous wastes at the LANL Facility, and the release of such wastes from the Facility, may present a substantial hazard to human health or the environment within the meaning of Section 74-4-10.1.A of the HWA.

9. The Secretary is in receipt of evidence that the Respondents' past and current handling, storage, treatment, and disposal of solid waste and hazardous waste at the Facility may present an imminent and substantial endangerment to health or the environment within the meaning of Section 74-4-13.A of the HWA.

10. This Order is necessary to protect health and the environment within the meaning of Section 74-4-13.A of the HWA.

11. The Department has the authority to require the Respondents to monitor radionuclide contaminants, including those radionuclide contaminants that are exempt from the definition of "solid waste" under Section 74-4-3.M of the HWA as source, special nuclear, or by-product material as defined under the Federal Atomic Energy Act of 1954, and to require the Respondents to report the results of such monitoring. Such monitoring and reporting is necessary for the Department to properly implement the regulation of hazardous wastes, hazardous waste constituents, and other solid wastes pursuant to the HWA and the Hazardous Waste Regulations. *United States v. New Mexico*, 32 F.3d 494 (10th Cir. 1994).

12. Pursuant to Section 6001(a) of RCRA, 42 U.S.C. § 6961(a), the United States, including DOE, is subject to and must comply with all Federal, State, interstate, and local requirements, both substantive and procedural, respecting control or abatement of solid waste or hazardous waste disposal and management in the same manner, and to the same extent, as any other person is subject to such requirements. Such requirements include requirements for permits and reporting, provisions for injunctive relief, and any sanctions that may be imposed by a court to enforce such injunctive relief. Such requirements include all administrative orders and all civil and administrative penalties and fines, regardless whether such penalties or fines are punitive or coercive in nature or are imposed for isolated, intermittent, or recurring violations. Such requirements include the requirements of the HWA and the Hazardous Waste Regulations and the requirements of this Order. Further, pursuant to Section 6001(a) of RCRA, 42 U.S.C. § 6961(a), the United States, including DOE, has expressly waived any otherwise applicable sovereign immunity with respect to such requirements, including any injunctive relief, administrative order, or civil or administrative penalty or fine.

13. The Respondents are jointly and severally liable to carry out each of the obligations of this Order. The failure of one of the Respondents to comply with any obligation of this Order shall in no way remove or diminish the obligation of the other Respondent to comply.

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III. GENERAL PROVISIONS

III.A PURPOSES

The purposes of this Order are: 1) to perform interim measures at the Facility to mitigate any potential threats to human health or the environment from the release of hazardous waste or hazardous constituents, or other solid wastes; 2) to fully determine the nature and extent of releases of hazardous waste and hazardous constituents at or from the Facility; 3) to identify and evaluate alternatives for corrective measures to clean up contaminants in the environment, and to prevent or mitigate the migration of hazardous waste or hazardous constituents at or from the Facility; and 4) to implement such corrective measures.

III.B DEFINITIONS

Unless otherwise expressly provided herein, the terms used in this Order shall have the meanings set forth in the HWA, RCRA, and their implementing regulations.

"Administrative Record" means the administrative record supporting this Order, which forms the basis for the terms of this Order, and which is available for review at the New Mexico Environment Department Hazardous Waste Bureau.

"Aggregate Area" means an area within a single watershed or canyon made up of one or more SWMUs or AOCs and the media affected or potentially affected by releases from those SWMUs or AOCs, and for which investigation or remediation, in part or in entirety, is conducted for the area as a whole in order to address area-wide contamination, geography, ecological risk assessment, and other factors. Aggregate areas may be grouped by watershed or within a watershed based on geologic and hydrologic features, contaminant source, transport pathways, exposure routes, receptors, potential cumulative risk, and potential locations for contaminants to accumulate. The area of aggregation must be appropriate for the type of assessment conducted and must be approved by the Department.

"Area of Concern" or "AOC" means any area that may have or had a release of hazardous waste or hazardous constituents, which is not a Solid Waste Management Unit, and which the Department determines may pose a threat to human health or the environment.

"Contaminant" means any hazardous constituent listed in 40 C.F.R. Part 261, Appendix VIII (incorporated by 20.4.1.200 NMAC) and 40 C.F.R. Part 264, Appendix IX (incorporated by 20.4.1.500 NMAC); any groundwater contaminant listed in the New Mexico WQCC Regulations at 20.6.2.3103 NMAC; any toxic pollutant listed in the WQCC Regulations at 20.6.2.7.SS NMAC; any radionuclide; perchlorate; high explosives; polychlorinated biphenyls; and any other substance present in soil, sediment, rock, surface water, groundwater, or air for which the Department determines that monitoring, other investigation, or a remedy is necessary to carry out the purposes of this Order.

"Department" means the New Mexico Environment Department, and any successor agencies.

"DOE" means the United States Department of Energy, and any successor agencies.

"EPA" means the United States Environmental Protection Agency, and any successor agencies.

"Facility" means the Los Alamos National Laboratory site owned by the United States Department of Energy and located on the Pajarito Plateau in Los Alamos County in North Central New Mexico, comprised of approximately 43 square miles and located approximately 60 miles north-northeast of Albuquerque and 25 miles northwest of Santa Fe.

"Groundwater" means any subsurface water in a liquid state.

"Hazard Index" or "HI" means the sum of more than one hazard quotient for multiple substances and/or multiple exposure pathways. The HI is calculated separately for chronic, subchronic, and shorter-duration exposures.

"Hazard Quotient" or "HQ" means the ratio of a single substance exposure level over a specified time period (e.g., subchronic) to a reference dose for that substance derived from a similar exposure period.

"Hazardous waste constituent" or "hazardous constituent" means any constituent identified in 20.4.1.200 NMAC (incorporating 40 C.F.R. Part 261, Appendix VIII), any constituent identified in 20.4.1.500 NMAC (incorporating 40 C.F.R. Part 264, Appendix IX), any constituent identified as a hazardous waste listed in 20.4.1.200 NMAC (incorporating 40 C.F.R. Part 261, Subpart D), or any constituent identified as a toxicity characteristic waste in 20.4.1.200 NMAC (incorporating 40 C.F.R. § 261.24, Table 1).

"High Explosives" or "HE" means a class of explosives that will detonate when a strong shock from an impact from a boostering explosive is received. The required shock is more than would be required for primary explosives. HE will burn without detonation.

"HWA" means the New Mexico Hazardous Waste Act, NMSA 1978 §§ 74-4-1 to 74-4-14.

"Hazardous Waste Regulations" means the New Mexico Hazardous Waste Management Regulations 20.4.1 NMAC.

"Interim Measures" or "IM" means actions that can be immediately implemented to minimize or prevent migration of contaminants and to minimize or prevent actual or potential human or ecological exposure to contaminants while long-term, final corrective action remedies are evaluated and, if necessary, implemented.

"Maximum Contaminant Level" or "MCL" means a maximum contaminant level under the Federal Safe Drinking Water Act, 42 U.S.C. §§ 300f to 300j-26, and the drinking water regulations promulgated thereunder.

"Material Disposal Area" or "MDA" means a waste disposal site where hazardous, radioactive, or mixed waste was disposed of on the ground surface or in excavated trenches, pits, or shafts. An MDA may be a landfill or a waste pile as defined at 40 C.F.R. § 260.10. Depending on the date of

the last placement of waste, an MDA may or may not be subject to closure and post-closure care requirements under RCRA, and may be subject to the requirements for either a regulated unit under 40 C.F.R. § 264.91 through § 264.100, or a solid waste management unit (SWMU), under 40 C.F.R. § 264.101.

"Permit" means the RCRA Permit issued to the Respondents for the Facility to operate a hazardous waste treatment and storage facility, EPA ID No. NM 0890010515.

"Pit" means an earthen surface impoundment constructed to retain waste.

"Radionuclide" means an unstable nuclide capable of spontaneous transformation into other nuclides through changes in its nuclear configuration or energy level. This transformation is accompanied by the emission of photons or particles.

"RCRA" means the Federal Resource Conservation and Recovery Act, 42 U.S.C. §§ 6901 to 6992k, also known as the Solid Waste Disposal Act.

"Reach" means a subsection of a watercourse (e.g., canyon system, river system, storm drain network) treated as a single unit for the purpose of characterization, monitoring, or remediation. The reach location and extent is not arbitrary and may be based upon the following or other considerations imposed by the Department: 1) consistent geomorphic characteristics (e.g., slope, channel material size); 2) consistent contaminant characteristics without significant spatial trends (e.g., no major tributaries supplying sediment and/or water of different types or contaminant concentrations); and 3) consistent current or future land use (e.g., industrial, residential, agricultural).

"Respondents" means the United States Department of Energy and the University of California.

"Secretary" means the Secretary of the New Mexico Environment Department or designated representative.

"Solid Waste Management Unit" or "SWMU" means any discernible unit or area at which solid waste has been placed at any time, and from which the Department determines there may be a risk of a release of hazardous constituents, irrespective of whether the unit or area was intended for the management of solid or hazardous waste. Placement of solid waste includes one time and accidental events that were not remediated, as well as any unit or area at which solid waste has been routinely and systematically placed.

"Surface Impoundment" means a lined or unlined, natural or fabricated depression that can be used to treat, store, or dispose of hazardous waste. Surface impoundments may also be referred to as pits, lagoons, ponds, or basins.

"TAL metals" means the list of 23 inorganic target analytes in water, soil, and sediment environmental samples defined by the U.S. EPA Contract Laboratory Program Statement of Work. The list consists of the following: aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, vanadium, and zinc.

"Technical Area" or "TA" means an administrative unit of area established to encompass operations at the Facility.

"Trench" means a long, narrow depression or excavation, natural or artificial, in the earth's surface.

"UCL" means the 95 percent upper confidence limit of the mean value. The UCL shall be calculated following the methodology in EPA (1992) *Supplemental Guidance to RAGS: Calculating the Concentration Term.*

"UTL" means the upper tolerance limit, which is a statistical estimate of the maximum concentration. The UTL shall be calculated in accordance with the Hazardous Waste Bureau Position Paper (March 2000) *Use of Tolerance Intervals for Determining Inorganic Background Concentrations.*

"Water Quality Control Commission (WQCC) Regulations" means the regulations promulgated by the New Mexico Water Quality Control Commission governing the quality of groundwater and surface water at 20.6.2 NMAC.

"Watershed" means a region or basin drained by, or contributing waters to, a river, stream, lake, or other body of water and separated from adjacent drainage areas by a divide such as a mesa, ridge, or other geologic feature.

III.C JURISDICTION

This Order is issued to the United States DOE and the University of California (hereinafter collectively referred to as Respondents) pursuant to Sections 74-4-10.1 and 74-4-13 of the HWA, NMSA 1978 §§ 74-4-1 to 74-4-14. (Repl. Pamp. 1993).

Congress has clearly and unambiguously waived the immunity of the United States for actions brought under RCRA or under State hazardous and solid waste laws in Section 6001 of RCRA, 42 U.S.C. § 6961.

III.D TERM OF ORDER

The effective date of this Order is the date a final Order, signed by the Secretary, is received by the Respondents.

This Order shall remain in effect until the Department determines in writing that all the requirements of the Order have been met.

III.E BINDING EFFECT

This Order shall apply to and bind the Respondents; their officers; directors; employees; agents; trustees; receivers; successors; assigns; all commissioned, non-commissioned, and civilian officers and personnel in the DOE and the Executive Branch of the Federal government having command authority or any other form of direct or indirect control over the management, funding, or operation of the Facility which in any way falls within the scope of this Order; and all other persons, including,

but not limited to, firms, corporations, subsidiaries, contractors, and consultants acting under or on behalf of the Respondents and within the scope of their employment.

No change in ownership, corporate, or partnership status relating to the Facility will in any way alter the Respondents' responsibilities under this Order. The Respondents shall be jointly and severally responsible for and liable for any failure to carry out all activities required of the Respondents by the express terms and conditions of this Order, irrespective of their use of employees, agents, or consultants to perform any such tasks.

Respondents shall give notice of this Order to any successor in interest prior to transfer of ownership or operation of the Facility and shall notify the Department at least thirty (30) working days prior to such transfer.

The Respondents shall require all contractors, subcontractors, laboratories, and consultants retained to conduct or monitor any portion of the work performed pursuant to this Order to comply with and abide by the terms of this Order.

III.F NOTICES

Any plan, report, notice, or other document or communication required under this Order shall comply with the reporting requirements of Section XI of this Order, and shall be sent or directed to:

Bureau Chief
New Mexico Environment Department
Hazardous Waste Bureau
2905 Rodeo Park Drive East, Building 1
Santa Fe, New Mexico 87505-6303

III.G WORK PLANS AND SCHEDULES

All work plans and associated schedules approved pursuant to this Order are incorporated into this Order and become enforceable under the terms of this Order, and under the HWA and RCRA, as of the date of receipt by Respondents of the Department's approval.

All work plans and associated schedules that the Respondents are required to prepare under this Order shall be submitted to the Department for review and approval. Upon review of the work plan and schedule, the Department will send the Respondents a written notice of approval or disapproval, and will state in writing the deficiencies and other reasons for any disapproval. A notice of disapproval may include modifications to the work plan or schedule necessary for the Department's approval, or other written comments. Upon receipt of a notice of disapproval, the Respondents shall revise the work plan or schedule to incorporate all modifications and comments, and otherwise correct all deficiencies that gave rise to the disapproval. Within thirty (30) days after receipt of a written disapproval, the Respondents shall re-submit the revised work plan or schedule to the Department for approval.

The Respondents shall comply with all applicable Federal, State, and local laws or regulations, and shall obtain all necessary approvals or permits to conduct the activities required by this Order and

perform their obligations required hereunder. The Department makes no representation with respect to approvals and permits required by Federal, State and local laws or regulations other than those required under the HWA or Hazardous Waste Regulations.

III.H OFFSITE ACCESS

To the extent any requirement of this Order, including any work plan approved under this Order, requires access to property not owned or controlled by DOE, the Respondents shall use their best efforts to obtain access from the present owners of such property to conduct required activities, and to allow the Department access to such property to oversee such activities. In the event that access is not obtained when necessary, the Respondents shall notify the Department in writing regarding their best efforts and their failure to obtain such access.

III.I ENTRY AND INSPECTION

In accordance with Section 74-4-4.3 of the HWA, the Respondents shall allow any authorized representative of the Department to enter the Facility at reasonable times to inspect the Facility and all Facility work sites; to oversee all work being performed under this Order; to conduct any tests necessary to ensure compliance with this Order and to verify the data submitted by the Respondents; to obtain samples of waste, soil, air, surface water, or groundwater; to inspect and copy documents relating to this Order or any requirement of this Order, including operating and field logs, monitoring data, contracts, manifests, shipping records, and other relevant records and documents; and to interview the Respondents' personnel and contractors performing work required by this Order.

The Respondents shall notify the Department in writing of any field sampling activities undertaken pursuant to any plan or requirement of this Order a minimum of fifteen (15) days prior to the sampling being conducted as required in Section IX of this Order, and shall provide split samples to the Department upon request.

The Respondents shall notify the Department in writing of any excavation, construction (including the construction of monitoring wells), or other corrective action activities undertaken pursuant to any plan or requirement of this Order a minimum of fifteen (15) days prior to beginning the excavation, construction, or other corrective action activity. Respondents shall provide the Department any blue print, diagram, or construction or other permits for any construction activity undertaken pursuant to this Order upon request.

Nothing in this Section (III.I) shall be construed to limit or impair in any way the inspection and entry authority of the Department under the HWA, the Hazardous Waste Regulations, RCRA, or any other applicable law or regulations.

III.J AVAILABILITY OF INFORMATION

In accordance with Section 74-4-4.3 of the HWA, the Respondents shall, within a reasonable time after a request from any authorized representative of the Department, furnish information to the Department relating to hazardous wastes that are or have been managed at the Facility.

Nothing in this Section (III.J) shall be construed to limit or impair in any way the information gathering authority of the Department under the HWA, the Hazardous Waste Regulations, RCRA, or any other applicable law or regulations.

III.K RECORD PRESERVATION

The Respondents shall maintain all documents, data, and other information required to be prepared under this Order for at least twenty-five (25) years after the completion of the corrective action for the entire Facility.

III.L RESERVATION OF RIGHTS AND OBLIGATIONS

Nothing in this Order shall be construed to preclude or in any way limit any powers, authorities, rights, or remedies that the Department has under the HWA or any other statute or regulation or under common law. Nothing in this Order shall constitute an express or implied waiver of immunity otherwise applicable to the Department, its employees, agents, or representatives.

The Department reserves all of the powers, authorities, rights, and remedies, whether administrative or judicial, civil or criminal, legal or equitable, that the Department has for any failure of the Respondents to comply with any of the requirements of this Order, including the right to bring any civil or administrative enforcement action for penalties or injunctive relief or both.

This Order shall not be construed to preclude or in any way limit the authority of the Department to take additional enforcement action pursuant to Section 74-4-10.1 or 74-4-13 of the HWA, or other applicable legal authorities, should the Department determine that such actions are warranted.

The Department reserves all of the powers, authorities, rights, and remedies, whether administrative or judicial, civil or criminal, legal or equitable, that the Department has for any past, present, or future violations of the HWA or the Hazardous Waste Regulations, including the right to bring any civil or administrative enforcement action for penalties or injunctive relief or both.

The Department reserves the right both to disapprove of work performed by the Respondents that is not in compliance with this Order and to require that the Respondents perform tasks in addition to those required by this Order.

This Order is not a permit, and compliance by the Respondents with the terms of this Order shall not in any way relieve the Respondents of their obligations to comply with the HWA, the Hazardous Waste Regulations, and any other applicable State, Federal, or local laws, regulations, and permits.

III.M ENFORCEMENT

Any violation of the requirements of this Order may subject the Respondents, and their officers, directors, employees, successors, and assigns, to a compliance order under Section 74-4-10 of the HWA or Section 3008(a) of RCRA, 42 U.S.C. § 6928(a); to an injunction under Sections 74-4-10, 74-4-10.1.E, or 74-4-13.B of the HWA, Section 3008(a) of RCRA, 42 U.S.C. § 6928(a), or Section 7002(a) of RCRA, 42 U.S.C. § 6972(a); to civil penalties under Sections 74-4-10, 74-4-10.1.E, or 74-4-13.B of the HWA, Section 3008(a) and (g) of RCRA, 42 U.S.C. § 6928(a) and (g), or Section

7002(a) of RCRA, 42 U.S.C. § 6972(a); to criminal penalties under Section 74-4-11 of the HWA or Section 3008(d), (e), and (f) of RCRA, 42 U.S.C. § 6928(d), (e), and (f); or to some combination of the foregoing.

Each requirement of this Order is an enforceable "requirement" of the HWA within the meaning of Section 74-4-10; an enforceable "requirement" of RCRA within the meaning of Section 3008(a)(1) of RCRA, 42 U.S.C. § 6928(a)(1); and an enforceable "condition, requirement, [or] prohibition" which has become effective pursuant to RCRA within the meaning of Section 7002(a)(1)(A) of RCRA, 42 U.S.C. § 6972(a)(1)(A).

III.N RELATIONSHIP TO WORK COMPLETED

This Order shall be construed to avoid duplication of work already satisfactorily completed. Investigations and other work that has been satisfactorily completed prior to the effective date of this Order, and that fulfills the substantive requirements of this Order, may be used to comply with this Order.

III.O INTEGRATION WITH PERMIT

Subsequent to the issuance of this Order, the Department may renew the Hazardous Waste Facility permit issued to the Respondents for the Facility under the HWA, and such permit may incorporate the requirements of this Order. The requirements of this Order shall not terminate upon issuance of such permit.

III.P OPPORTUNITY TO APPEAL

Pursuant to Section 74-4-14 of the HWA, Respondents may appeal this Order to the court of appeals within thirty (30) days after issuance of this Order.

III.Q SEVERABILITY

If any provision or authority of this Order is held by a court of competent jurisdiction to be invalid, the remainder of the Order shall remain in force and shall not be affected thereby. Additionally, if the application of this Order to any party or circumstance is held by a court of competent jurisdiction to be invalid, the application of this Order to other parties or circumstances shall remain in force and shall not be affected thereby.

IV. FACILITY INVESTIGATION

IV.A GENERAL REQUIREMENTS

This Section (IV.A) provides general requirements for the investigation of contamination at the Facility. The requirements of this Section (IV.A) shall apply to the canyon watershed investigations under Section IV.B and the TA investigations under Section IV.C.

IV.A.1 Background

Prior to the issuance of this Order, the Respondents began investigations to evaluate for the presence of contamination at the Facility. The results of previous investigation work are to be incorporated into the investigations conducted under this Order. However, additional investigation is necessary to fully characterize the nature, extent, fate, and transport of contaminants that have been released to the environment, including air, soil, sediment, surface water, and groundwater, as a result of Facility operations.

The Respondents have established a groundwater-monitoring network for the purpose of hydrogeologic characterization and groundwater quality sampling. The current Facility monitoring network includes municipal supply wells, test wells, monitoring wells, and springs. This monitoring network has been determined by the Department to be inadequate for the purpose of groundwater characterization and monitoring, as required under 40 C.F.R. Part 264, Subpart F. The current groundwater-monitoring network is not specifically located and designed to detect releases or potential releases from Facility TAs, SWMUs, AOCs, or other current and former Facility sites. In addition, the current groundwater monitoring program is not designed to collect consistently valid and useful data concerning contaminants in groundwater.

The Respondents have prepared and are implementing a HWP, dated May 1998, to characterize the hydrogeologic system beneath the Facility. Under the HWP, the Respondents are installing additional groundwater monitoring wells, which will become part of the groundwater-monitoring network. This Order requires the Respondents to proceed with implementation of the HWP. However, the wells the Respondents have proposed to install in the HWP are not sufficient, in number or location, to fully detect contamination or to conduct compliance monitoring in accordance with the HWA. This Order requires monitoring well installation in addition to the wells to be installed under the HWP. Based on the results of groundwater investigations or other information, the Department may require modification of the number and location of piezometers and wells to be installed as part of this Order or the HWP.

IV.A.2 General Facility Information

The Respondents shall submit to the Department the following information and, unless otherwise specified, shall update and resubmit the information annually:

1. Facility-wide topographic map (one-time submittal);

2. Facility-wide geologic maps, surface geology, and structure contour maps (one-time submittal);

3. Maps depicting TAs (current and former), including all SWMUs and AOCs;

4. Maps and tables indicating the surveyed coordinates and locations of all existing springs, wells, and surface water gaging stations;

5. Fault and high-fracture density zone maps;

6. Maps presenting the discharge points of seeps and springs, with tables indicating estimated flow, associated stratigraphic units, discharge point elevations, and contaminant concentrations and radionuclide activities;

7. Alluvial groundwater maps depicting known saturated aquifer thickness and extent and suspected extent of contamination, and presenting detected contaminant concentrations/ activities;

8. Perched-intermediate groundwater maps presenting aquifer thickness and flow direction data, known and suspected vertical and lateral extents of contamination, and detected contaminant concentrations and activities;

9. Regional groundwater maps depicting measured groundwater elevations, known flow direction(s), and the detected contaminant concentrations and activities;

10. The Facility's existing Hydrogeologic Atlas including water-level contour map of regional aquifer including known radii-of-effects from pumping of municipal supply wells;

11. Diagrams showing groundwater flow regimes as indicated by water chemistry (Stiff, Piper diagrams, etc.) for all groundwater zones; and

12. Monthly water level data presented graphically and in tabular format.

The information shall be submitted to the Department, in hardcopy and CD-ROM, beginning on March 31, 2003, and no later than March 31 of each subsequent calendar year. The information also shall be made accessible to the public electronically by posting on the Facility web site no later than March 31 of each year.

IV.A.3 Groundwater Investigation

The Respondents shall conduct investigations of groundwater to fully characterize the nature, vertical and lateral extent, fate, and transport of groundwater contamination originating from the Facility. The investigation shall include an evaluation of the physical, biological, chemical, and radiochemical factors influencing the transport of contaminants in groundwater. The Respondents shall conduct groundwater investigations in Facility TAs and canyon watersheds in accordance with the specific requirements of Sections IV.B and IV.C, and shall conduct investigations of regional groundwater in accordance with the specific requirements of the HWP, and as otherwise provided in this Section (IV). The HWP is incorporated into this Order and its requirements are made an

enforceable part of this Order. The Respondents shall implement the groundwater investigation requirements in accordance with the schedule set forth in Section XII. All data shall be collected according to EPA and industry-accepted methods and procedures, and in accordance with Section IX of this Order.

IV.A.3.a Objectives

The Respondents shall implement the groundwater investigations, including all sampling and analysis, to determine the following:

1. nature, rate, and extent of historical and current releases of contaminants to groundwater;

2. aquifer boundaries;

3. the horizontal and vertical extent of each zone of saturation;

4. the depth to groundwater, groundwater elevations, water table elevations, and potentiometric surface distributions;

5. groundwater flow directions and velocities;

6. migration of groundwater across hydrostratigraphic boundaries and the potential effects of contaminant migration;

7. watershed and regional water balance information including:

    - recharge and discharge locations, rates, and volumes,

    - evapotranspiration data,

    - stream-flow data as requested by the Department;

8. water supply well pumping influences, seasonal monthly pumping rates, and annual amount of water withdrawn;

9. saturated and unsaturated hydraulic-conductivity ($K_{x,y,z}$), porosity, effective porosity, permeability, transmissivity, particle-size, storage coefficients, and estimated fracture/secondary porosity for each hydrostratigraphic unit from core and geophysical logging of boreholes;

10. contaminant concentrations and activities from soil, rock, sediment, and vapor sample analyses and absorption coefficients (K_ds) for each hydrostratigraphic unit; and

11. changes in groundwater chemistry resulting from the May 2000 Cerro Grande Fire.

In selecting sites for new wells, the Respondents shall consider paleotopography, fracture density and orientation, source areas, contaminant characteristics, geologic structures, groundwater flow direction, and the known and potential occurrences of groundwater. All existing and newly installed

wells and piezometers shall be surveyed in accordance with the requirements described in Sections IX.B and X.

IV.A.3.b Groundwater Monitoring Plan

Within ninety (90) days after the effective date of this Order, the Respondents shall submit to the Department for approval an interim Facility-wide groundwater-monitoring plan. The plan shall provide for all groundwater monitoring necessary to fulfill the requirements of this Order and the HWP. The plan shall state the proposed locations and frequency of groundwater sampling, the proposed parameters for analysis, and the proposed methods for sampling and analysis. The existing wells and springs listed in Table XII-1 shall be used for the monitoring plan, until an adequate groundwater monitoring network has been installed. The Respondents shall include all production wells in the groundwater-monitoring plan. The groundwater-monitoring plan shall comply with the investigation methods and procedures set forth in Section IX of this Order. The plan shall be prepared in accordance with Section XI.B of this Order.

The Respondents shall revise and update the interim groundwater monitoring plan annually to include newly installed monitoring wells; to remove wells not providing good-quality data, if approved by the Department; and to make any other appropriate changes. The Respondents shall submit the revised and updated plan to the Department for approval ninety (90) days after each anniversary of the effective date of this Order. After completing the installation of all additional monitoring wells in a canyon watershed as described in Section IV.B of this Order and any additional wells deemed necessary by the Department, the Respondents shall submit to the Department for approval long-term, watershed-specific groundwater monitoring plans, hence replacing the interim groundwater monitoring plan.

The groundwater monitoring requirements of this Order, and of the HWP, do not necessarily fulfill all the groundwater monitoring requirements of the Hazardous Waste Regulations, 20.4.1.500 NMAC (incorporating 40 C.F.R. Part 264, Subpart F).

IV.A.3.c Geophysical Investigations

The Respondents shall conduct geophysical and geochemical investigations in accordance with this Section (IV) and Section IX of this Order. The Respondents shall collect core and open-hole geophysical measurements from each boring as specified by the Department. Cased-hole geophysical logging may be approved by the Department on a site-specific basis, but is not preferred because of the limited logging tool suite and reduced resolution of currently available geophysical equipment.

IV.A.3.d Background Investigation

The Respondents shall determine the background concentrations for naturally occurring metals and radionuclides in alluvial aquifer, intermediate zone, and regional aquifer groundwater. Within 180 days after the effective date of this Order, the Respondents shall submit to the Department for approval a work plan to determine Facility background concentrations for naturally occurring metals and radionuclides in groundwater. The work plan shall be prepared in accordance with Section XI.B of this Order. The Respondents shall determine the background concentrations for TAL metals,

general chemistry parameters, and radionuclides specified by the Department. Background concentrations shall be determined, at least in part, by collecting groundwater samples from wells located upgradient of the Facility. Within one year after the effective date of this Order, the Respondents shall submit to the Department a background concentration investigation report stating the background concentration for each metal, general chemistry parameter, and radionuclide, and stating the bases for selecting each such concentration. The investigation report shall be prepared in accordance with Section XI.C of this Order.

IV.A.3.e Monitoring Wells and Piezometers

The Respondents shall comply with the requirements of this Section (IV.A.3.e) for the installation of all alluvial monitoring wells, piezometers, intermediate zone monitoring wells, and regional monitoring wells.

All well construction and installation shall be conducted in accordance with Sections IX and X of this Order, and according to the schedule set forth in Section XII of this Order. All monitoring and sampling shall be conducted in accordance with Section IX of this Order, and according to the schedule set forth in Section XII of this Order.

The Department shall approve all drilling locations, monitoring well and piezometer construction and installation details, sampling depths, and abandonment activities prior to the start of the activities.

IV.A.3.e.i Alluvial Wells and Piezometers

The Respondents shall meet the following requirements in the installation of all alluvial monitoring wells and piezometers:

1. The alluvial well borings shall be advanced to minimum depths of five ft below the alluvium-bedrock interface.

2. Samples of alluvial sediments and underlying bedrock shall be collected for hydraulic and soil property testing and for analysis to determine the presence of contaminants at depths or intervals approved by the Department and in accordance with the methods described in Section IX.B of this Order.

3. Alluvial wells and piezometers shall be constructed and developed in accordance with Section X of this Order. Wells and piezometers that are abandoned shall be abandoned in accordance with the procedures for abandonment in Section X.D of this Order.

4. At a minimum, samples shall be obtained from each boring between the ground surface and one ft below the ground surface (0.0-1.0 ft interval), at five-ft intervals, at the alluvium-bedrock contact, and at the maximum depth of each boring in accordance with the methods described in Section IX.B of this Order.

5. Field screening and chemical analyses of collected samples shall be conducted in accordance with Section IX of this Order.

6. Selected soil, rock, and sediment samples collected during drilling activities shall be submitted to an analytical laboratory for the required analyses.

7. Site-specific or watershed-specific work plans shall be prepared in accordance with Section XI.B of this Order. The Respondents may request site-specific modifications to the required analytical suite based on known site or watershed histories and previous investigation results in the site-specific investigation or monitoring work plans submitted to the Department prior to the start of field activities.

8. Groundwater samples shall be submitted for the analyses required in this Section (IV) and Section IX of this Order.

9. Groundwater monitoring data and groundwater samples shall be collected from each well at the frequencies specified in Section XII and in accordance with all other requirements of this Section (IV) and Section IX of this Order.

IV.A.3.e.ii Intermediate Wells

The Respondents shall meet the following requirements in the installation of all intermediate zone characterization and monitoring wells:

1. Geophysical measurements and soil, rock, vapor, and groundwater samples shall be collected from each boring prior to well construction in accordance with Section IX of this Order.

2. After completion of the borings, the Respondents shall submit a monitoring well design plan to the Department for approval prior to construction of the intermediate zone wells. The Respondents shall not leave any borehole open or cased with drill casing for longer than five (5) days.

3. The Department may impose specific conditions for well construction, require borings to be extended to the regional aquifer, or require the drilling of additional borings that intersect intermediate perched saturated zones or the regional aquifer based on investigation results.

4. Field screening and sample collection of soil, rock, vapor, and groundwater samples shall be conducted in accordance with Section IX of this Order.

5. Selected soil, rock, and sediment samples shall be submitted to an analytical laboratory for the required analyses.

6. Site-specific or watershed-specific work plans shall be prepared in accordance with Section XI of this Order. Site-specific modifications to the required analytical suite based on known site or watershed histories and previous investigation results may be requested by the Respondents in site-specific investigation or monitoring work plans submitted to the Department prior to the start of field activities.

7. Groundwater samples shall be submitted for the analyses required in Sections IV.B below and Section IX of this Order.

8. Groundwater monitoring data and groundwater samples shall be collected from each well at the frequencies specified in Section XII and in accordance with the requirements of Section IX of this Order.

IV.A.3.e.iii Regional Wells

The Respondents shall meet the following requirements in the installation of all regional aquifer groundwater characterization and monitoring wells:

1. The proposed locations, depths and details of drilling, sampling, and well construction shall be discussed in a work plan prepared in accordance with Section XI.B of this Order or other document approved by the Department prior to well installation.

2. After completion of the borings, a monitoring well design plan shall be submitted to the Department for approval prior to construction of the regional aquifer wells. No borehole shall be left open or cased with drill casing for longer than five (5) days.

3. Geophysical measurements and soil, rock, vapor, and groundwater samples shall be collected from the borings prior to well construction in accordance with Section IX of this Order.

4. The borings shall be monitored for the presence of vapor-phase contaminants prior to well construction.

5. Based on the results of vapor monitoring, the Department may require that the Respondents construct the wells to accommodate vapor monitoring in addition to groundwater monitoring and sampling.

6. Field screening and sample collection of soil, rock, vapor, and groundwater samples shall be conducted in accordance with Section IX of this Order.

7. Selected soil, rock, and sediment samples shall be submitted to an analytical laboratory for the required analyses.

8. Site- or watershed-specific work plans shall be prepared in accordance with Section XI.B of this Order. The Respondents may request site-specific modifications to the required analytical suite in the site-specific investigation or monitoring work plans submitted to the Department, based on known site or watershed histories and previous investigation results, prior to the start of field activities.

9. Groundwater samples shall be submitted for the analyses required under Sections IV, V and VI of this Order.

10. Groundwater monitoring data and groundwater samples shall be collected from each well at the frequencies specified in Section XII and in accordance with all other requirements of this Section (IV), Section IX of this Order, and the HWP.

IV.A.3.e.iv Well Completion

The Respondents shall submit to the Department a well completion summary fact sheet within 30 days of completion of each intermediate zone or regional aquifer well or group of alluvial aquifer wells. Investigation reports that summarize the results of the site-specific investigations shall be prepared in accordance with the format described in Section XI.C of this Order. The investigation reports (that must include all well completion details) shall be submitted to the Department within 120 days after completion of field investigation activities.

IV.A.3.f Springs

This Section (IV.A.3.f) outlines the requirements for characterization and monitoring of groundwater from springs. The Department has identified the following as minimum characterization and monitoring needs:

1. Springs used to monitor groundwater shall be sampled as close to the source as possible and shall be sampled at the same locations during each sampling event.

2. The sampling point for each spring shall be located in accordance with the survey methods described in Section IX.B of this Order or by other survey methods approved by the Department. The elevation of each spring shall be determined to the accuracy described in Section IX.B.

3. Spring water flow rates shall be measured. In addition, the seep or spring effluent pH, specific conductance, dissolved oxygen, temperature, and oxidation-reduction potential shall be measured at the sample location during each sampling event. The Respondents shall measure field water quality parameters to determine the stability of the groundwater chemistry prior to sample collection and shall follow the procedures outlined in Section IX of this Order.

4. Groundwater and spring samples shall be submitted to an analytical laboratory for analyses of the general chemistry, organic, inorganic, and radionuclide constituents listed below. The Respondents may request modification of the required analytical suite and monitoring frequency in the site-specific, canyon-specific, and Facility-wide work plan submittals based on specific conditions and information acquired during previous investigation and monitoring activities. The Department shall approve all modifications to the monitoring and sampling methods and analytical suite prior to sample collection. General chemistry parameters shall, at a minimum, include nitrate, nitrite, ammonia, total kjeldahl nitrogen (TKN), phosphate, sulfate, carbonate and bicarbonate, and other site-specific, watershed-specific, or groundwater zone-specific parameters listed in Section IX.B.2.i below. Samples shall be collected for organic analyses that include VOCs, semivolatile organics (SVOCs), HE compounds, HE degradation products, PCBs, and dioxins/furans listed in 40 C.F.R. Part 264, Appendix IX. Inorganic analyses shall include TAL metals, silicon, lithium, molybdenum, cyanide, total uranium, and perchlorate. Radionuclide analyses shall include gross alpha/beta, tritium, strontium-90, technetium-99, cesium-137, isotopic americium, isotopic uranium, isotopic plutonium, and gamma spectroscopy. The Department also may require testing for additional analytes not listed above.

The Respondents shall submit periodic monitoring reports beginning with the first quarter after the effective date of this Order and quarterly thereafter. The periodic monitoring reports shall be prepared in accordance with the requirements listed in Section XI of this Order, shall summarize all field activities and analytical results generated in fulfillment of the requirements outlined in this section (IV.A.3.f), and shall be submitted within 120 days of the completion of field activities.

IV.A.4 Sediment Investigation

The Respondents shall conduct investigations to fully characterize the nature, extent, fate, and transport of sediments and contaminants in sediments in the canyons located within and downgradient of the Facility. The Respondents shall conduct the sediment investigations in accordance with the general requirements of this Section (IV.A.4), and the specific requirements of Sections IV.B and IV.C. All monitoring and sampling shall be conducted in accordance with the investigation methods and procedures set forth in Section IX of this Order. The Respondents shall implement the sediment investigation requirements in accordance with the schedule set forth in Section XII.

The Respondents shall conduct the following activities in the sediment investigations:

1. All types and sources of contaminants that were historically discharged or released to each canyon watershed shall be identified.

2. The current surface water hydrology in each of the canyons shall be characterized. Current hydrologic conditions shall be compared to pre-Cerro Grande Fire conditions in those canyons affected by the Cerro Grande Fire.

3. Identify the areas of sediment accumulation in each canyon from the western boundary of the Facility to the Rio Grande. Identify areas of sediment accumulation from the head to the mouth of those canyons that head within the Facility boundaries.

4. Identify reaches, as defined in this Order, within each canyon based on the information collected to fulfill the requirements of Paragraph 3 above. Each reach shall be selected and investigated in accordance with Chapter 5 of the Facility's Core Document for Canyons Investigations, April 1997 (LA-UR-96-2083).

5. Conduct geomorphic characterization, as defined in the Facility's Core Document for Canyons Investigations, April 1997 (LA-UR-96-2083), of each reach and evaluate for the presence of contaminants within each reach.

6. Identify a minimum of two areas of current fine-grained sediment accumulation in each canyon upstream from the western boundary of the westernmost TA in each canyon system for use in determining background conditions if the canyon system was affected by the Cerro Grande Fire.

7. Conduct a contaminant survey at all locations within each canyon reach where contaminant and sediment accumulation is most likely to occur and also where sediment accumulation rates have significantly increased since the Cerro Grande Fire.

8. Collect sediment samples from the surveyed locations for field screening and laboratory analysis as required by the Department. Sample collection shall focus on locations where contamination is detected at levels greater than established background levels and on geomorphic units where contamination is likely to accumulate.

IV.A.5 Surface Water Investigation

The Respondents shall conduct investigations to fully characterize the current surface water hydrology, and the nature, extent, fate, and transport of sediments and contaminants in surface water at and downgradient of the Facility. The investigation shall include an evaluation of the physical, biological, chemical, and radiochemical factors influencing the transport of contaminants in surface water. All monitoring and sampling shall be conducted in accordance with the investigation methods and procedures set forth in Section IX of this Order. The Respondents shall implement the surface water investigation requirements in accordance with the schedule set forth in Section XII.

The Respondents shall conduct the following activities in the surface water investigations:

1. Conduct surface water monitoring at the LANL Stations designated in Table IV.A.5-1 of this Section (IV.A.5) and at all other locations required by the Department.

2. Surface water monitoring shall consist of stream level and flow velocity measurements, measurement of the parameters described in Section IX.B of this Order, and general chemistry parameters as specified in Section IX.B.2 or by the Department.

3. Surface water samples shall be collected at each station for laboratory analysis of the specific analytical suites specified in Table IV.A.5-1, and any other parameters required by the Department.

4. Surface water monitoring and sampling shall be conducted, where flow is sufficient for sample collection, in conjunction with groundwater monitoring events and after seasonal and precipitation events that produce stream flow in volumes large enough to allow for sample collection.

Table IV.A.5-1

Surface Water Monitoring and Sampling Stations

Canyon and Location	Monitoring Station	Required Analytical Suite
Los Alamos/Pueblo Canyon Watershed Gage Stations		
Los Alamos Canyon (Reservoir, or above Ice Rink, or below Ice Rink)	E024, E025, or E026	Metals, PCBs, Radionuclides
Los Alamos Canyon above DP Canyon	E030	Metals, PCBs, Radionuclides
DP Canyon above TA-21	E038	Metals, PCBs, Radionuclides
DP Canyon below meadow at TA-21	E039	Metals, PCBs, Radionuclides
DP Canyon above Los Alamos Canyon	E040	Metals, Radionuclides
Los Alamos above SR-4	E042	Metals, Radionuclides
Los Alamos below LA Weir (Downstream Facility Boundary)	E050	Metals, PCBs, Radionuclides
Pueblo Canyon above Acid Canyon	E055	Metals, PCBs, Radionuclides
South Fork of Acid Canyon	Station number to be determined.	Metals, PCBs, Radionuclides
Acid Canyon above Pueblo Canyon	E056	Metals, PCBs, Radionuclides
Pueblo Canyon above SR 502 (Downstream Facility Boundary)	E060	Metals, PCBs, Dioxins/Furans, Radionuclides
Sandia Canyon Watershed Gage Stations		
Sandia Canyon, right fork at Power Plant (South Fork)	E121	Metals, Molybdenum, PCBs, Radionuclides
Sandia Canyon, left fork at Asphalt Plant (North Fork)	E122	Metals, PCBs
Sandia Canyon below Wetlands	E123	Metals, Molybdenum, PCBs
Sandia Canyon above Firing Range	E124	Metals, HE, PCBs, Radionuclides
Sandia Canyon above SR 4 (Downstream Facility Boundary)	E125	Metals, HE, PCBs, Radionuclides
Mortandad Canyon Watershed Gage Stations		
Mortandad Canyon below Effluent Canyon	E200	Metals, Perchlorate, PCBs, Radionuclides
Mortandad Canyon above Ten Site Canyon	E201	Metals, Perchlorate, PCBs, Radionuclides
TA-50 South (MDA C)	E201.3	Metals, Radionuclides
Ten Site Canyon above Mortandad Canyon	E201.5	Metals, Radionuclides
Mortandad Canyon above Sediment	E202	Metals, Radionuclides

Canyon and Location	Monitoring Station	Required Analytical Suite
Traps		
Mortandad Canyon below Sediment Traps	E203	Metals, Radionuclides
Mortandad Canyon at Facility Boundary (Downstream Facility Boundary)	E204	Metals, Perchlorate, Radionuclides
Cañada del Buey near TA-46	E218	Metals, PCBs, Radionuclides, Suspended Sediment Concentration
Cañada del Buey near MDA G	E225	Metals, PCBs, Radionuclides
Cañada del Buey above SR 4 (Downstream Facility Boundary)	E230	Metals, PCBs, Radionuclides
Pajarito Canyon Watershed Gage Stations		
Pajarito Canyon below SR 501	E240	Metals, Radionuclides
Pajarito Canyon above Starmer's Gulch	E241	Metals
Starmer's Gulch above Pajarito Canyon	E242	Metals
La Delfe Tributary above Pajarito Canyon	E242.5	Metals, HE
Pajarito Canyon above Two-Mile Canyon Confluence	E243	Metals, HE, Radionuclides
Two Mile Canyon at TA-3	E243.5	Metals, Dioxin/Furans, Radionuclides
Two Mile Canyon, above Pajarito Canyon Confluence	E244	Metals, Dioxin/Furans, HE, Radionuclides, PCBs
Three Mile Canyon, above Pajarito Canyon Confluence	E246	Metals, HE, Radionuclides, PCBs
Pajarito Canyon above TA-18	E245	Metals, HE, Radionuclides, PCBs
Pajarito Canyon above Three Mile Canyon	E245.5	Metals, HE, Radionuclides, PCBs
Pajarito Canyon (TA-54-MDA G)	E247	Metals, PCBs, Radionuclides
Pajarito Canyon (TA-54-MDA G)	E227	Metals, PCBs, Radionuclides
Pajarito Canyon (TA-54-MDA G)	E248.5	Metals, Radionuclides, PCBs
Pajarito Canyon (TA-54-MDA G)	E249	Metals, PCBs, Radionuclides
Pajarito Canyon above SR 4 (Downstream Facility Boundary)	E250	Metals, HE, Dioxins/Furans, PCBs, Radionuclides
Water Canyon Watershed Gage Stations		
Water Canyon above SR 502	E252	Metals, Radionuclides
Cañon de Valle	E253	Metals, Radionuclides
Cañon de Valle below MDA P	E256	Metals, HE

Canyon and Location	Monitoring Station	Required Analytical Suite
Cañon de Valle tributary at Burning Grounds	E257	Metals, HE
Water Canyon above S-Site Canyon	E260	Metals, HE
S-Site Canyon above Water Canyon	E261	Metals, HE
Cañon de Valle above Water Canyon	E262	Metals, HE, Radionuclides
Water Canyon below MDA AB	E262.5	Metals, HE, Radionuclides
Water Canyon at SR 4	E263	Metals, HE, Radionuclides
Indio Canyon at SR 4	E264	Metals, HE, Radionuclides
Water Canyon below SR 4 (Downstream Facility Boundary)	E265	Metals, Radionuclides, PCBs
Potrillo Canyon at Lower Slobovia	E266	Metals, HE, Radionuclides
Potrillo Canyon above SR 4 (Downstream Facility Boundary)	E267	Metals, Radionuclides
Ancho Canyon Watershed Gage Stations		
Ancho Canyon, north fork below SR 4 (TA-39)	E274	Metals, HE, PCBs, Radionuclides
Ancho Canyon, below SR 4 (Downstream Facility Boundary)	E275	Metals, HE, PCBs, Radionuclides
Chaquehui Canyon Watershed Gage Stations		
Chaquehui Canyon at TA-33 (South Site)	E338	Metals, Radionuclides
Chaquehui Canyon at TA-33 (Main Site)	E340	Metals

IV.A.6 Reporting

The Respondents shall submit to the Department periodic monitoring reports including the results of the groundwater, surface water, and springs monitoring and sampling over the previous reporting period. The reports shall be prepared in accordance with Section XI.D of this Order. The reports shall be submitted within 120 days after completion of the monitoring event and in accordance with the schedule set forth in the approved work plan.

IV.B CANYON WATERSHED INVESTIGATIONS

IV.B.1 Los Alamos/Pueblo Canyon Watershed

IV.B.1.a Background

The Los Alamos/Pueblo Canyon watershed encompasses roughly 57 square miles and is located at the north end of the Facility. The watershed contains numerous springs as well as perennial and

ephemeral streams and alluvial groundwater systems. Los Alamos Townsite, Los Alamos County, Santa Fe County, and Pueblo of San Ildefonso tribal lands are located within the Los Alamos/Pueblo Canyon watershed. Facility operations have discharged treated and untreated effluent into the watershed from the 1940s to the present. Runoff from mesa top SWMUs and AOCs at former and current TAs-0, 1, 2, 3, 21, 43, 53, 62, 72, 73 and 74 have contributed to contaminant releases and contaminant migration within the canyon systems. Metals, perchlorate, tritium, strontium-90, uranium isotopes, nitrates, hydrocarbons and other contaminants have been detected in the Los Alamos/Pueblo Canyon watershed groundwater.

This section (IV.B.1) of the Order addresses the specific requirements for the investigation of Los Alamos and Pueblo Canyons and selected tributaries, including Acid and DP Canyons. The Los Alamos/Pueblo Canyon watershed also includes Guaje, Rendija, and Barrancas Canyons (collectively known as the North Canyons). The characterization and monitoring requirements for these canyons are included in Section IV.B.6 of this Order. Regional aquifer wells proposed in the HWP for the Los Alamos/Pueblo Canyon watershed shall be installed according to the schedule listed in Section XII of this Order. Groundwater monitoring and sampling in Los Alamos and Pueblo Canyons shall be conducted in accordance with the schedule listed in Section XII of this Order.

DP Canyon and an undesignated canyon east of TA-53 are significant contaminant-bearing, tributary side canyons of Los Alamos Canyon, based on historical Facility activities. DP Canyon joins Los Alamos Canyon east of TA-21 at the east end of the Los Alamos Townsite. TAs-2, 41, and 43 are located within the Los Alamos Canyon flood plain in the vicinity of the Los Alamos Townsite. TAs-21, 73, and former TA-1, are located on the mesa, from west to east, north of Los Alamos Canyon. TAs-62, 61, 53 and 72 are located from west to east along the mesa (South Mesa) south of Los Alamos Canyon.

Pueblo Canyon is located on the north side of the Los Alamos Townsite and extends from the Jemez Mountains to its confluence with Los Alamos Canyon approximately 4.5 miles east of the Los Alamos Townsite at the intersection of State Road 502 and State Road 4. TAs-72, 73 and former TAs-1 and 45 are located from west to east along the mesa south of Pueblo Canyon. Acid Canyon joins Pueblo Canyon from the south opposite former TA-45 and is considered a significant, contaminant-bearing, tributary canyon of Pueblo Canyon with regard to former Facility operations. Facility TAs are not present on the north side of the Canyon.

Facility activities have been conducted in the vicinity of the Los Alamos Townsite and the Los Alamos/Pueblo Canyon watershed since the establishment of the Facility in the 1940s. Historical Facility operations resulted in direct and indirect discharge as well as accidental releases of contaminants to Los Alamos and Pueblo Canyons and their tributaries. The documented discharges and releases were primarily in the form of contaminated wastewater generated during research and manufacturing operations on the surrounding mesas in the vicinity of the Los Alamos Townsite. In addition, discharges and releases of contaminants were documented in Los Alamos Canyon resulting from operations conducted at TAs-2 and 41. Possible releases may also originate from debris generated during TA-1 demolition activities and deposited on hillsides located above Los Alamos Canyon, opposite the Townsite.

Facility operations that affected Pueblo Canyon include the release of contaminants to Pueblo Canyon via Acid Canyon from former TAs-1 and 45. Historical activities at TAs-21 and 53 and former TAs-1, 2, and 41 released contaminants into Los Alamos Canyon and its tributary side canyons (DP Canyon and the undesignated canyon located east of TA-53). Historical Facility operations released both hazardous constituents and radionuclides.

IV.B.1.b General Investigation Requirements

The general investigation requirements for the Los Alamos/Pueblo Canyon watershed shall include:

1. investigation of canyon outfalls and drainages from the mesa top TAs,

2. investigation of canyon alluvial sediments,

3. surface water monitoring and sampling, and

4. groundwater monitoring and sampling.

The general investigation activities required for the Los Alamos/Pueblo Canyon watershed shall primarily focus on fate and transport of contaminants from the point of origin to the Los Alamos/Pueblo Canyon watershed drainage system and, if necessary, to the regional aquifer and to the Rio Grande. The source areas located on mesa tops shall be addressed in separate investigations in this Section (IV), where appropriate.

IV.B.1.c Historical Investigation

The Respondents shall conduct an investigation of contaminants that may have been discharged or released into the Los Alamos/Pueblo Canyon watershed during historical operations at the Facility. The investigation shall include the known or suspected source of any groundwater contaminants, and a review of existing data and other information acquired during previous investigations. In conducting the investigation, the Respondents shall review and confirm the construction details and historical use of all existing and demolished TA buildings and other structures; pits, shafts, trenches, landfills, surface impoundments, and other SWMUs; wastewater treatment, conveyance, and disposal systems; subsurface utility corridors; and other possible sources of discharges or releases of contaminants. The Respondents shall also review all investigation borings, excavations, sampling events, and other sources of information on contamination. The Respondents shall submit to the Department a historical investigation report for the Los Alamos/Pueblo Canyon Watershed, which shall be included as an appendix to the Pueblo Canyon Investigation Work Plan under Section IV.B.1.d.i. The report shall contain, at a minimum, the following information:

1. A list of all past or present SWMUs, AOCs, and other sites in or bordering the Los Alamos/Pueblo Canyon watershed that may have contributed contaminants to the canyon drainages.

2. A list of all past or present outfalls, National Pollutant Discharge Elimination System (NPDES)-permitted discharges, and other discharge locations that may have contributed contaminants to the canyon drainages.

3. A description of the location, construction details, operational history, and present status of each such SWMU, AOC, and other site listed under Paragraph 1 and each outfall, NPDES discharge, and other discharge location listed under Paragraph 2. The Respondents shall depict all such locations in one or more figures.

4. A description of the known disposal history of each SWMU, AOC, and other site listed under Paragraph 1 and each outfall, NPDES discharge, and other discharge location listed under Paragraph 2. This description shall include all known and suspected material disposed, discharged, or released; the volume of each discharge or release; the flow rate of each discharge or release; and the contaminants present in each discharge or release. The Respondents shall report whether the disposal history of any SWMU, AOC, or other unit is unknown or incomplete and its source.

5. A description of each previous investigation of the sources, extent, or characteristics of contamination in the Los Alamos/Pueblo Canyon watershed, regardless of whether or not such investigation was completed.

6. A summary of any results and conclusions of each previous investigation described in Paragraph 5, including the known or suspected dates of waste disposal, discharge, or release, and the circumstances related to the discharge or release of contamination.

7. A description of the location, construction details, history, and present status of each investigation well, boring, and excavation in the Los Alamos/Pueblo Canyon watershed. The Respondents shall depict all such locations in one or more figures. The results of historical aquifer characterization, surface water study, and all sampling events shall be included, if available. A site map encompassing the watershed and pertinent regional investigation locations shall be included in the summary.

8. A description of the sample collection methods and the types of field and laboratory analyses performed on each sample obtained from each media during the previous investigations.

9. Tables summarizing the data collected from each investigation well, boring, and excavation. The results shall present only analyte and radionuclide detections and data quality exceptions reported by the analytical laboratory that may mask analyte and radionuclide detections.

11. A summary of data quality exceptions and interpretations of all compromised data.

12. A summary of all contradictory investigation results and the rational for acceptance or rejection of selected investigation results.

13. A list of general chemistry, metals and radionuclide background concentrations and documentation of the methods for establishing the background values.

14. A table summarizing the field and laboratory analytical results obtained from the four most recent groundwater monitoring and sampling events. The results shall include groundwater monitoring and sampling conducted in the Los Alamos Canyon aggregate watershed. A site plan presenting the locations of all wells and piezometers shall be included with the summary.

15. A table summarizing the field and laboratory analytical results obtained from the four most recent surface water monitoring and sampling events. The results shall include surface water monitoring and sampling conducted in the Los Alamos Canyon aggregate watershed. A site plan presenting the locations of all surface-water monitoring and sampling stations shall be included with the summary.

16. A table summarizing the known hydraulic properties, including groundwater flow direction and velocity estimates, of the alluvial, intermediate, and regional aquifers based on testing results obtained at locations within Los Alamos Canyon and Pueblo Canyon, if available. Groundwater flow directions and elevations may be presented on a map.

The summaries shall include references to historical documents within the summary text citing the document title, page number, and table or figure number. The full reference citations shall be presented as a separate section in each summary document using the standard United States Geological Survey (USGS) format for reference citations. The Facility project leader for corrective action at the Los Alamos/Pueblo Canyon watershed shall meet with Department representatives to discuss the content and presentation of the information required in investigation work plans and reports. The Respondents shall provide complete data and information to the extent it is available, and shall identify the need for any additional data at each unit. The Department will evaluate the information and request changes as necessary. The Respondents shall submit new or updated information to the Department as soon as it becomes available.

IV.B.1.d Pueblo Canyon Investigation

IV.B.1.d.i Pueblo Canyon Investigation Work Plan

The Respondents have submitted to the Department the Work Plan for Los Alamos and Pueblo Canyons, dated November 1995, and the addendum to the Work Plan, dated February 2002. The Los Alamos and Pueblo Canyons Work Plan is incorporated herein by reference and made an enforceable part of this Order. The Respondents shall implement the work plan. If the Department determines that the work plan is inadequate to fully investigate Pueblo Canyon, the Department will require the Respondents to submit a supplemental work plan that meets the requirements of this Section (IV.B.1.d). The supplemental work plan shall be prepared in accordance with Section XI.B of this Order. If deemed necessary, the supplemental work plan shall address additional investigations of the sources of contamination and the nature and extent of contamination in sediments, surface water, and groundwater in Pueblo Canyon, including monitoring and reporting. The supplemental work plan shall propose the frequency for submitting periodic monitoring reports.

IV.B.1.d.ii Pueblo Canyon Source Area Investigation

The Respondents shall investigate the sources and extent of contamination in Pueblo Canyon and its tributaries. The investigation shall include, at a minimum, the following activities:

1. All outfalls that historically discharged effluent water to Pueblo Canyon and its tributaries shall be identified.

2. All potential receptors that may have been affected by historical releases of contaminants to Pueblo Canyon, including groundwater, shall be identified.

3. All contaminants that were historically discharged to Pueblo Canyon and its tributaries from the outfalls shall be identified.

4. A radionuclide survey of the bed and banks of the stream course in Pueblo Canyon and its tributaries shall be conducted.

5. All areas of fine-grained sediment accumulation beginning at the outfall locations in Pueblo Canyon and its tributaries shall be identified.

6. Surface sediment samples shall be collected from the stream banks and overbank deposits at the locations where sediments are most likely to accumulate after storm events that result in surface water runoff.

7. Samples shall be submitted to a laboratory for analysis of TAL metals, total uranium, radionuclides, and other analytes as required by the Department.

IV.B.1.d.iii Pueblo Canyon Sediment Sampling

The Respondents shall investigate sediments in Pueblo Canyon. Such investigation shall include, at a minimum, the following activities:

1. All areas of sediment accumulation shall be identified from the confluence of Acid and Pueblo Canyons to the intersection of Pueblo Canyon and Los Alamos Canyon. In addition, a minimum of three areas of fine-grained sediment accumulation shall be identified in Pueblo Canyon directly upstream of the confluence of Acid Canyon and Pueblo Canyons.

2. Any additional sources of contaminants that were historically discharged to Pueblo Canyon and its tributary canyons shall be identified.

3. A radionuclide survey shall be conducted of areas of sediment accumulation where sediment accumulation rates have increased significantly since the Cerro Grande Fire and in areas not previously surveyed during historical investigations in Pueblo Canyon and its tributaries.

4. Surface sediment samples shall be collected from the surveyed locations where radionuclide contamination is detected at levels greater than established background levels.

5. The samples shall be submitted to a laboratory for analysis of TAL metals, total uranium, cyanide, molybdenum, tungsten, and radionuclides, and any additional analytes required by the Department.

IV.B.1.d.iv Pueblo Canyon Surface Water Monitoring

The Respondents shall conduct surface water monitoring and sampling within Pueblo Canyon. The surface water monitoring and sampling program shall be designed to characterize the current surface water hydrology and to assess contaminant and sediment transport, and surface water quality related to historical releases of contaminants to the canyon watershed. The affects of the Cerro Grande Fire on watershed conditions shall also be evaluated. The surface water monitoring and sampling in Pueblo Canyon shall include, at a minimum, the following activities:

1. The current surface water hydrology in the canyon system shall be characterized. Current surface water hydrologic conditions shall be compared to pre-Cerro Grande Fire conditions.

2. Surface water shall be monitored at LANL Station number E060, and at the following locations:

    - a newly-installed gaging station located directly below the confluence of the south fork of Acid Canyon and Acid Canyon,
    - a gaging station located directly above the confluence of Acid and Pueblo Canyons,
    - a gaging station located directly below the confluence of Acid and Pueblo Canyons,
    - a monitoring station located immediately below the intersection of Graduation Canyon and Pueblo Canyons,
    - a gaging station located at the approximate midpoint between the confluence of Graduation and Pueblo Canyons, and
    - the intersection of Pueblo and Los Alamos Canyons.

3. Monitoring of surface water consisting of stream level and flow velocity measurements, measurement of the parameters described in Section IX.B of this Order and general chemistry parameters.

4. Sampling of surface water collected at each station for laboratory analysis of PCBs, perchlorate, radionuclides, TAL metals, total uranium, molybdenum, tungsten, and cyanide.

Surface water monitoring and sampling shall be conducted, where possible, in conjunction with groundwater monitoring events and after seasonal and precipitation events that produce stream flow in volumes large enough to allow for sample collection.

IV.B.1.d.v Pueblo Canyon Alluvial Groundwater Well Installation

The Respondents shall conduct a survey to locate all existing wells in Pueblo Canyon and ascertain the status of all existing and former wells and borings. Based on the results of the well survey, the Department shall determine if additional alluvial monitoring wells shall be constructed in Pueblo Canyon in addition to those listed in Paragraph 1 below. The Department shall specify the locations and schedule for the construction of the additional alluvial monitoring wells.

The Respondents shall identify the extent of saturation within the canyon and identify recharge areas and zones where alluvial groundwater infiltrates to underlying geologic units. The Respondents shall install additional monitoring wells and piezometers in Pueblo Canyon. Such installation shall, at a minimum, meet the requirements of Section IV.A.3.e of this Order, and the following requirements:

1. At least three monitoring wells shall be installed in Pueblo Canyon. One of the wells shall be located immediately downstream of the intersection of Acid and Pueblo Canyons and approximately 1,800 ft east of well PAO-2. The second well shall be located east of well PAO-2 at the east end of the estimated zone of alluvial groundwater saturation located in the vicinity of the confluence of Acid and Pueblo Canyons. The third monitoring well shall be located approximately 300 ft east of the confluence of Pueblo Canyon and the unnamed side canyon that forms the northern boundary of North Mesa.

2. At least three piezometers shall be installed at locations between PAO-2 and PAO-2.5 to determine possible leakage across the Rendija and Guaje Mountain Faults, and that penetrate any previously observed perched horizon.

3. Five to seven temporary borings shall be drilled between PAO-2.5 and PAO-3 and five to seven borings shall be drilled east of PAO-3, to evaluate changes in the lateral and vertical extent of saturation in the canyon alluvium and Puye Formation that may have occurred as a result of the Cerro Grande Fire.

4. Alluvial monitoring wells PO-4A and PO-4B shall be replaced and shall be located in the vicinity of PO-4A and PO-4B.

5. Additional wells shall be installed as required by the Department pursuant to this Order.

6. Samples of alluvial sediments and underlying bedrock shall be collected at locations designated by the Department in accordance with the methods described in Section IX.B of this Order.

7. At a minimum, samples shall be obtained from each boring between the ground surface and one ft below the ground surface (0-1.0 ft interval), at five-ft intervals, at the alluvial sediment-bedrock interface, and at the maximum depth of each boring in accordance with the methods described in Section IX.B of this Order.

8. The samples shall be submitted to a laboratory for analysis of PCBs, perchlorate, TAL metals, total uranium, cyanide, and radionuclides.

9. If sediment samples collected from other intervals in the borings display field screening evidence of the presence of radionuclides, then those samples shall also be submitted toa laboratory for analysis of the analytes listed in Paragraph 7 above.

10. All monitoring wells shall be installed in accordance with Section X of this Order.

11. Tests shall be conducted to determine aquifer characteristics, surface water infiltration rates, and vertical and horizontal groundwater flow velocities.

IV.B.1.d.vi Pueblo Canyon Regional Groundwater Well Installation

The Respondents shall install additional regional monitoring wells in Pueblo Canyon. Such installation shall, at a minimum, meet requirements in Section IV.A.3.e and the following requirements:

1. Two wells intersecting the regional aquifer shall be located in Pueblo Canyon or on the mesa top east of Acid Canyon.

2. One well intersecting the regional aquifer shall be located immediately north of TA-73.

3. The Respondents shall install any other wells required by the Department pursuant to this Order.

4. The Respondents shall investigate for the presence of intermediate perched groundwater during the drilling of the regional monitoring wells described in this Section (IV.B.1.d.vi). The Respondents shall construct the regional wells to have the capability to monitor and sample intermediate perched groundwater, if present.

IV.B.1.d.vii Pueblo Canyon Groundwater Monitoring

The Respondents shall monitor and sample all wells specified below containing alluvial, intermediate, and regional groundwater in accordance with Sections IV.B, IX, and XII of this Order, and as specified below.

1. Groundwater samples shall be collected from alluvial monitoring wells POI-4 and APCO-1, and from all newly installed alluvial wells in Pueblo Canyon.

2. Alluvial groundwater samples shall be submitted to a laboratory for analysis of general chemistry parameters as described in Section IX.B.2.i of this Order, radionuclides, perchlorate, TAL metals, total uranium, cyanide, molybdenum, tungsten, and for other analytes specified by the Department. In addition, the groundwater samples obtained from the newly installed alluvial well located east of North Mesa, as described in Section IV.B.1.d.v, Paragraph 1, shall be analyzed for VOCs, dioxins and furans.

3. Groundwater samples shall be collected from intermediate monitoring wells TW-1a, TW-2a, and POI-4 in Pueblo Canyon. TW-1a and TW-2a shall be plugged and abandoned according to the procedures in Section X.D. Groundwater shall be monitored from TW-1a and TW-2a until the wells are properly abandoned.

4. Intermediate zone groundwater samples shall be submitted to a laboratory for analysis of general chemistry parameters as described in Section IX.B.2.i of this Order, radionuclides, perchlorate, TAL metals, total uranium, cyanide, molybdenum, tungsten, and for other analytes specified by the Department.

5. Groundwater samples shall be collected from regional monitoring wells TW-1, TW-2, and TW-4. TW-1 and TW-2 shall be plugged and abandoned according to the procedures described in Section X.D. Groundwater shall be monitored from TW-1 and TW-2 until the wells are properly abandoned.

6. Regional groundwater samples shall be submitted to a laboratory for analysis of general chemistry parameters as described in Section IX.B.2.i of this Order, radionuclides, perchlorate, TAL metals, total uranium, cyanide, molybdenum, tungsten, and other analytes specified by the Department.

7. A long-term groundwater monitoring and sampling work plan shall be submitted to the Department for approval. The work plan shall include the specifics for conducting groundwater sampling in the Los Alamos/Pueblo Canyon watershed prior to implementation of the groundwater sampling program.

IV.B.1.d.viii Pueblo Canyon Investigation Report

The Respondents shall submit an investigation report to the Department for approval that presents the results of the field activities, summarizes the data collected, and presents the recommendations and conclusions. The investigation report shall also include the results of the Los Alamos Canyon investigation. The investigation report shall be prepared in accordance with Section XI.C of this Order and shall be submitted by the date specified in Section XII of this Order.

The Respondents shall submit a well abandonment report for TW-1, TW-1a, TW-2, and TW-2a to the Department within thirty (30) days of completing the well abandonment activities.

IV.B.1.e Los Alamos Canyon Investigation

The Department has identified the following primary sources of contaminants released to Los Alamos Canyon:

- TA-1 – Los Alamos Townsite hillsides 135 and 137 through 141 (radionuclides, metals).
- TA-2 – canyon bottom TA formerly housing three nuclear reactors (radionuclides, metals).
- TA-21 – mesa top TA containing several process areas and MDAs A, B, T, U, V; DP tank farm; and multiple outfalls (radionuclides, metals, SVOCs, VOCs, acids, perchlorate, petroleum, chlorine and nitrogen products, PCBs, ethers, sodium, fluorine, ammonium citrate, and HE).
- TA-41 – canyon bottom TA formerly used for weapons development site (radionuclides, metals, acids, SVOCs, and VOCs).

- TA-53 – mesa top TA containing a proton accelerator and associated facilities, a medical isotope production facility, surface impoundments (removed), and outfalls (radionuclides, metals, PCBs, SVOCs, and VOCs).

IV.B.1.e.i Los Alamos Canyon Investigation Work Plan

The Respondents have submitted to the Department the Work Plan for Los Alamos and Pueblo Canyons, dated November 1995, and the addendum to the Work Plan, dated February 2002. The Los Alamos and Pueblo Canyons Work Plan is incorporated herein by reference and made an enforceable part of this Order. The Respondents shall implement the work plan. If the Department determines that the work plan is inadequate to fully investigate Los Alamos Canyon, the Department will require the Respondents to submit a supplemental work plan that meets the requirements of this Section (IV.B.1.e). The supplemental work plan shall be prepared in accordance with Section XI.B of this Order. If deemed necessary, the supplemental work plan shall address investigations of the sources of contamination and the nature and extent of contamination in sediments, surface water, and groundwater in Pueblo Canyon, including monitoring and reporting. The supplemental work plan shall propose the frequency for submitting periodic monitoring reports.

IV.B.1.e.ii Los Alamos Canyon Source Area Investigations

The Respondents shall investigate the sources and extent of contamination in Los Alamos Canyon. The investigation shall include, at a minimum, the following activities:

1. All sources of contamination, in addition to the sites identified in this Section (IV.B.1.e), which historically released contaminants and/or discharged effluent water to Los Alamos Canyon, shall be identified.

2. All potential receptors that may be affected by historical releases of contaminants to Los Alamos Canyon and its tributary canyons, including groundwater, shall be identified.

3. All drainages emanating from source areas shall be identified, and all areas of sediment accumulation within the source area drainages and in the vicinity of the canyon bottom discharge points of each individual drainage shall be identified.

4. All contaminants that were historically released or discharged to Los Alamos Canyon and the physical properties and degradation products of the substances shall be identified.

5. All areas of fine-grained sediment deposition where sediments associated with specific source area drainages are likely to accumulate in Los Alamos Canyon shall be identified.

6. Surface sediment samples shall be collected from the drainages at the downslope end of the source areas, at associated areas of sediment accumulation at the mouth of the source area drainages in the canyon bottom, and at stream bank and overbank locations within the drainages where contaminants are likely to accumulate.

7. Samples shall be analyzed by a laboratory for TAL metals, total uranium, cyanide, perchlorate, PCBs, radionuclides, and any other analytes identified by the Department as being appropriate for the sample location and source area.

IV.B.1.e.iii Los Alamos Canyon Sediment Sampling

The Respondents shall investigate sediments in Los Alamos Canyon. Such investigation shall include, at a minimum, the following activities:

1. All areas of sediment accumulation from the western boundary of TA-43 to the Rio Grande shall be identified. In addition, a minimum of two areas of fine-grained sediment accumulation in Los Alamos Canyon upstream from the western boundary of TA-43 shall be identified.

2. Any additional sources of contaminants that were historically discharged to Los Alamos Canyon watershed shall be identified.

3. A radionuclide survey of areas of sediment accumulation where sediment accumulation rates have increased significantly since the Cerro Grande Fire and in areas not previously surveyed during historical investigations in Los Alamos Canyon from the western boundary of TA-43 to the Rio Grande shall be conducted.

4. Surface sediment samples shall be collected from the surveyed locations where radionuclide contamination is detected at levels greater than established background levels.

5. The samples shall be submitted to a laboratory for analysis of TAL metals, total uranium, cyanide, molybdenum, tungsten, PCBs, perchlorate, radionuclides, and all other analytes specified by the Department.

IV.B.1.e.iv Los Alamos Canyon Surface Water Monitoring

The Respondents shall conduct surface water monitoring and sampling within Los Alamos Canyon, DP Canyon, and the undesignated canyon east of TA-53. The surface water monitoring and sampling program shall be designed to characterize the current surface water hydrology and to assess contaminant and sediment transport and surface water quality related to historical releases of contaminants to the canyon watersheds. The affects of the Cerro Grande Fire on watershed conditions shall also be evaluated. The surface water monitoring and sampling in the three canyons shall include, at a minimum, the following:

1. The current surface water hydrology in the canyon system shall be characterized. The current surface water hydrologic conditions shall be compared to the pre-Cerro Grande Fire conditions.

2. Surface water shall be monitored and sampled at existing Facility Station numbers E025, E030, E038, E039, E040, and E042. In addition, surface water shall be monitored and sampled at monitoring stations located at the eastern boundary of TA-2, directly upstream of the confluence of Los Alamos and DP Canyons, at the midpoint between DP Canyon and the

mouth of the undesignated canyon located east of TA-53, and immediately downstream of the intersection of Los Alamos Canyon and the undesignated canyon located east of TA-53.

3. Surface water monitoring shall consist of stream level and flow velocity measurements, measurement of the parameters described in Section IX.B of this Order, and general chemistry parameters.

4. Surface water samples shall be collected at each station for laboratory analysis of radionuclides, PCBs, perchlorate, TAL metals, total uranium, molybdenum, tungsten, and cyanide.

Surface water monitoring and sampling shall be conducted, where possible, in conjunction with groundwater monitoring events and after significant seasonal and precipitation events that result in surface water flow in volumes sufficient for sample collection.

IV.B.1.e.v Los Alamos Canyon Alluvial Groundwater Well Installation

The Respondents shall install additional alluvial monitoring wells in Los Alamos Canyon. Such installation shall, at a minimum, meet the requirements of Section IV.A.3.e, and the following requirements:

1. The extent of alluvial aquifers within the canyon shall be identified, and recharge areas and zones where alluvial groundwater infiltrates to underlying geologic units shall be identified.

2. A survey shall be conducted to locate all existing wells in Los Alamos Canyon and ascertain the status of all existing and former wells and borings. Based on the results of the well survey, the Department will determine whether additional monitoring wells shall be constructed in Los Alamos Canyon in addition to those listed in Paragraph 3 below.

3. At least four monitoring wells shall be installed in Los Alamos Canyon. The wells shall be located at the following locations: 1) 500 ft upstream of the intersection of Los Alamos and DP Canyons, 2) immediately downstream of the intersection of Los Alamos and DP Canyons, 3) at the approximate midpoint between existing wells LAO-3 and LAO-4, and 4) approximately midway between existing wells LAO-4 and LAO-4.5. In addition, well LAO-1.2 shall be replaced, properly plugged, and abandoned.

4. At least five piezometers shall be installed between LAO-1.2 and LAO-1.6(g), at locations approved by the Department, to evaluate whether two zones of saturation exist in the alluvium and to determine the extent of saturation west of LAO-1.8, if present.

5. The borings shall be drilled in accordance with Section IX of this Order. The monitoring wells shall be drilled to a minimum of 5 ft below the contact between the canyon alluvium and the underlying bedrock.

6. Cores of the alluvium and the bedrock shall be obtained from each boring for permeability and adsorption coefficient (K_d) testing.

7. Samples obtained from each boring shall be screened in the field for the presence of radionuclides. In addition, the samples obtained from the borings located downstream of DP Canyon shall be field screened for the presence of hydrocarbons.

8. Samples shall be selected for laboratory analysis based on field screening. The samples displaying the greatest evidence of contamination shall submitted to a laboratory for analysis of radionuclides, PCBs, perchlorate, TAL metals, total uranium, molybdenum, tungsten, and cyanide. Samples obtained from the borings located downstream of DP Canyon for laboratory analysis shall also be analyzed for VOCs, SVOCs, HE, and diesel-range organics (DRO by EPA Method 8015M).

9. The samples obtained from the alluvium at the contact between the alluvium and the underlying bedrock shall be analyzed if field screening evidence of contamination is detected in the samples obtained from an individual boring.

10. If sediment samples collected from other intervals in the borings display field screening evidence of the presence of radionuclides, then those samples also shall be analyzed by a laboratory for the analytes listed in Paragraph 8 above.

11. Monitoring wells shall be constructed in the borings in accordance with Section X of this Order.

12. Tests shall be conducted to determine aquifer characteristics, surface water infiltration rates and vertical and horizontal groundwater flow velocities in Los Alamos and DP Canyons.

IV.B.1.e.vi Los Alamos Canyon Intermediate Groundwater Well Installation

The Respondents shall install intermediate groundwater monitoring wells in Los Alamos Canyon. Such installation shall, at a minimum, meet the requirements of Section IV.A.3.e, and the following requirements:

1. One intermediate monitoring well shall be installed between LAO-4.5 and LAO-6.

2. Additional wells shall be installed as required by the Department pursuant to this Order.

3. The Respondents shall install additional intermediate groundwater monitoring wells in the vicinity of Los Alamos Canyon, at targeted depths determined by the Department, as required.

Based on the results of groundwater monitoring and sampling, the Department may require additional monitoring wells in the vicinity of Los Alamos Canyon.

IV.B.1.e.vii Los Alamos Canyon Regional Groundwater Well Installation

The Respondents shall install regional monitoring wells in Los Alamos Canyon. Such installation shall, at a minimum, meet requirements in Section IV.A.3.e and the following requirements:

1. The Respondents shall, at a minimum, construct two monitoring wells associated with Los Alamos Canyon intersecting the regional aquifer as described in Section IV.A.3.e. One well shall be located in Los Alamos Canyon north of the undesignated canyon located east of TA-53. The other well shall be placed in a location suitable for obtaining background regional aquifer data.

IV.B.1.e.viii Los Alamos Canyon Groundwater Monitoring

The Respondents shall monitor and sample all wells specified below containing alluvial, intermediate, and regional groundwater in accordance with Sections IV.B and IX of this Order, and as specified below:

1. Groundwater samples shall be collected from existing alluvial monitoring wells LAO-B, LAO-0.3, LAO-0.6, LAO-0.91, LAO-1.6(g), LAO-1.8, LLAO-1b, LLAO-3, LLAO-4, LLAO-5, LAO-1.2, LAO-2, LAO-3A, LAO-4.5C, LAO-5, LAO-6, LAO-6A, LAUZ-1, and LAUZ-2; New Mexico Highway Department wells MW-3, MW-5, MW-6, and MW-9; and the proposed wells listed in Section IV.B.1.e.v above.

2. Alluvial groundwater samples shall be submitted to a laboratory for analysis of general chemistry parameters as described in Section IX.B.2.i of this Order, radionuclides, PCBs, perchlorate, TAL metals, total uranium, cyanide, molybdenum, tungsten, VOCs, SVOCs, and for any other analytes specified by the Department.

3. Groundwater samples shall be collected from intermediate monitoring wells LADP-3, R-9i, LAOI(a)-1.1, and all wells installed in the future that intersect intermediate zone groundwater in Los Alamos Canyon.

4. Intermediate groundwater samples shall be submitted to a laboratory for analysis of general chemistry parameters as described in Section IX.B.2.i of this Order, radionuclides, perchlorate, TAL metals, total uranium, cyanide, molybdenum, tungsten, and for other analytes specified by the Department.

5. Groundwater samples shall be obtained from regional wells R-5, R-7, R-9, TW-3, and all regional wells installed in the future in Los Alamos Canyon. TW-3 shall be plugged and abandoned according to the procedures in Section X.D. Groundwater shall be monitored from TW-3 until the well is properly abandoned.

6. Regional groundwater samples shall be submitted to a laboratory for analysis of general chemistry parameters as described in Section IX.B.2.i of this Order, radionuclides, perchlorate, TAL metals, total uranium, cyanide, molybdenum, tungsten, and for other analytes specified by the Department.

7. As described in Section IV.B.1.d.vii, Paragraph 7, a long-term groundwater monitoring and sampling work plan shall be submitted to the Department for approval. The work plan shall include the specifics for conducting groundwater sampling in the Los Alamos/Pueblo Canyon watershed prior to implementation of the groundwater sampling program.

IV.B.1.e.ix Los Alamos Canyon Investigation Report

The Respondents shall submit an investigation report to the Department for approval that presents the results of the field activities, summarizes the data collected, and presents the recommendations and conclusions. The investigation report shall also include the results of the Pueblo Canyon investigation. The investigation report shall be prepared in accordance with Section XI.C of this Order and shall be submitted by the date specified in Section XII of this Order.

The Respondents shall submit a well abandonment report for TW-3 to the Department within thirty (30) days of completing the activity.

IV.B.2 Mortandad Canyon Watershed

IV.B.2.a Background

The Mortandad Canyon watershed is located in the central portion of the Facility and covers approximately ten square miles. Tribal lands of the Pueblo of San Ildefonso are directly adjacent to the Facility's eastern boundary and encompass the eastern end of Mortandad Canyon. The Mortandad Canyon watershed contains several tributary canyons that have received contaminants released during Facility operations. The most prominent tributary canyons include Ten Site Canyon, "Pratt" Canyon, "Effluent" Canyon and Cañada del Buey. Although Cañada del Buey is included in the Mortandad Canyon watershed, its characterization is included in the Work Plan for Sandia Canyon and Cañada del Buey.

Current and former TAs located in the Mortandad Canyon watershed include TAs-3, 4, 5, 18, 35, 42, 46, 48, 50, 51, 52, 54, 55, and 59. The primary sources of contamination in this watershed include historic and current releases of contaminants from outfalls and spills at TA-35 and TA-50, including the Radioactive Liquid Waste Treatment facility at TA-50. RCRA constituents, including metals and VOCs, have historically been released into the canyons. Nitrates, perchlorate, molybdenum, manganese, tritium, strontium-90, and isotopic plutonium are some of the contaminants that have been detected in the Mortandad Canyon alluvial groundwater. Effluent discharges from TA-50 produce ephemeral downstream surface water flow and perennial alluvial groundwater system saturated zones within Mortandad Canyon. In addition, nitrate, perchlorate, fluoride, and tritium were detected in samples of intermediate zone groundwater during the drilling of regional aquifer well R-15 located east of the confluence of Mortandad and Ten Site Canyons. Perchlorate also was detected in core samples obtained from the vadose zone close to the top of the regional aquifer, indicating that the groundwater zones beneath the Pajarito Plateau are interconnected.

IV.B.2.b Mortandad Canyon Investigation

IV.B.2.b.i Mortandad Canyon Investigation Work Plan

The Respondents have submitted to the Department the Work Plan for Mortandad Canyon, dated September 1997. The Mortandad Canyon Work Plan is incorporated herein by reference and made an enforceable part of this Order. The Respondents shall implement the work plan. If the Department determines that the work plan is inadequate to fully investigate Mortandad Canyon, the Department will require the Respondents to submit a supplemental work plan that meets the

requirements of this Section (IV.B.2.b). The supplemental work plan shall be prepared in accordance with Section XI.B of this Order. If deemed necessary, the supplemental work plan shall address investigations of the sources of contamination, and the nature and extent of contamination in sediments, surface water, and groundwater in Mortandad Canyon, including monitoring and reporting. The supplemental work plan shall propose the frequency for submitting periodic monitoring reports.

IV.B.2.b.ii Mortandad Canyon Alluvial Groundwater Well Installation

The Respondents shall install alluvial monitoring wells in Mortandad Canyon. Such installation shall, at a minimum, meet requirements in Section IV.A.3.e and the following requirements:

1. One alluvial monitoring well shall be installed directly upstream from the Mortandad-Effluent Canyon confluence. In addition, the Respondents shall install one alluvial monitoring well (proposed alluvial well MCO-6.8) and six piezometers, including one nested piezometer set, in the canyon bottom located approximately midway between existing wells MT-3 and MT-4. These wells and piezometers shall be used in conjunction with existing wells and piezometers to determine groundwater flow direction(s) and gradient(s) and to investigate alluvial system groundwater loss to the Cerro Toledo interval at that location.

2. Wells MCO-2 and MCO-3 shall be replaced. Immediately following installation of the replacement wells, MCO-2 and MCO-3 shall be abandoned in accordance with Section X of this Order.

3. One alluvial well shall be installed in Ten Site Canyon approximately 1,000 ft west of the confluence of Mortandad and Ten Site Canyons. A nested piezometer set shall be installed in the vicinity of the well if groundwater is present in the newly installed well.

4. Three monitoring wells shall be installed in Cañada del Buey upgradient of CDBO-6 to investigate the source of alluvial saturation. At a minimum, the borings shall be advanced to the depth of the vapor-phase notch (horizontal zone of weathering between units Qbt 1v and Qbt 1g of the Bandelier Tuff).

5. Four monitoring wells shall be installed between wells CDBO-6 and CDBO-7 to identify the boundaries of alluvial saturation.

6. Three wells shall be installed to the top of the Bandelier Tuff intersecting the alluvial water in the vicinity of regional well R-13.

The groundwater monitoring system shall be designed to detect contamination upgradient and downgradient from the permeable reactive barrier located between wells MCO-4 and MCO-5.

IV.B.2.b.iii Mortandad Canyon Intermediate Groundwater Well Installation

The Respondents shall install intermediate monitoring wells in Mortandad Canyon. Such installation shall, at a minimum, meet requirements in Section IV.A.3.e and the following requirements:

1. A minimum of ten wells shall be installed intersecting the intermediate zone groundwater. The wells shall be used to determine the number and extent of intermediate perched saturated zones, the gradients, directions, and velocity of groundwater flow, and the extent of contamination present in each saturated zone. Additional wells shall be installed intersecting the intermediate zones of saturation, as required by the Department, to adequately characterize the intermediate zone groundwater conditions. The wells shall be located as follows:

   - one approximately 0.25 mile downgradient from the TA-50 outfall;
   - one in upper Ten Site Canyon at the location of borehole 35-2028;
   - one at the approximate location listed in Paragraph 3 in Section IV.B.2.b.ii;
   - one in the vicinity of well MCO-4;
   - one in the vicinity of well R-15;
   - one in the vicinity of well MCO-13;
   - one in the vicinity of well GS-2 on the south side of the Mortandad Canyon bench;
   - one between wells GS-1 and TW-8;
   - one approximately 1,500 ft east of well PM-5 along the access road to Mortandad Canyon; and
   - one approximately 3,500 ft east of well PM-5 along the access road to Mortandad Canyon.

2. The Respondents shall install additional intermediate groundwater monitoring wells in the vicinity of Mortandad Canyon, at targeted depths determined by the Department, as required.

IV.B.2.b.iv Mortandad Canyon Regional Groundwater Well Installation

The Respondents shall install regional monitoring wells in Mortandad Canyon. Such installation shall, at a minimum, meet requirements in Section IV.A.3.e and the following requirements:

1. All wells proposed for Mortandad Canyon in the Hydrogeologic Work Plan shall be installed according to the schedule set forth in Section XII of this Order.

2. Well TW-8 shall be replaced. Prior to abandonment, neutron logging of TW-8 shall be performed. Immediately following installation of the replacement well, TW-8 shall be abandoned in accordance with Section X of this Order.

3. HWP regional well R-14 shall be completed. One well shall be installed intersecting the top of the regional aquifer in the vicinity of regional well R-13. In addition, one well shall be installed intersecting the regional aquifer downgradient from the TA-50 outfall at a location approved by the Department and one in between gaging station GS-1 and well TW-8.

IV.B.2.b.v Mortandad Canyon Groundwater Monitoring

The Respondents shall monitor and sample all Mortandad Canyon wells containing alluvial, intermediate, and regional groundwater in accordance with Sections IV.B and IX of this Order and the following requirements:

1. Groundwater samples shall be obtained from alluvial wells MCO-2, MCO-3, MCO-4B, MCO-5, MCO-6, MCO-6B, MCO-7, MCO-7.5, MT-4, TSWB-6, CDBO-1 through 9, and all alluvial wells installed in the future at the frequency described in Section XII of this Order. Groundwater from MCO-2 and MCO-3 shall be monitored until the wells are properly plugged and abandoned. The MCO-2 and MCO-3 replacement wells shall be monitored once installed.

2. Groundwater samples shall be obtained from intermediate wells MCOBT-4.4, MCOBT-8.5, and all intermediate wells installed in the future at the frequency described in Section XII of this Order.

3. Groundwater samples shall be obtained from regional wells R-15, R-22, TW-8, and all regional wells installed in the future at the frequency described in Section XII of this Order. TW-8 shall be monitored until the well is properly plugged and abandoned. The TW-8 replacement well shall be monitored once installed.

4. Groundwater samples shall be collected from the alluvial, intermediate zone, and regional monitoring wells in Mortandad Canyon for submittal to a laboratory for analysis of general chemistry parameters as described in Section IX.B.2.i of this Order, radionuclides, perchlorate, TAL metals, total uranium, molybdenum, tungsten, cyanide, VOCs, SVOCs, and for other analytes specified by the Department.

5. A long-term groundwater monitoring and sampling work plan shall be submitted to the Department for approval. The work plan shall include the specifics for conducting groundwater sampling in Mortandad Canyon watershed prior to implementation of the groundwater sampling program.

IV.B.2.b.vi Mortandad Canyon Investigation Report

The Respondents shall submit to the Department for approval an investigation report that presents the results of the field activities, summarizes the data collected, and presents the recommendations and conclusions. The investigation report shall be prepared in accordance with Section XI.C of this Order and shall be submitted by the date specified in Section XII of this Order.

IV.B.3 Water Canyon/Cañon de Valle Watershed

IV.B.3.a Background

The Water Canyon/Cañon de Valle watershed is located in the southern portion of the Facility and encompasses an area of approximately 19 square miles. Cañon de Valle, located on the western portion of the Pajarito Plateau, is the main tributary to Water Canyon. The heads of both canyon

watersheds are located in the Sierra de Los Valles. The watershed supplies numerous springs, ephemeral and perennial surface water flow, and alluvial groundwater systems. Tributaries that may contribute contamination to Water Canyon include Indio, Fence, and Potrillo Canyons that join Water Canyon on the eastern side of the Facility. The TAs located within this watershed include TAs 9, 11, 14, 15, 16, 28, 36, 37, 39, 49, 67, 68, 70, and 71. In general, this portion of the Facility has been used for weapons testing, explosives testing, and explosives production and has received effluent from outfalls containing HE, metals, and VOCs. Storm water runoff from firing sites, open burn/open detonation units, surface disposal sites, and other mesa top SWMUs and AOCs are known or are suspected to have contributed to the contamination detected within the watershed. The contaminants detected in soil, rock, and sediment samples obtained from various locations within the watershed during previous investigations include barium and other RCRA metals, HE, VOCs, pesticides, and depleted uranium. Contaminants detected in groundwater samples obtained from wells located within the watershed include barium, HE and associated degradation products, and VOCs.

IV.B.3.b Water Canyon/Cañon de Valle Investigation

IV.B.3.b.i Water Canyon/Cañon de Valle Investigation Work Plan

The Respondents shall submit to the Department for approval a work plan for the investigation of contamination in Water Canyon and Cañon de Valle that meets the requirements of this Section (IV.B.3.b). The work plan shall be prepared in accordance with Section XI.B of this Order, and shall be submitted by the date specified in Section XII of this Order. The work plan shall address investigations of the sources of contamination, and the nature and extent of contamination in sediments, surface water, and groundwater in Water Canyon and Cañon de Valle, including monitoring and reporting. The work plan shall propose the frequency for submitting periodic monitoring reports.

Upon Department approval, the Respondents shall implement the work plan. Upon Department approval, the work plan shall be incorporated herein by reference and become an enforceable part of this Order.

IV.B.3.b.ii Water Canyon/Cañon de Valle Alluvial Groundwater Well Installation

The Respondents shall install alluvial monitoring wells in Water Canyon/Cañon de Valle. Such installation shall, at a minimum, meet the requirements of Section IV.A.3.e, and the following requirements:

1. The Beta Hole and all WCO wells shall be replaced with monitoring wells constructed in accordance with the requirements of Section X of this Order. The Beta Hole and all existing WCO wells shall be abandoned after replacement in accordance with the requirements of Section X of this Order.

2. Two alluvial aquifer wells shall be installed between well WCO-1 and the Water Canyon-Cañon de Valle confluence.

3. Three alluvial wells shall be installed at locations approved by the Department downstream from the active TA-16 operational areas in Cañon de Valle and its tributaries to assess extent of saturation in the alluvial aquifer system.

4. Three nested piezometers shall be installed at locations approved by the Department in the vicinity of the Burning Ground location.

5. Four nested piezometer sets shall be installed in the canyon alluvium located between SWSC Spring and monitoring well 16-2659.

6. Three nested and transected piezometer sets shall be installed to assess vertical and lateral groundwater flow directions in the middle portion of Water Cañon at a location where the canyon alluvium directly overlies the Cerro Toledo interval.

7. One alluvial aquifer well shall be installed in Water Canyon located between the mouths of Martin Spring Canyon and Cañon de Valle.

IV.B.3.b.iii Water Canyon/Cañon de Valle Regional Groundwater Well Installation

The Respondents shall install regional groundwater monitoring wells in Water Canyon/Cañon de Valle. Such installation shall, at a minimum, meet the requirements of Section IV.A.3.e of this Order and the following requirements:

1. HWP regional wells R-24, R-26, R-27, and R-28 shall be completed according to the schedule set forth in Section XII of this Order.

2. Regional aquifer well R-25 shall be replaced at the current location of well R-25 or at an alternate location approved by the Department.

IV.B.3.b.iv Water Canyon/Cañon de Valle Groundwater Monitoring

The Respondents shall monitor and sample all wells specified below containing alluvial, intermediate zone, and regional groundwater in accordance with Sections IV.B and IX of this Order.

1. Groundwater samples shall be obtained from alluvial wells 16-2655, 16-2656, 16-2657, 16-2658, 16-2659, WCO-1, WCO-2, WCO-3, Beta Hole, and all alluvial wells installed in the future at the frequency described in Section XII of this Order.

2. Groundwater samples shall be obtained from intermediate wells CdV-15-3, CdV-37-2, and all intermediate wells installed in the future at the frequency described in Section XII of this Order.

3. Groundwater samples shall be obtained from regional wells CdV-15-3, CdV-37-2, and all regional wells installed in the future at the frequency described in Section XII of this Order.

4. Groundwater samples shall be collected from the alluvial, intermediate, and regional monitoring wells in Water Canyon/Cañon de Valle for submittal to a laboratory for analysis of general chemistry parameters as described in Section IX.B.2.i of this Order, radionuclides, perchlorate, TAL metals, total uranium, cyanide, molybdenum, tungsten, VOCs, SVOCs, HE, and for other analytes specified by the Department.

5. A long-term groundwater monitoring and sampling work plan shall be submitted to the Department for approval. The work plan shall include the specifics for conducting groundwater sampling in the Water Canyon/Cañon de Valle watershed prior to implementation of the groundwater sampling program.

IV.B.3.b.v Water Canyon/Cañon de Valle Investigation Report

The Respondents shall submit to the Department for approval an investigation report that presents the results of the field activities, summarizes the data collected, and presents the recommendations and conclusions for Water Canyon/Cañon de Valle. The investigation report shall be prepared in accordance with Section XI.C of this Order and shall be submitted by the date specified in Section XII of this Order.

IV.B.4 Pajarito Canyon Watershed

IV.B.4.a Background

The Pajarito Canyon watershed is located in the central portion of the Facility and is approximately 13 square miles in area. The head of the watershed is located in the Sierra de los Valles. Two major tributary canyons, Two Mile and Three Mile Canyons, intersect Pajarito Canyon on the Facility property. Facility-related contamination has been detected in water samples obtained from perennial and ephemeral streams, alluvial groundwater systems, and springs supplied by intermediate zone groundwater from the Bandelier Tuff. The TAs located within this watershed include TAs-3, 6, 7, 8, 9, 14, 15, 18, 22, 23, 36, 40, 46, 50, 54, 55, 58, 59, 64, 65, 66, 67, and 69. The contaminant release history from approximately 379 SWMUs varies widely and includes releases from outfalls, septic systems, spills, open detonations from firing sites, and MDAs.

IV.B.4.b Pajarito Canyon Investigation

IV.B.4.b.i Pajarito Canyon Investigation Work Plan

The Respondents have submitted to the Department the Work Plan for Pajarito Canyon, dated September 1998. The Work Plan for Pajarito Canyon is incorporated herein by reference and made an enforceable part of this Order. The Respondents shall implement the work plan. If the Department determines that this work plan is inadequate to fully investigate Pajarito Canyon, the Department will require the Respondents to submit a supplemental work plan that meets the requirements of this Section (IV.B.4.b). The supplemental work plan shall be prepared in accordance with Section XI.B of this Order. If deemed necessary, the supplemental work plan shall address investigations of the sources of contamination, and the nature and extent of contamination in sediments, surface water, and groundwater in Pajarito Canyon, including monitoring and reporting. The supplemental work plan shall propose the frequency for submitting periodic monitoring reports.

IV.B.4.b.ii Pajarito Canyon Alluvial Groundwater Well Installation

The Respondents shall install alluvial groundwater monitoring wells in Pajarito Canyon. Such installation shall, at a minimum, meet the requirements of Section IV.A.3.e of this Order and the following requirements:

1. Monitoring wells shall be installed at the locations proposed in the Work Plan for Pajarito Canyon.

2. Proposed alluvial monitoring well 3MAO-2 shall be moved into reach TH1 East, located in the south fork of Three Mile Canyon, to investigate historic outfall discharges in the upper portion of the Three Mile Canyon sub-basin.

3. One alluvial monitoring well shall be installed in Two Mile Canyon upgradient from its confluence with Pajarito Canyon.

4. Well PCO-3 shall be redeveloped or, if required by the Department, replaced.

5. Four alluvial aquifer system piezometers, including one nested piezometer set, shall be installed in Pajarito Canyon downstream from the drainages associated with TA-54.

IV.B.4.b.iii Pajarito Canyon Intermediate Groundwater Well Installation

The Respondents shall install intermediate groundwater monitoring wells in Pajarito Canyon. Such installation shall, at a minimum, meet the requirements of Section IV.A.3.e of this Order and the following requirements:

1. Two nested piezometer sets shall be installed in the vicinity of well PCO-3 to assess the vertical gradients in the Gauje Pumice Bed and the Cerros del Rio Basalt.

2. One intermediate zone monitoring well shall be installed between the flood retention structure and proposed well PCAO-6.

3. Additional intermediate zone wells shall be installed, as required under Section IV.C.1.c.viii, MDA G Intermediate Groundwater Well Installation.

4. The Respondents shall install additional intermediate groundwater monitoring wells in the vicinity of Pajarito Canyon, at targeted depths determined by the Department, as required.

IV.B.4.b.iv Pajarito Canyon Regional Groundwater Well Installation

The Respondents shall install regional groundwater monitoring wells in Pajarito Canyon. Such installation shall, at a minimum, meet the requirements of Section IV.A.3.e of this Order and the following requirements:

1. Monitoring wells shall be installed at the locations proposed in the Facility's Work Plan for Pajarito Canyon, dated September 1998.

2. Regional aquifer wells R-16, R-17, R-18, R-20, R-21, and R-23 shall be installed as proposed under the HWP, in accordance with the schedule specified in Section XII of this Order.

3. Additional regional aquifer wells shall be installed, as required under Section IV.C.1.c.ix, MDA G Regional Groundwater Well Installation.

IV.B.4.b.v Pajarito Canyon Groundwater Monitoring

The Respondents shall monitor and sample all wells specified below containing alluvial, intermediate zone and regional groundwater in accordance with Sections IV.B and IX of this Order.

1. Groundwater samples shall be obtained from alluvial wells BG-1, BG-4, 18-MW-5, 18-MW-7, 18-MW-8, 18-MW-9, 18-MW-10, 18-MW-11, 18-MW-12, 18-MW-16, 18-MW-17, 18-MW-18, PCO-1, PCO-2, PCO-3, and all alluvial wells installed in the future at the frequency described in Section XII of this Order.

2. Groundwater samples shall be obtained from the intermediate zone of regional well R-19 and all intermediate zone wells installed in the future at the frequency described in Section XII of this Order.

3. Groundwater samples shall be obtained from regional wells R-19, R-22, and all regional wells installed in the future at the frequency described in Section XII of this Order.

4. Groundwater samples shall be collected from the alluvial, intermediate zone, and regional monitoring wells in Pajarito Canyon for submittal to a laboratory for analysis of general chemistry parameters as described in Section IX.B.2.i of this Order, radionuclides, perchlorate, TAL metals, total uranium, cyanide, VOCs, SVOCs, HE, and for other analytes specified by the Department.

5. A long-term groundwater monitoring and sampling work plan shall be submitted to the Department for approval. The work plan shall include the specifics for conducting groundwater sampling in the Pajarito Canyon watershed prior to implementation of the groundwater sampling program.

IV.B.4.b.vi Pajarito Canyon Investigation Report

The Respondents shall submit to the Department for approval an investigation report that presents the results of the field activities, summarizes the data collected, and presents the recommendations and conclusions for Pajarito Canyon. The investigation report shall be prepared in accordance with Section XI.C of this Order and shall be submitted by the date specified in Section XII of this Order.

IV.B.5 Sandia Canyon Watershed

IV.B.5.a Background

The Sandia Canyon watershed is approximately 5.5 square miles in area. The head of the canyon is located on the Pajarito Plateau at TA-3. Perennial stream flow and saturated alluvial aquifer conditions occur in the upper and middle portions of the canyon system because of sanitary wastewater and cooling tower discharges to the canyon from operating facilities. A wetland of approximately seven acres has developed as a result of the wastewater and cooling tower discharges in the upper portion of the canyon. PCBs have been detected in sediment samples obtained from the wetland area and mercury has been detected in baseline surface water samples. Seasonal rainstorms occasionally produce runoff that extends stream flow to the Rio Grande. The only known perennial spring in the watershed (Sandia Spring) is located in lower Sandia Canyon.

TAs located in the Sandia Canyon watershed include TAs 3, 53, 60, 61, and 72 and include approximately 264 SWMUs and AOCs. The types of SWMUs and AOCs vary from industrial outfalls to open-detonation firing sites.

IV.B.5.b Sandia Canyon Investigation

IV.B.5.b.i Sandia Canyon Investigation Work Plan

The Respondents have submitted to the Department the Work Plan for Sandia Canyon and Cañada del Buey, dated September 1999. The Work Plan for Sandia Canyon and Cañada del Buey is incorporated herein by reference and made an enforceable part of this Order. The Respondents shall implement the work plan. If the Department determines that the work plan is inadequate to fully investigate Sandia Canyon, the Department will require the Respondents to submit a supplemental work plan that meets the requirements of this Section (IV.B.5.b). The supplemental work plan shall be prepared in accordance with Section XI.B of this Order. If deemed necessary, the supplemental work plan shall address investigations of the sources of contamination, and the nature and extent of contamination in sediments, surface water, and groundwater in Sandia Canyon, including monitoring and reporting. The supplemental work plan shall propose the frequency for submitting periodic monitoring reports.

IV.B.5.b.ii Sandia Canyon Groundwater Well Installation

In addition to the Facility's Work Plan for Sandia Canyon and Cañada del Buey, the Respondents shall install alluvial and regional groundwater monitoring wells in Sandia Canyon. Such installation shall, at a minimum, meet the requirements of Section IV.A.3.e of this Order and the following requirements:

1. The Respondents shall install alluvial aquifer monitoring wells SCAO-1, SCAO-2, and SCAO-3 at the locations proposed in the Work Plan for Sandia Canyon and Cañada del Buey, dated September1999.

2. Four piezometers shall be installed in the vicinity of the alluvial aquifer monitoring wells listed in Paragraph 1 above. The piezometers shall include a minimum of one nested

piezometer set near well SCAO-1 and also one nested piezometer set in the vicinity of SCAO-3 if groundwater is determined to be present.

3. One intermediate aquifer well shall be installed in the vicinity of regional aquifer well R-12.

4. Regional aquifer wells R-10 and R-11 shall be installed at the locations identified in the HWP according to the schedule set forth in Section XII of this Order.

5. The Respondents shall install additional intermediate groundwater monitoring wells in the vicinity of Sandia Canyon, at targeted depths determined by the Department, as required.

IV.B.5.b.iii Sandia Canyon Groundwater Monitoring

The Respondents shall monitor and sample all wells specified below containing groundwater in accordance with Sections IV.B and IX of this Order.

1. Groundwater samples shall be obtained from wells SCO-1, SCO-2, R-12, and all wells installed in the future at the frequency described in Section XII of this Order.

2. Groundwater samples shall be collected from all monitoring wells in Sandia Canyon for submittal to a laboratory for analysis of general chemistry parameters as described in Section IX.B.2.i of this Order, radionuclides, perchlorate, TAL metals, total uranium, cyanide, molybdenum, tungsten, VOCs, SVOCs, HE, and for other analytes specified by the Department. In addition, groundwater samples from the alluvial monitoring wells shall be analyzed for PCBs.

3. A long-term groundwater monitoring and sampling work plan shall be submitted to the Department for approval. The work plan shall include the specifics for conducting groundwater sampling in the Sandia Canyon watershed prior to implementation of the groundwater sampling program.

IV.B.5.b.iv Sandia Canyon Investigation Report

The Respondents shall submit to the Department for approval an investigation report that presents the results of the field activities, summarizes the data collected, and presents the recommendations and conclusions. The investigation report shall be prepared in accordance with Section XI.C of this Order and shall be submitted by the date specified in Section XII of this Order.

IV.B.6 Other Canyons: Ancho, Chaquehui, Indio, Potrillo, Fence, and North Canyons (Guaje, Barrancas, and Rendija)

IV.B.6.a Background

Ancho Canyon is located in the southern portion of the Facility and is approximately seven square miles in area. During monsoon summer rains, large floods have damaged roads and buildings within the floodplain. The Ancho Canyon watershed is located entirely within TAs 33, 39, 49, and 70. It contains approximately 33 SWMUs, including industrial outfalls, underground hydronuclear testing sites, MDAs, and active and inactive firing sites. Contaminants that have been detected in

sediments, surface water, or shallow groundwater during previous investigations conducted in the watershed include mercury and other metals, HE compounds, organic constituents, and radionuclides, including depleted uranium.

The Chaquehui Canyon watershed is located in the southeast portion of the Facility at TA-33. The watershed extends for a distance of approximately three miles across the Facility to its confluence with the Rio Grande. Total drainage area of the watershed is approximately 1.6 square miles. There are approximately 61 SWMUs and AOCs in the watershed that vary from inactive industrial outfalls to MDAs. Surface-water flow is ephemeral; however, two springs are present along the south-facing wall of the main-drainage. Doe Spring issues from the Chaquehui Formation at an estimated rate of two gallons per minute (gpm). Springs 9 and 9A also provide perennial flow from the Chaquehui Formation. Contaminants above background levels have been detected in historical samples of sediments and surface water obtained in the canyon.

Indio Canyon, a south entering sub-basin to Water Canyon, originates on Facility property at an elevation of about 6,860 ft above mean sea level (msl) and extends for about three miles to its confluence with Water Canyon. The total drainage area of the basin is approximately 0.5 square miles. Although a detailed hydrologic investigation has yet to be performed in the canyon, the Department believes that groundwater and surface-water flow in the canyon is ephemeral. The drainage basin is located in TA-39. There are no known SWMUs or AOCs in the canyon; however, air dispersion from nearby firing sites may have impacted the drainage. Contaminants above background levels have been detected in sediments and surface water samples obtained from the canyon.

Portillo and Fence Canyons are part of the Water Canyon Watershed. Potrillo Canyon heads at an elevation of approximately 7,240 ft above msl, and extends for about seven miles to its confluence with Water Canyon. Fence Canyon originates at an elevation of approximately 7,000 ft above msl, and extends for about three miles to its confluence with Potrillo Canyon. The confluence of these two canyons is near State Road 4. The drainage areas of Potrillo Canyon and Fence Canyon are approximately 3.4 square miles and 1.1 square miles, respectively. TAs 15, 36, 68, and 71 are located within these canyons. There are approximately 53 SWMUs within the watershed. The SWMUs vary from inactive septic tanks to open-detonation firing sites. Contaminants above background levels have been detected in sediments and surface water samples obtained from the canyons.

Sources of contamination in these canyons are numerous, vary spatially, and are distinct in terms of their histories and characteristics. Radionuclides, inorganics, and organics may have been released into the canyon-bottom sediments, surface water, and shallow groundwater, although the presence, distribution, rate, and extent of these contaminants have not been determined. These canyons are a concern because: 1) contaminant sources have not been adequately characterized; 2) large volumes of a variety of contaminants have or potentially have been released to the environment; 3) contaminants may have affected soil, sediment, surface water, and groundwater, as well as ecological receptors; 4) the horizontal and vertical extent of contamination in soil, sediment, surface water, and groundwater has yet to be determined; and 5) potentially contaminated sediments are moving offsite to the Rio Grande.

Guaje, Barrancas, and Rendija Canyons are part of the Los Alamos Canyon watershed. Rendija and Barrancas Canyons terminate at Guaje Canyon from the south. Guaje Canyon terminates at Los Alamos Canyon approximately one mile upstream of the Rio Grande. Of these drainages, Guaje Canyon is the largest, encompassing approximately 26 square miles, and heads on the Sierra de Los Valles at an elevation of about 10,400 ft. Rendija Canyon has a drainage area of approximately 9.5 square miles, and heads on the Sierra de Los Valles at an elevation of about 9,800 ft. The drainage area of Barrancas is approximately 4.9 square miles. The only active TA in the canyons is TA-74, a portion of which is located in Bayo and Barrancas Canyons. There are approximately 18 SWMUs and AOCs in these drainages. These SWMUs are primarily related to mortar impact areas, firing ranges, and golf course effluent discharges.

Surface-water flow in upper Guaje Canyon is perennial and extends for about three miles. Flow is supplied by two springs that may discharge from the Guaje Pumice Bed at an elevation of about 8,800 ft. Base flow along the mid-reach portion of perennial flow is estimated at 0.4 cubic ft per second (cfs), based on historical flow records. It is assumed that perched groundwater exists in the alluvium along the perennial reach. Flow east of the perennial reach is ephemeral. In 1996, two shallow test holes were drilled approximately three miles east of the perennial flow between the Los Alamos and Guaje faults. Each borehole penetrated saturation from near ground surface to total depth (23 ft and 103 ft below ground surface, respectively). The 103-ft borehole penetrated continuous saturation in the alluvium and the Puye Formation; therefore, this may be a zone of recharge to the regional and/or intermediate aquifers. Regional aquifer water-supply wells in Guaje Canyon were first installed in the early 1950s. In recent years there have been additional replacement wells drilled. The depths to water at these wells vary depending on their location. Depth to water in the lower portion of the canyon tends to be shallow (100-200 ft and was artesian prior to early 1950s), while water levels in the upper portion near the Rendija Canyon confluence have water-table depths ranging from 400 to 500 ft bgs.

Surface-water flow in Rendija and Barrancas Canyons is ephemeral and normally flows only during the summer monsoon season; therefore, it is assumed that these canyons do not contain canyon-bottom saturation.

Contaminant sources are primarily associated with upper Rendija Canyon (firing and mortar-impact sites). Contaminants at the sites may include trace metals, organics, and radionuclides. Active sedimentation processes occur within these drainages, and the results of sampling conducted in these canyons have periodically detected trace metals, organics, and radionuclides in sediments at concentrations greater than background levels. The presence, distribution, rate, and extent of these contaminants in these canyons have not been determined.

IV.B.6.b Investigations for the Other Canyons

IV.B.6.b.i Investigation Work Plans for the Other Canyons

The Respondents shall submit to the Department for approval a work plan for the investigation of contamination in Ancho, Chaquehui, and Indio Canyons that meets the requirements of this Section (IV.B.6.b). The work plan shall be prepared in accordance with Section XI.B of this Order, and shall be submitted by the date specified in Section XII of this Order. The work plan shall address investigations of the sources of contamination, and the nature and extent of contamination in

sediments, surface water, and groundwater in Ancho, Chaquehui, and Indio Canyons, including monitoring and reporting. The work plan shall propose the frequency for submitting periodic monitoring reports. Upon Department approval, the Respondents shall implement the work plan. Upon Department approval, the work plan shall be incorporated herein by reference and become an enforceable part of this Order.

The Respondents shall submit to the Department for approval a work plan for the investigation of contamination in Portillo and Fence Canyons that meets the requirements of this Section (IV.B.6.b). The work plan shall be prepared in accordance with Section XI.B of this Order, and shall be submitted by the date specified in Section XII of this Order. The work plan shall address investigations of the sources of contamination, and the nature and extent of contamination in sediments, surface water, and groundwater in Portillo and Fence Canyons, including monitoring and reporting. The work plan shall propose the frequency for submitting periodic monitoring reports. Upon Department approval, the Respondents shall implement the work plan. Upon Department approval, the work plan shall be incorporated herein by reference and become an enforceable part of this Order.

The Respondents have submitted to the Department the Work Plan for the North Canyons, dated September 2001. The North Canyons Work Plan is incorporated herein by reference and made an enforceable part of this Order. The Respondents shall implement the work plan. If the Department determines that the work plan is inadequate to fully investigate the North Canyons, the Department will require the Respondents to submit a supplemental work plan that meets the requirements of this Section (IV.B.6.b). The supplemental work plan shall be prepared in accordance with Section XI.B of this Order. If deemed necessary, the supplemental work plan shall address investigations of the sources of contamination, and the nature and extent of contamination in sediments, surface water, and groundwater in the North Canyons, including monitoring and reporting. The supplemental work plan shall propose the frequency for submitting periodic monitoring reports.

IV.B.6.b.ii Groundwater Well Installation for the Other Canyons

The Respondents shall install an alluvial groundwater monitoring well in Ancho Canyon. Such installation shall, at a minimum, meet the requirements of Section IV.A.3.e of this Order and the following requirements:

1. One alluvial monitoring well shall be installed down gradient of MDA Y at TA-39.

IV.B.6.b.iii Groundwater Monitoring for the Other Canyons

The Respondents shall monitor and sample all wells specified below containing groundwater in accordance with Sections IV.B and IX of this Order and the following requirements.

1. Groundwater samples shall be obtained from Ancho Canyon intermediate and regional monitoring wells DT-5a, DT-9, DT-10, R-31, and all monitoring wells installed in the future at the frequency described in Section XII of this Order.

2. Groundwater samples shall be collected from the monitoring wells for submittal to a laboratory for analysis of general chemistry parameters as described in Section IX.B of this

Order, radionuclides, perchlorate, TAL metals, total uranium, cyanide, VOCs, SVOCs, HE, and for other analytes specified by the Department.

3. A long-term groundwater monitoring and sampling work plan shall be submitted to the Department for approval. The work plan shall include the specifics for conducting groundwater sampling in the Ancho Canyon watershed prior to implementation of the groundwater sampling program.

IV.B.6.b.iv Investigation Reports for the Other Canyons

The Respondents shall submit to the Department for approval an investigation report that presents the results of the field activities, summarizes the data collected, and presents the recommendations and conclusions for Ancho, Chaquehui, and Indio Canyons. The investigation report shall be prepared in accordance with Section XI.C of this Order and shall be submitted by the date specified in Section XII of this Order.

The Respondents shall submit to the Department for approval an investigation report that presents the results of the field activities, summarizes the data collected, and presents the recommendations and conclusions for Potrillo and Fence Canyons. The investigation report shall be prepared in accordance with Section XI.C of this Order and shall be submitted by the date specified in Section XII of this Order.

The Respondents shall submit to the Department for approval an investigation report that presents the results of the field activities, summarizes the data collected, and presents the recommendations and conclusions for the North Canyons. The investigation report shall be prepared in accordance with Section XI.C of this Order and shall be submitted by the date specified in Section XII of this Order.

IV.C TECHNICAL AREA INVESTIGATIONS

IV.C.1 Technical Area 54

IV.C.1.a Background

TA-54 is located at the eastern end of Mesita del Buey on the east side of the Facility. Mesita del Buey trends southeast-northwest and is bounded to the south by Pajarito Canyon and to the north by Cañada del Buey. Ephemeral streams are present in portions of both Pajarito Canyon and Cañada del Buey; therefore, groundwater is present intermittently in the alluvial sediments in both canyons adjacent to TA-54. The surficial geology of the mesa generally consists of surface soils present to depths less than three feet underlain by the Tshirege member of the Bandelier Tuff. The elevation of Mesita del Buey is approximately 6,600 to 6,900 ft above msl. The elevation of the mesa is generally 100 ft to 150 ft higher than the elevations of the adjacent Pajarito and Cañada del Buey canyon bottoms.

Hazardous, radioactive, and mixed wastes have been stored at TA-54 from the 1950s to the present. TA-54 includes four MDAs designated MDA G, H, J, and L; a waste characterization, container storage, and transfer facility (transfer facility); and administrative and support areas. The transfer

facility is located at the western end of TA-54. MDA H (SWMU 54-004) and J (SWMU 54-005) are located approximately 500 ft and 1,000 ft southeast of the transfer facility, respectively. MDA L (SWMU 54-006) and administrative offices are located approximately one mile southeast of the transfer facility. MDA G (SWMUs 54-013(b), 54-014(b-d), 54-015(k), 54-017, 54-018, 54-019, and 54-020) is located approximately one-half mile southeast of MDA L.

MDA G at TA-54 has been used as the Facility's primary radioactive disposal facility since 1957. Solid and liquid wastes were disposed at MDAs G, H, and L. MDAs G and L are also operating as hazardous and radioactive waste container storage areas. Currently, the Respondents report that MDA G is used for the disposal of low-level radioactive waste in pits and storage of mixed and transuranic waste. The Respondents report that hazardous and mixed wastes were disposed of in pits, trenches, and shafts at MDA G until 1990. MDA H is an inactive hazardous and radioactive waste disposal area that received classified or sensitive wastes and debris contaminated with radioactive, hazardous, and explosive constituents between 1960 and 1989. MDA L was used between 1959 and 1986 for disposal of mostly liquid hazardous and radioactive wastes into pits, trenches, and shafts.

The Facility disposed of trash and other generally nonhazardous waste at MDA J. MDA J is currently being closed under the authority of the Department's Solid Waste Bureau and is not included in this Order.

Environmental investigations at TA-54 show that contaminant releases have occurred at MDAs G, H, and L. However, characterization data for TA-54 are not adequate to delineate the extent of the contaminant releases or to determine the threat to human health and the environment from direct exposures and from contaminant transport to groundwater.

IV.C.1.b Historical Investigation

The Respondents shall conduct an investigation of contaminants that may have been discharged or released at MDAs G and L at TA-54 during the history of the Facility. The investigation shall include a review of existing data and other information acquired during previous investigations. In conducting the investigation, the Respondents shall review and confirm the construction details and historical use of all existing and demolished TA buildings and other structures; pits, shafts, trenches, landfills, surface impoundments, and other SWMUs; wastewater treatment, conveyance, and disposal systems; subsurface utility corridors; and other possible sources of discharges or releases of contaminants. The Respondents shall also review all investigation borings, excavations, sampling events, and other sources of information on contamination. The Respondents shall submit to the Department historical investigation reports for MDAs G and L at TA-54, which shall be included as appendices to the Investigation Work Plans under Sections IV.C.1.c.i and IV.C.1.e.i, respectively. The reports shall contain, at a minimum, the following information:

1. A description of the location, construction details, operational history, and present status of each such pit, shaft, or other structures at MDAs G and L. All such locations shall be depicted in one or more figures.

2. A description of the known or suspected disposal history of MDAs G and L. This description shall include all known and suspected materials disposed, discharged, or

released; the volume of each discharge or release; and the contaminants present in each discharge or release. The Respondents shall report whether the disposal history of each SWMU is unknown or incomplete.

3. A description of each previous investigation of the sources, extent, or characteristics of contamination at MDAs G and L, regardless of whether or not such investigation was completed.

4. A summary of any results and conclusions of each previous investigation described in Paragraph 3, including the known or suspected dates of waste disposal, the dates of each contaminant discharge or release, and the circumstances related to the contaminant release.

5. A description of the location, construction details, history, and present status of each investigation well, boring, and excavation within the boundaries of TA-54. The Respondents shall depict all such locations in one or more figures. A site map encompassing the entire TA and pertinent regional investigation locations shall be included in the description.

6. A description of the sample collection methods and the types of field and laboratory analyses performed on each sample obtained from each media during the previous investigations.

7. Tables summarizing the data collected from each investigation well, boring, and excavation. The results shall present only analyte and radionuclide detections and data quality exceptions reported by the analytical laboratory that may mask analyte and radionuclide detections.

8. A summary of data quality exceptions and interpretations of all compromised data.

9. A summary of all contradictory investigation results and the rational for acceptance or rejection of selected investigation results.

10. A list of general chemistry, metals, and radionuclide background concentrations and documentation of the methods used for establishing the background values.

The summaries shall include references to historical documents within the summary text citing the document title, page number, and table or figure number. The full reference citations shall be presented as a separate section in each summary document using the standard USGS format for reference citations. The Facility project leader for corrective action at TA-54 shall meet with Department representatives to discuss the content and presentation of the information required in this section (IV.C.1.b). The Respondents are responsible for providing complete information with regard to the available data and the need for additional data at each unit. The Department shall evaluate the information and request changes as necessary. The Department's evaluation and approval will address the Respondents' general approach to site characterization and plan for acquiring additional data required to complete the site investigations at TA-54.

IV.C.1.c MDA G Investigation

IV.C.1.c.i MDA G Investigation Work Plan

The Respondents shall submit to the Department for approval a work plan for the investigation of contamination at MDA G that meets the requirements of this Section (IV.C.1.c). The work plan shall be prepared in accordance with Section XI.B of this Order and shall be submitted by the date specified in Section XII of this Order. The work plan shall address investigations of the disposal units; migration pathways; the connections to potential receptors including groundwater; and the nature and extent of contamination in soil, rock, sediments, groundwater (where present), and soil vapor at MDA G, including monitoring and reporting. The work plan shall propose the frequency for submitting periodic monitoring reports.

Upon Department approval, the Respondents shall implement the work plan. Upon Department approval, the work plan shall be incorporated herein by reference and become an enforceable part of this Order.

IV.C.1.c.ii MDA G Survey of Disposal Units

The Respondents shall conduct a survey of the disposal units at MDA G. The Respondents shall determine the dimensions and total depth of each disposal shaft and pit, and the base profile, topography, low elevation point, and down-slope end of the base of each shaft and pit.

The dimensions and base elevations of each pit and shaft shall be determined using as-built construction drawings and boring logs. If unavailable, ground penetrating radar, magnetic surveys, or other methods shall be used. The methods used to evaluate the pits and shafts shall be approved by the Department prior to implementation. The survey shall be completed prior to implementation of the drilling explorations under Section IV.C.1.c.iii.

IV.C.1.c.iii MDA G Drilling Explorations

The Respondents shall conduct subsurface explorations in order to acquire data to characterize the extent of contamination and to characterize fracture density, fracture orientation, and fracture fill material. The fracture characterization of the rock formations underlying MDA G shall be completed utilizing data acquired from outcrop, cores, and downhole geophysical and video data. The methods and locations for collecting rock fracture data shall be approved by the Department prior to data collection.

The Respondents shall determine the following prior to the implementation of drilling explorations:

1. The dimensions and total depths of each shaft and disposal pit.

2. The base profile, topography, low elevation point, and the down-slope end of the base of each disposal pit.

The dimensions and base elevations of each disposal pit and shaft shall be determined using as-built construction drawings or boring logs, if available, ground penetrating radar, magnetic surveys, or

other methods. The methods used to evaluate the dimensions of the pits and shafts shall be approved by the Department prior to implementation.

The Respondents shall, at a minimum, meet the following requirements for completing subsurface explorations in the pit and shaft areas at MDA G:

1. A minimum of one boring shall be advanced directly adjacent to the down-slope end of each disposal pit, one boring at the down slope end of each row of disposal shafts, and one boring at the low elevation point of each pit.

2. A minimum of one boring per every 3,600 square ft shall be advanced in a shaft field and one boring per every 60 ft shall be advanced in a shaft row.

3. The borings shall be drilled to minimum depths of 20 ft below the base of the pits and a minimum of 20 ft below the base of the deepest shafts in a shaft row or shaft field.

4. The borings shall be advanced a minimum of 25 ft below detected vapor-phase, soil, rock, or groundwater contamination as detected by field screening or previous investigations.

5. Each borehole shall be characterized using geophysical logging techniques approved by the Department.

6. A general design for vapor monitoring well construction shall be submitted to the Department for approval prior to the start of subsurface explorations at TA-54.

7. Each boring shall be completed as a vapor monitoring well. The screened intervals, and methods and materials used to construct each vapor monitoring well shall be based upon information obtained during drilling activities and open-hole vapor sampling field screening results, and shall be approved by the Department prior to well construction.

8. Based on observations made during the drilling of borings 54-1015 and 54-1016 in 1995, perched groundwater may be present at depths ranging between 500 ft and 600 ft below the ground surface. A minimum of one boring shall be advanced at MDA G to evaluate for the presence of perched groundwater and vapor-phase contamination at depth beneath the site.

9. A minimum of three TA-54-specific wells shall be advanced that intersect the regional aquifer at locations approved by the Department. Two wells shall be located in Cañada del Buey, upgradient of MDA G and MDA L and between MDA G and MDA L, respectively. One well shall be located in Pajarito Canyon downgradient of MDA L.

10. The borings shall be advanced using hollow-stem auger drilling methods where practicable or other drilling methods approved by the Department.

11. All borings not completed as monitoring wells (vapor or groundwater monitoring wells) shall be properly plugged and abandoned. Documentation of proper well abandonment shall be submitted to the Department within 30 days of abandonment.

IV.C.1.c.iv MDA G Soil and Rock Sampling

The Respondents shall, at a minimum, meet the following requirements for completing soil and rock sampling during subsurface drilling explorations at MDA G:

1. Soil and rock samples shall be obtained from each boring at ten-ft intervals and from the bedrock directly below the base elevation of each pit or shaft. A sample also shall be obtained at the maximum depth of each boring.

2. The samples shall be collected and screened in accordance with the methods described in Section IX.B of this Order.

3. A detailed log of each boring shall be maintained. The results of all field screening shall be included in the corresponding boring log.

4. A minimum of six cores shall be obtained from selected borings, at depths approved by the Department, for permeability testing in accordance with Section IX.B of this Order.

5. A minimum of two samples shall be selected from each boring for submittal to a laboratory for analysis of VOCs, SVOCs, pH, HE compounds, PCBs, dioxins, furans, nitrates, perchlorate, TAL metals, total uranium, cyanide, and radionuclides.

6. The sample displaying the greatest field screening evidence of VOC or radionuclide concentrations shall be selected for submittal to the analytical laboratory for chemical analysis of the analytes listed in Paragraph 5 above. If field-screening evidence of contamination is not observed in a boring, the sample obtained from the bedrock directly below the base elevation of each pit or shaft shall be submitted for chemical analysis of the analytes listed in Paragraph 4 above.

7. The sample obtained from the maximum depth of each boring also shall be submitted to an analytical laboratory for analysis of the analytes listed in Paragraph 5 above.

IV.C.1.c.v MDA G Canyon Alluvial Sediment Sampling

The Respondents shall, at a minimum, meet the following requirements for completing canyon alluvium sampling during subsurface explorations adjacent to MDA G:

1. Soil borings shall be advanced through the alluvium into the underlying bedrock at four locations in Pajarito Canyon and two locations in Cañada del Buey approved by the Department.

2. Samples of alluvial sediments and underlying bedrock shall be collected at locations approved by the Department and in accordance with the methods described in Section IX.B of this Order.

3. At a minimum, samples shall be obtained from each boring between the ground surface and one ft below the ground surface (0-1.0 ft interval), at five-ft intervals, at the alluvial

sediment-bedrock interface, and at the maximum depth of each boring in accordance with the methods described in Section IX.B of this Order.

4. The samples shall be submitted to an analytical laboratory for analysis of HE compounds, PCBs, dioxins, furans, nitrates, perchlorate, TAL metals, total uranium, cyanide, and radionuclides.

5. If sediment samples collected from other intervals in the borings display field screening evidence of the presence of radionuclides, then those samples shall also be submitted to an analytical laboratory for analysis of the analytes listed in Paragraph 4 above.

IV.C.1.c.vi MDA G Vapor Monitoring

The Respondents shall, at a minimum, collect vapor samples from discrete zones in each vapor monitoring well or boring at depths approved by the Department and shall collect vapor as total well or boring vapor samples for field and laboratory analyses in accordance with the following requirements.

1. Vapor samples shall be collected from newly drilled borings during site investigation activities.

2. An investigation vapor monitoring and sampling work plan shall be submitted to the Department for approval within 180 days of the effective date of this Order.

3. Vapor sampling shall be conducted at MDA G in each existing and newly constructed vapor well and boring.

4. Samples of subsurface vapors shall be collected from vapor monitoring points at discrete zones, selected based on investigation and monitoring results, and as total well subsurface vapor samples.

5. A long-term subsurface vapor monitoring and sampling program work plan shall be submitted to the Department for approval prior to implementation of the vapor monitoring and sampling program at MDA G.

IV.C.1.c.vii MDA G Alluvial Groundwater Well Installation

The Respondents shall construct monitoring wells at four locations in Pajarito Canyon and at two locations in Cañada del Buey to be approved by the Department. Such installation shall, at a minimum, meet the requirements of Section IV.A.3.e of this Order and the following requirements:

1. The monitoring well borings shall be advanced to depths of five ft below the alluvium-bedrock interface.

2. The monitoring wells shall be constructed and developed in accordance with Section X of this Order.

3. Groundwater samples shall be collected from each well in accordance with Sections IV.C.1.and IX of this Order.

IV.C.1.c.viii MDA G Intermediate Groundwater Well Installation

The Respondents shall construct one intermediate depth well at MDA G to monitor for the presence of perched groundwater and vapor-phase contamination at depths between 150 ft and 700 ft below the ground surface. Such installation shall, at a minimum, meet the requirements of Section IV.A.3.e of this Order and the following requirements:

1. The boring shall be drilled to a minimum depth of 700 ft below the ground surface.

2. Vapor and groundwater samples shall be collected from the boring prior to well construction.

3. A monitoring well design plan shall be submitted to the Department for approval prior to construction of the intermediate well.

4. The Department may impose specific conditions for well construction, require the boring to be extended to the regional aquifer, or require the drilling of additional borings that intersect the intermediate perched zones or regional aquifer based on the sampling results.

IV.C.1.c.ix MDA G Regional Groundwater Well Installation

The Respondents shall, at a minimum, construct three monitoring wells associated with TA-54 and intersecting the regional aquifer. Such installation shall, at a minimum, meet the requirements of Section IV.A.3.e of this Order and the following requirements:

1. The wells shall be located at the locations described in Section IV.C.1.c.iii, Paragraph 9, of this Order.

2. The borings shall be monitored for the presence of vapor-phase contaminants prior to well construction.

3. Based on the results of vapor monitoring, the Department may require that the Respondents construct the wells to accommodate vapor monitoring in addition to groundwater monitoring and sampling.

IV.C.1.c.x MDA G Groundwater Monitoring

The Respondents shall monitor and sample all wells containing alluvial, intermediate perched, and/or regional groundwater in accordance with Sections IV.A and IX of this Order.

1. Groundwater samples shall be collected from each saturated zone intersecting the monitoring wells

2. Groundwater samples shall be submitted to a laboratory for analysis of general chemistry parameters as described in Section IX.B of this document, VOCs, SVOCs, HE compounds,

perchlorate, TAL metals, total uranium, cyanide, radionuclides, and for other analytes specified by the Department.

3. The groundwater sampling shall be conducted in accordance with Section IX.B of this Order.

4. As described in Section IV.B.4.b.v, Paragraph 5, a long-term groundwater monitoring and sampling work plan shall be submitted to the Department for approval. The work plan shall include the specifics for conducting groundwater sampling at MDA G as part of the Pajarito Canyon watershed groundwater monitoring program prior to implementation of the groundwater sampling program.

IV.C.1.c.xi MDA G Investigation Report

The Respondents shall submit to the Department for approval an investigation report that presents the results of the field activities, summarizes the data collected, and presents the recommendations and conclusions for the MDA G. The Respondents shall follow the investigation report format outlined in Section XI and the compliance schedule in Section XII.

IV.C.1.d MDA H Investigation

An investigation at MDA H is currently in progress. However, as part of that investigation, the Respondents shall complete the investigation at MDA H by implementing the subsurface investigation requirements described below. As part of that investigation, the Respondents shall confirm that no additional areas at MDA H were used for disposal purposes other than the nine currently known disposal shafts.

IV.C.1.d.i MDA H General Subsurface Investigation Requirements

The Respondents shall delineate the following subsurface conditions to complete the investigation at MDA H:

1. The horizontal and vertical extent of soil, rock, groundwater, and vapor-phase contamination.

2. The migration pathways and distance of contaminant migration in all subsurface media.

The subsurface conditions shall be characterized by collecting and evaluating samples of soils, rock, groundwater (where present), and subsurface vapors for field screening and laboratory analysis.

IV.C.1.d.ii MDA H Drilling Explorations

The Respondents shall conduct subsurface explorations in order to acquire data to characterize the extent of contamination, and to characterize fracture density, fracture orientation, and fracture fill material. The fracture characterization in the rock formations underlying MDA H shall be completed utilizing data acquired from outcrop, drill cuttings and core data, and downhole geophysical and video data. The methods and locations for collecting rock fracture data shall be approved by the Department prior to data collection.

The Respondents shall characterize the existing tritium plume at MDA H. The following are minimum requirements for completing subsurface explorations at MDA H:

1. A minimum of four borings shall be advanced at the anticipated outer limits of the tritium plume in locations north, south, east, and west of MDA H at locations approved by the Department prior to the start of drilling activities.

2. The borings shall be advanced a minimum of 100 ft below the ground surface or a depth of 25 ft below the level of detected vapor-phase tritium, tritium in soil, rock, or groundwater as detected by field screening. If contamination is not detected, the borings shall be advanced to depths 25 ft below the depth of vapor-phase tritium detected during previous investigations. One of the borings shall be drilled to a minimum depth of 150 ft or to the Cerro Toledo unit. The location of the deeper boring shall be approved by the Department.

3. A detailed log of each boring shall be maintained. The results of all field screening shall be included in the corresponding boring log.

4. The Respondents shall cease drilling activities and notify the Department immediately if groundwater is encountered in any of the borings. Drilling shall not resume in any boring where groundwater has been encountered until the Department has approved, in writing, the strategy for continued borehole advancement and well construction.

5. The borings shall be advanced using hollow-stem auger drilling methods, where practicable, or other drilling methods approved by the Department.

6. Each borehole shall be characterized using geophysical logging techniques approved by the Department.

7. A general design for vapor monitoring well construction shall be submitted to the Department for approval prior to the start of subsurface explorations at MDA H.

8. Each boring shall be completed as a vapor monitoring well. The screened intervals, and methods and materials used to construct each vapor monitoring well shall be based upon information obtained during drilling activities and open-hole vapor sampling field screening results, and shall be approved by the Department prior to well construction.

If contamination is detected at the base of 54-1023, then the Respondents shall prepare a work plan for submittal to the Department for additional subsurface investigation directly beneath MDA H. Upon approval by the Department, the Respondents shall implement the work plan in order to determine the vertical extent of contamination beneath MDA H. Boring 54-1023 shall be maintained as a vapor monitoring well. The level of contamination shall be determined at the base of well 54-1023.

IV.C.1.d.iii MDA H Soil and Rock Sampling

The Respondents shall, at a minimum, complete the following requirements for soil and rock sampling during subsurface explorations at MDA H:

1. Soil and rock samples shall be obtained from each boring at ten-ft intervals. A sample also shall be obtained at the maximum depth of each boring.

2. The samples shall be collected using split barrel samplers lined with brass sleeves or by coring methods.

3. The samples shall be screened in the field for the presence of VOCs, pH, and radionuclides using methods approved by the Department. In addition, the drill cuttings generated from each boring shall be screened for the presence of radionuclides during drilling activities.

4. A minimum of two cores shall be obtained from selected borings, at depths approved by the Department, for permeability testing using American Society for Testing and Materials (ASTM) methods.

5. A minimum of two samples from each boring shall be selected for laboratory analysis of moisture content, tritium, VOCs, SVOCs, pH, PCBs, dioxins, furans, HE compounds, nitrates, perchlorate, TAL metals, total uranium, cyanide, and radionuclides.

6. The sample displaying the greatest field screening evidence of VOC and/or radionuclide concentrations shall be selected for submittal to the analytical laboratory. If field-screening evidence of contamination is not observed in a boring, the sample corresponding to the maximum depth of the shafts shall be selected for laboratory analyses.

7. The sample obtained from the maximum depth of each boring shall be submitted to the analytical laboratory for the analyses listed in Paragraph 5 above.

IV.C.1.d.iv MDA H Sediment Sampling

The Respondents shall, at a minimum, meet the following requirements for completing canyon alluvium sampling during subsurface explorations adjacent to MDA H:

1. One sediment sample shall be collected at the approximate location of boring 54-5132.

2. The sample shall be obtained at the interface between the alluvial sediments and bedrock.

3. The sample shall be submitted to an analytical laboratory for analysis of HE compounds, PCBs, dioxins, furans, nitrates, perchlorate, TAL metals, total uranium, cyanide, and radionuclides.

IV.C.1.d.v MDA H Vapor Monitoring

The Respondents shall, at a minimum, collect subsurface vapor samples at MDA H for field and laboratory analyses in accordance with Section IX.B of this Order.

1. Vapor samples shall be collected from newly drilled borings during site investigation activities.

2. An investigation vapor monitoring and sampling work plan shall be submitted by the Respondents to the Department for approval in accordance with Section XII of this Order.

3. Vapor sampling shall be conducted at MDA H in each existing and newly constructed vapor monitoring well and boring.

4. Samples of subsurface vapors shall be collected by the Respondents from vapor monitoring points at discrete zones, selected based on investigation and monitoring results, and as total well or boring subsurface vapor samples. The Department shall approve the depths for discrete vapor sample collection.

5. A long-term subsurface vapor monitoring and sampling program work plan shall be submitted to the Department for approval prior to implementation of the vapor monitoring and sampling program at MDA H.

IV.C.1.d.vi MDA H Groundwater Well Installation

The Respondents shall construct monitoring wells in soil borings drilled in either canyon bottom if groundwater is observed during subsurface explorations conducted to fulfill the requirements of this Order. If no groundwater is encountered during this investigation, the Respondents shall defer groundwater monitoring until groundwater investigation at MDAs L and G are evaluated. The need for further groundwater investigation and monitoring at MDA H shall be determined by the Department.

IV.C.1.d.vii MDA H Investigation Report

The Respondents shall submit to the Department for approval an investigation report that presents the results of the field activities, summarizes the data collected, and presents the recommendations and conclusions for MDA H. The investigation report shall be prepared in accordance with Section XI.C of this Order and shall be submitted by the date specified in Section XII of this Order.

IV.C.1.e MDA L Investigation

IV.C.1.e.i MDA L Investigation Work Plan

The Respondents shall submit to the Department for approval a work plan for the investigation of contamination at MDA L that meets the requirements of this Section (IV.C.1.e). The work plan shall be prepared in accordance with Section XI.B of this Order and shall be submitted by the date specified in Section XII of this Order. The work plan shall address investigations of the disposal units; migration pathways; the connections to potential receptors including groundwater; and the nature and extent of contamination in soil, rock, sediments, groundwater (where present), and soil vapor at MDA L, including monitoring and reporting. The work plan shall propose the frequency for submitting periodic monitoring reports.

Upon Department approval, the Respondents shall implement the work plan. Upon Department approval, the work plan shall be incorporated herein by reference and become an enforceable part of this Order.

IV.C.1.e.ii MDA L Survey of Disposal Units

The Respondents shall conduct a survey of the disposal units at MDA L. The Respondents shall determine the dimensions and total depth of each disposal shaft and pit, and the base profile, topography, low elevation point, and down-slope end of the base of each shaft and disposal pit.

The dimensions and base elevations of each pit and shaft shall be determined using as-built construction drawings and boring logs. If unavailable, ground penetrating radar, magnetic surveys, or other methods shall be used. The methods used to evaluate the pits and shafts shall be approved by the Department prior to implementation. The survey shall be completed prior to implementation of the drilling explorations under Section IV.C.1.e.iii.

IV.C.1.e.iii MDA L Drilling Explorations

The Respondents shall conduct subsurface explorations in order to acquire data to characterize the extent of contamination, and to characterize fracture density, fracture orientation, and fracture fill material. The fracture characterization in the rock formations underlying MDA L shall be completed utilizing data acquired from outcrop, core data, and downhole geophysical and video data. The methods and locations for collecting rock fracture data shall be approved by the Department prior to data collection.

The Respondents shall, at a minimum, meet the following requirements for completing subsurface explorations in the pit and shaft areas at MDA L:

1. A minimum of one boring shall be advanced directly adjacent to the locations of the down-slope end of each disposal pit, one boring at the low elevation point of each disposal pit, and one boring at the down slope end of each row of disposal shafts.

2. A minimum of one boring per every 60 ft shall be advanced in a shaft row.

3. The borings shall be drilled to minimum depths of 20 ft below the base of the pits and a minimum of 20 ft below the base of the deepest shafts in a shaft row or shaft field.

4. The borings shall be advanced a minimum of 25 ft below detected vapor-phase, soil, rock, or groundwater contamination as detected by field screening or previous investigations.

5. The borings shall be advanced using hollow-stem auger drilling methods, where practicable, or other drilling methods approved by the Department.

6. Each borehole shall be characterized using geophysical logging techniques approved by the Department.

7. A general design for vapor monitoring well construction shall be submitted to the Department for approval prior to the start of subsurface explorations at MDA L.

8. Each boring shall be completed as a vapor monitoring well. The screened intervals, and methods and materials used to construct each vapor monitoring well shall be based upon

information obtained during drilling activities and open-hole vapor sample field screening results, and shall be approved by the Department prior to well construction.

9. A minimum of three TA-54-specific wells that intersect the regional aquifer shall be installed at locations approved by the Department. The well locations shall be established at the locations and under the conditions described in Section IV.C.1.e.viii.

IV.C.1.e.iv MDA L Soil and Rock Sampling

The Respondents shall, at a minimum, meet the following requirements for completing soil and rock sampling during subsurface explorations at MDA L:

1. Soil and rock samples shall be collected from each boring at ten-ft intervals and from the bedrock directly below the base elevation of each pit or the deepest shaft in the shaft row. A sample also shall be obtained at the maximum depth of each boring.

2. Samples shall be collected using split-barrel samplers lined with brass sleeves or by coring methods.

3. Samples shall be screened in the field for the presence of VOCs, pH, and radionuclides using methods approved by the Department. In addition, the drill cuttings generated from each boring shall be screened for the presence of radionuclides during drilling activities.

4. A detailed log of each boring shall be maintained. The results of all field screening shall be included in the corresponding boring log.

5. A minimum of three cores shall be collected from selected borings, at depths approved by the Department, for permeability testing using ASTM Methods.

6. A minimum of two samples from each boring shall be selected for submittal to a laboratory for analysis of VOCs, SVOCs, pH, PCBs, dioxins, furans, HE compounds, nitrates, perchlorate, TAL metals, total uranium, cyanide, and radionuclides.

7. The sample displaying the greatest field screening evidence of VOC and/or radionuclide concentrations shall be selected for submittal to the analytical laboratory for analysis of the analytes listed in Paragraph 6 above. If field screening evidence of contamination is not observed in a boring, the sample obtained from the bedrock directly below the base elevation of each pit or shaft shall be submitted for chemical analysis of the analytes listed in Paragraph 6 above.

8. The sample obtained from the maximum depth of each boring shall be analyzed by a laboratory for the analytes listed in Paragraph 6 above.

IV.C.1.e.v MDA L Canyon Alluvium and Sediment Sampling

The Respondents shall, at a minimum, meet the following requirements for completing soil and bedrock sampling during canyon alluvium sampling adjacent to MDA L:

1. Soil borings shall be advanced through the alluvium into the underlying bedrock at one location in Pajarito Canyon and at one location in Cañada del Buey.

2. Samples of alluvial sediments and underlying bedrock shall be collected at locations approved by the Department and in accordance with the methods described in Section IX.B of this Order.

3. At a minimum, samples from each boring shall be collected between the ground surface and one ft below the ground surface (0-1.0 ft interval), at five-ft intervals, at the alluvial sediment-bedrock interface, and at the maximum depth of each boring in accordance with the methods described in Section IX.B of this Order.

4. Samples shall be submitted to a laboratory for analysis of HE compounds, PCBs, dioxin, furan, nitrate, perchlorate, TAL metals, cyanide, and radionuclide concentrations.

5. If sediment samples collected from other intervals in the borings display field screening evidence of the presence of radionuclides, those samples shall also be analyzed for the analytes listed in Paragraph 4 above.

IV.C.1.e.vi MDA L Vapor Monitoring

The Respondents shall, at a minimum, collect vapor samples at MDA L in each existing and newly constructed vapor well and boring at discrete zones approved by the Department and as total borehole/well samples. The samples shall be collected and analyzed in accordance with Section IX.B of this Order.

1. Vapor samples shall be collected from newly drilled borings during site investigation activities.

2. An investigation vapor monitoring and sampling work plan shall be submitted to the Department for approval in accordance with Section XII of this Order.

3. Vapor sampling shall be conducted at MDA L in each existing and newly constructed vapor well and boring.

4. Subsurface vapor samples shall be collected from vapor monitoring points at discrete zones, selected based on investigation and monitoring results, and as total well or boring subsurface vapor samples.

5. A long-term subsurface vapor monitoring and sampling program work plan shall be submitted to the Department for approval prior to implementation of the vapor monitoring and sampling program at MDA L.

IV.C.1.e.vii MDA L Alluvial Groundwater Well Installation

The Respondents shall advance monitoring well borings in the alluvium at one location in Pajarito Canyon and one location in Cañada del Buey approved by the Department.

1. The monitoring well borings shall be advanced to depths of five ft below the alluvium-bedrock interface.

2. The monitoring wells shall be constructed and developed in accordance with Section X of this Order.

3. Groundwater samples shall be collected from each well in accordance with Sections IV.C.1and IX of this Order.

IV.C.1.e.viii MDA L Intermediate Groundwater Well Installation

The Respondents shall, at a minimum, install one intermediate depth well at MDA L to evaluate for the presence of perched groundwater and vapor-phase contamination at depths between 150 ft and 700 ft below the ground surface as described in Section IV.C.1.c.vii. The Respondents shall submit a monitoring well design plan to the Department for approval prior to construction of the intermediate well at MDA L.

1. The boring shall be drilled to a minimum depth of 700 ft below the ground surface.

2. Vapor and groundwater samples shall be collected from the boring prior to well construction.

3. A monitoring well design plan shall be submitted to the Department for approval prior to construction of the intermediate well.

4. The Department may impose specific conditions for well construction, require the boring to be extended to the regional aquifer, or require the drilling of additional borings that intersect the intermediate perched zones or regional aquifer based on the sampling results.

IV.C.1.e.ix MDA L Regional Groundwater Well Installation

The Respondents shall, at a minimum, construct three monitoring wells associated with TA-54 intersecting the regional aquifer as described in Section IV.C.1.c.ix above.

1. Two wells shall be located in Cañada del Buey, upgradient of MDA G and MDA L and between MDA G and MDA L, respectively.

2. One well shall be located in Pajarito Canyon downgradient of MDA L.

3. The borings shall be monitored for the presence of vapor-phase contaminants prior to well construction.

4. Based on the results of vapor monitoring, the Department may require that the Respondents construct the wells to accommodate vapor monitoring in addition to groundwater monitoring and sampling.

IV.C.1.e.x MDA L Groundwater Monitoring

The Respondents shall monitor and sample all wells containing alluvial, intermediate perched, and/or regional groundwater in accordance with Sections IV.A and IX of this Order.

1. Groundwater samples shall be collected from each saturated zone intersecting the monitoring wells for analysis of general chemistry parameters as described in Section IX.B of this Order and for VOCs, SVOCs, HE compounds, perchlorate, TAL metals, total uranium, cyanide, and radionuclides, and for other analytes specified by the Department.

2. The groundwater sampling shall be conducted in accordance with Section IX.B of this Order.

3. As described in Section IV.B.4.b.v, Paragraph 5, a long-term groundwater monitoring and sampling work plan shall be submitted to the Department for approval. The work plan shall include the specifics for conducting groundwater sampling at MDA L as part of the Pajarito Canyon watershed prior to implementation of the groundwater-sampling program.

IV.C.1.e.xi MDA L Investigation Report

The Respondents shall submit to the Department for approval an investigation report that presents the results of the field activities, summarizes the data collected, and presents the recommendations and conclusions for MDA L. The investigation report shall be prepared in accordance with Section XI.C of this Order and shall be submitted by the date specified in Section XII of this Order.

IV.C.2 Technical Area 21

IV.C.2.a Background

TA-21 is located on DP Mesa, which is located on the northern side of the Facility. DP Mesa trends southeast-northwest and is bounded on the south by Los Alamos Canyon and on the north by DP Canyon. Los Alamos Canyon heads in the Sierra de Los Valles and DP Canyon heads on the Pajarito Plateau at the Los Alamos Townsite, which borders TA-21 to the west. The majority of the land area surrounding TA-21 is industrial and/or commercial, however there is a residential area located on the northern rim of DP Canyon near the canyon head.

TA-21 is the former plutonium processing area. Plutonium processing operations began at TA-21 in 1945 and ceased in 1978. TA-21 was divided into DP West and DP East. The primary function of DP West was the production of metal and metal-alloys of plutonium. DP East began operation in 1945 to process polonium and actinium as well as to produce initiators, a weapons component. TA-21 contains five MDAs: A, B, T, U, and V.

Native soil cover and fill material of various thickness are underlain by the Tshirege Member of the Bandelier Tuff, the Cerro Toledo interval, and the Otowi Member of the Bandelier Tuff. The elevation of DP Mesa is roughly 7,140 ft above mean sea level. The mesa top is generally 100 to 400 ft higher than the canyon bottom elevations of DP and Los Alamos Canyons.

Ephemeral streams, which likely recharge the canyon alluvial aquifers, are present in portions of DP and Los Alamos Canyons. DP Spring, which is located east of the main portion of TA-21, emits

from the contact between colluvial fill and the Tshirege Member of the Bandelier Tuff. Tritium and strontium have been detected in this spring. One Los Alamos County municipal supply well, Otowi-4, is located at the Los Alamos-DP Canyon confluence.

TA-21 contains 112 SWMUs which fall into four broad categories: 1) deep liquid releases from seepage and absorption beds; 2) near-surface and surface liquid releases from septic systems and outfalls; 3) subsurface waste disposal such as landfills and disposal pits and shafts; and 4) surface contamination areas affected by fallout from stack emissions and surface spills.

This section (IV.C.2) of the Order addresses site-specific requirements for MDAs A, B, T, U, and V. SWMU 21-011(k) and SWMU 21-024(f) are considered to be high priority SWMUs; however, these sites are addressed separately in Section VI of this Order because corrective action activities are ongoing at these SWMUs. The remaining SWMUs located at TA-21 shall be addressed in accordance with Section V of this Order.

MDA A (SWMU 21-014) was used for disposal of liquid and solid waste during two time periods: 1945 to 1949 and 1969 to 1977. During the first disposal period (1945-1949), waste was disposed in two pits located at the east end of the SWMU and in two large underground tanks. During the second disposal period (1969-1977), decontamination and decommissioning debris generated at TA-21 was disposed of in a large pit located in the center of the MDA.

The two pits at the east end of the MDA were constructed in 1945 and are estimated to contain approximately 1,000 cubic yards of waste. Wastes streams included laboratory equipment, building construction debris, chemicals, and various other types of solid and liquid waste. In addition to subsurface disposal, 55-gallon drums of iodide waste were stored on the eastern portion of the MDA in the 1950s. Corrosion of the drums resulted in releases of liquid waste to the ground surface. The total volume of liquid and the exact chemical content stored and released from the drums is unknown.

The "general's tanks" are two subsurface 50,000-gallon steel tanks located on the western end of MDA A. The Facility used the tanks to store liquid waste containing plutonium-239/240. The liquid contents of the tanks were removed between 1975 and 1983 and transported to the TA-21 waste treatment facility (TA-21-257). Although the liquid was removed from the tanks, an unknown volume of radioactive sludge remains in the tank bottoms. In 1985 the ports to the tanks were sealed to prevent additional rainwater from entering and accumulating in the tanks.

In 1969, the Facility constructed a large pit (approximately 7,000 cubic yards in volume) in the center of MDA A (Center Pit). The Center Pit was constructed to receive debris from TA-21 decommissioning activities. In 1972 the Center Pit was enlarged to accommodate a total of approximately 18,750 cubic yards of decommissioning material. Following completion of TA-21 decommissioning activities in 1974, an unknown volume of waste of an unspecified nature was placed in the Center Pit to fill the excavation prior to placement of a soil cover on the pit. A soil cover was placed over the Center Pit in May 1978. Based on historical information provided to the Department by the Respondents, contaminants placed into the Center Pit include plutonium-239/240, plutonium-238, uranium-235, depleted uranium, other unspecified radionuclides, and asphalt.

MDA B (SWMU 21-015) covers approximately six acres and is the largest solid waste disposal area within TA-21. Based on historical information provided to the Department by the Respondents, the subsurface disposal pits at MDA B occupy a surface area of approximately 5,575 square yards, with an approximate volume capacity of 27,780 cubic yards. MDA B consists of two areas, an unpaved eastern area, and a paved and fenced western area. The exact number of pits at MDA B is unknown; however, based on historical information provided to the Department by the Respondents, a minimum of five disposal pits exist.

Disposal began at MDA B in 1945 and lasted until 1948. MDA B was favored by the Facility as a disposal site because sufficient space for disposal was available. In 1948, a high intensity fire burned at MDA B. The fire is believed to have lasted only two hours and burned an area of approximately 2,500 square ft in the MDA. The exact location of the fire is unknown. The probable cause of the fire is believed to have been spontaneous combustion of mixed chemicals probably containing plutonium, americium, and fission products. After the fire, the MDA was closed and no longer received waste. Subsidence occurred, and the resulting depressions were used for the disposal of concrete and soil generated during construction activities. In 1966 the western portion of the MDA was compacted, paved, and fenced. Surface stabilization of the eastern portion of the MDA began in July 1982 and completed in October 1982. Capping studies began for the eastern portion of the MDA in 1987 to evaluate alternative cover designs.

Based on information provided by the Respondents, hazardous chemicals may be present at MDA B. Chemical disposal repeatedly occurred at the eastern portion of the MDA. Chemicals believed to be disposed in MDA B include various organic chemicals, perchlorates, ethers, and solvents. In addition, Respondents' documents indicate the possibility of spent chemicals, chemical mixtures, old chemicals, and corrosive gases located in a trench or trenches at the eastern end of the MDA. In addition, radioactive solid waste material, mainly plutonium, polonium, uranium, americium, curium, radioactive lanthanum, actinium, and waste products from a water boiler were also disposed of in MDA B. Information also indicates that at least one truck contaminated with fission products from the Trinity test and various other large pieces of debris were disposed at MDA B.

MDA T consists of SWMUs 21-001, 21-010(a-h), 21-011(a, c-j), 21-016(a-c), and 21-028(a), and AOCs C-21-009 and C-21-012. MDA T is approximately 2.21 acres and consists of four absorption beds used to dispose of liquid waste; a retrievable waste storage area; a series of disposal shafts; an acid holding tank and acid sump; a structure (TA-21-186); a caisson built at the northwest corner of absorption bed 1 in 1959; an inactive container storage area for alcohol, acetone, and freon; and two surface spills of americium-241 paste (C-21-009 and C-21-012). MDA T is believed to be one of the oldest disposal areas at the laboratory, operating from 1945 to 1983. References indicate that MDA T may have received waste as early as 1942, but documented disposal did not occur until 1945.

The Facility used the absorption beds to dispose of liquid waste from 1945 until 1952, when the industrial liquid waste treatment facility (SWMU 21-010) was constructed to treat waste prior to disposal. Approximately 10,450 gallons of ammonium citrate waste were discharged to the beds from 1951 to 1952 at which time the beds became clogged from the discharge. Liquid waste from various operations at TA-21 continued to be discharged to the beds until 1967. The exact composition of the wastewater is unknown.

The disposal shafts at MDA T received liquid and solid waste from May 1968 to April 1983. The shafts are generally located between absorption beds 2 and 4, range from approximately 15 to 69 ft deep, and are six to eight ft in diameter. Waste streams disposed in the shafts include mixed waste, plant sludge, and radioactive wash water. In addition, five concrete-lined shafts contained bathyspheres filled with plutonium-239/240.

A retrievable waste storage area was used from 1974 to 1983 to store transuranic radionuclides in retrievable waste containers. The waste was pumped from a pug mill into corrugated metal pipes. The pipes were capped on both ends using one foot of "cold cement." In August 1984, 69 pipes were removed and relocated to MDA G. The remaining 158 pipes were removed and relocated to MDA G in 1986. Following pipe removal, the site was reclaimed and no further waste storage activities were conducted.

Two AOCs are located at MDA T. These AOCs are associated with releases of americium-241 in a cement paste form. The spills are a direct result of shaft and corrugated metal pipe filling activities. Spill C-21-009 is believed to have occurred in 1978 while filling an asphalt-lined shaft. The exact location of the spill is unknown; therefore contamination located around the asphalt-lined shafts is probably related to this spill. Release C-21-012 resulted from a 1976 spill during pipe filling activities. The exact location of this spill is also unknown; therefore, contamination between absorption beds 1 and 3 may be directly attributed to the spill.

MDA U (SWMUs 21-017(a-c) and 21-022(f)) covers approximately 0.2 acres and consists of two absorption beds used for the subsurface disposal of liquid wastewater and an associated sump located between the two beds. MDA U is believed to have received wastewater from Buildings 21-152 and 21-153 from 1948 until 1968. MDA U continued to receive cooling tower effluent from the Tritium Systems Test Assembly cooling tower until sometime after 1976. The exact composition and amount of wastewater disposed of is unknown. However, the primary contaminants released are believed to be polonium-210 and actinium-227. Historical data suggest that tritium, uranium, and plutonium contamination is present at the site. Additional contaminants may be identified during future investigation activities.

MDA V (SWMUs 21-013(b and g) and 21-018(a and b)) operated continuously from 1945 to 1961 and comprises approximately 0.88 acre consisting of three absorption beds used for the subsurface disposal of wastewater generated from a laundry operation at Building 20 [SWMU 21-018(b)]. Based on historical information, each pit is estimated to be 25 ft wide by 220 ft long and approximately six ft deep, and filled with two ft of cobbles, covered with a one-ft layer of gravel, followed by one foot of soil and tuff. The holding capacity of each pit is estimated to be 60,000 gallons. All wastewater was discharged into the first pit, which acted as a grease sump. The first pit was designed to fill with water to a depth of two ft from the bottom of the pit before overflow pipes would deliver water to the second pit and then onto the third pit. The volume of wastewater reaching pits two and three is unknown. The Respondents have estimated that approximately 40 million gallons of wastewater was disposed of at MDA V. Wastewater discharged to the pits may have contained plutonium, polonium, strontium, barium, and lanthanum. In addition, elevated concentrations of tritium were detected in soil samples collected from MDA V in 1982.

IV.C.2.b Historical Investigation

The Respondents shall conduct an investigation of contaminants that may have been discharged or released at MDAs A, B, T, U, and V at TA-21 during the historical operations at the Facility. The investigation shall include the known or suspected source of any groundwater contaminants, and a review of existing data and other information acquired during previous investigations. In conducting the investigation, the Respondents shall review and confirm the construction details and historical use of all existing and demolished TA buildings and other structures; pits, shafts, trenches, landfills, surface impoundments, and other SWMUs; wastewater treatment, conveyance, and disposal systems; subsurface utility corridors; and other possible sources of discharges or releases of contaminants. The Respondents shall also review all investigation borings, excavations, sampling events, and other sources of information on contamination. The Respondents shall submit to the Department historical investigation reports for MDAs A, B, T, U, and V, which shall be included as appendices to the MDAs A, B, T, U, and V Investigation Work Plans under Sections IV.C.2.c.i, IV.C.2.d.i, IV.C.2.e.i, IV.C.2.f.i, and IV.C.2.g.i, respectively. The reports shall contain, at a minimum, the following information:

1. A description of the location, construction details, operational history, and present status of each absorption bed, shaft, trench, pit, or other structure at the sites. All such locations shall be depicted in one or more figures.

2. A description of the known or suspected disposal history of each absorption bed, shaft, trench, pit, or other structure at the sites listed under Paragraph 1. This description shall include all known and suspected materials disposed, discharged, or released; the volume of each discharge or release; the flow rate of each discharge or release; and the contaminants present in each discharge or release. The Respondents shall report whether the disposal history is incomplete or unknown.

3. A description of each previous investigation of the sources, extent, or characteristics of contamination at MDAs A, B, T, U, and V, regardless of whether or not such investigation was completed.

4. A summary of any results and conclusions of each previous investigation described in Paragraph 3, including the known or suspected dates of waste disposal, the suspected dates of contaminant releases, and the circumstances related to the contaminant releases.

5. A description of the location, construction details, history, and present status of each investigation well, boring, and excavation at each MDA, SWMU, and AOC within the TA boundary. All such locations shall be depicted in one or more figures. A site map encompassing the entire TA and pertinent regional investigation locations shall be included in the description.

6. A description of the sample collection methods and the types of field and laboratory analyses performed on each sample obtained from each media during the previous investigations.

7. Tables summarizing the data collected from each investigation well, boring, and excavation.

The results shall present only analyte and radionuclide detections and data quality exceptions reported by the analytical laboratory that may mask analyte and radionuclide detections.

8. A summary of data quality exceptions and interpretations of all compromised data.

9. A summary of all contradictory or anomalous investigation results and the rationale for acceptance or rejection of the data.

10. A list of general chemistry, metals, and radionuclide background concentrations and documentation of the methods used for establishing the background values.

The summaries shall include references to historical documents within the summary text citing the document title, page number, and table or figure number. The full reference citations shall be presented as a separate Section in each summary document using the standard USGS format for reference citations. The Facility project leader for TA-21 corrective action activities shall meet with Department representatives to discuss the content and presentation of the information required in this Section. The Respondents are responsible for providing complete information with regard to the available data and the need for additional data at each unit. The Department shall evaluate the information and request changes as necessary. The Department's evaluation and approval will address the Respondents' general approach to site characterization and plan for acquiring additional data required to complete the site investigations at TA-21.

IV.C.2.c MDA A Investigation

IV.C.2.c.i MDA A Investigation Work Plan

The Respondents shall submit to the Department for approval a work plan for the investigation of contamination at MDA A that meets the requirements of this Section (IV.C.2.c). The work plan shall be prepared in accordance with Section XI.B of this Order, and shall be submitted by the date specified in Section XII of this Order. The work plan shall address investigations of the disposal units, migration pathways and the connections to potential receptors including groundwater, and the nature and extent of contamination in soil, rock, sediments, groundwater (where present), and soil vapor (if detected) at MDA A, including monitoring and reporting. The work plan shall propose the frequency for submitting periodic monitoring reports.

Upon Department approval, the Respondents shall implement the work plan. Upon Department approval, the work plan shall be incorporated herein by reference and become an enforceable part of this Order.

IV.C.2.c.ii MDA A Survey of Disposal Units

The Respondents shall conduct a survey of the disposal units at MDA A. The Respondents shall determine the dimensions and total depth of each disposal trench, absorption bed, shaft, pit, and other unit; and the base profile, topography, low elevation point, and down-slope end of the base of each disposal trench, shaft, pit, and absorption bed.

The dimensions and base elevations of each trench, absorption bed, pit, shaft, and other unit shall be determined using as-built construction drawings and boring logs. If unavailable, ground penetrating radar, magnetic surveys, or other methods shall be used. The methods used to evaluate the disposal units shall be approved by the Department prior to implementation. The survey shall be completed prior to implementation of the drilling explorations under Section IV.C.2.c.iii.

IV.C.2.c.iii MDA A Drilling Explorations

The Respondents shall conduct subsurface explorations in order to obtain sufficient data to characterize the extent of contamination, and to characterize fracture density, fracture orientation, and fracture fill material or the absence of fracture fill material in bedrock underlying MDA A. The fracture characterization of the rock formations underlying MDA A shall be completed utilizing data acquired from outcrops, cores, and downhole geophysical and video log data. A discussion of the sampling methods and potential locations for collecting rock fracture data shall be included within the required Investigation Work Plan for MDA A. The Department, prior to field investigation and data collection activities, shall approve the methods and locations for the fracture investigation activities.

The subsurface investigation activities at MDA A shall, at a minimum, meet the following requirements:

1. A minimum of 15 borings shall be advanced using hollow-stem auger drilling methods where practical or other drilling methods approved by the Department. Three of the borings shall be advanced to the base of the Cerro Toledo interval. All borings shall be drilled in accordance with Section IX of this Order. The Department, prior to drilling, shall approve the location of the borings and the drilling method.

2. Each borehole shall be characterized using geophysical logging techniques approved by the Department.

3. A monitoring well shall be installed if groundwater (perched or regional) is encountered during drilling activities or if geophysical results indicate possible zone(s) of saturation. The wells shall be constructed in accordance with Section X of this Order.

4. Vapor monitoring wells shall be installed in the borings if vapor-phase contamination is detected during drilling activities.

5. All borings not completed as monitoring wells (vapor or groundwater monitoring wells) shall be properly plugged and abandoned as described in Section X.D. Documentation of proper well abandonment shall be submitted to the Department within thirty (30) days of abandonment.

IV.C.2.c.iv MDA A Soil and Rock Sampling

The following are minimum requirements for conducting soil and rock sampling during subsurface explorations activities at MDA A:

1. Soil samples shall be collected continuously for the first 40 ft and at ten-ft intervals there after.

2. Samples shall be collected and screened in accordance with the methods described in Section IX.B of this Order.

3. A minimum of four core samples from the tuff overlying the Cerro Toledo shall be collected and submitted for laboratory permeability testing in accordance with Section IX.B of this Order.

4. Field screening and laboratory sample selection shall be biased toward evidence of contamination, lithologic contacts, fractures, fracture fill material, surge beds and other higher permeability units identified during investigation activities. The samples shall be collected and screened in accordance with the methods described in Section IX.B of this Order.

5. Sediment, soil, and rock samples shall, at a minimum, be obtained from the intervals described in Paragraph 1 above and from the bedrock directly below the base elevation of each absorption bed or shaft. A sample also shall be obtained at the maximum depth of each boring.

6. A minimum of four samples shall be selected from each boring for submittal to a laboratory for analysis of VOCs, SVOCs, HE, pH, PCBs, dioxins, furans, nitrates, perchlorate, TAL metals, total uranium, cyanide, and radionuclides. The sample exhibiting the highest field screening detection; the sample obtained from the maximum depth in each boring that displays field screening evidence of contamination; the sample located immediately below the base of any pit, tank or other structure; and the sample from the total boring depth shall be submitted for laboratory analysis.

IV.C.2.c.v MDA A Sediment Sampling

All TA-21 outfalls shall be investigated in accordance with Section IV.A.4 of this Order. The characterization of the drainages shall be included in the work plan prepared to fulfill the requirements of Section IV.A.4 of this Order.

IV.C.2.c.vi MDA A Vapor Monitoring

The Respondents shall determine if vapor-phase contamination is present beneath the Site. If vapor-phase contamination is detected, the Respondents shall install vapor monitoring wells in the borings and conduct vapor monitoring and sampling as outlined in Section IX.B of this Order. Prior to well construction, the Respondents shall submit a vapor monitoring and sampling work plan to the Department for approval. If vapor-phase contamination is detected, the Respondents shall, at a minimum, collect vapor samples from discrete zones in each vapor monitoring well or boring at depths approved by the Department. These data will be used to evaluate the need for additional monitoring and investigation.

IV.C.2.c.vii MDA A Intermediate Groundwater Well Installation

If intermediate zone groundwater is encountered or if geophysical or other evidence suggests the presence of intermediate perched groundwater during the required subsurface investigations for MDA A, the Department may require intermediate groundwater monitoring well(s) be installed. The minimum depth of the subsurface investigations for MDA A will be the base of the Cerro Toledo interval. If groundwater is detected, these monitoring wells shall target all potential intermediate perched water bearing intervals identified during subsurface explorations at MDA A. If required, the Respondents shall include the well(s) in the TA-21 monitoring and sampling plan.

IV.C.2.c.viii MDA A Regional Groundwater Well Installation

The Respondents shall install regional groundwater monitoring wells if the Department determines the need for additional wells intersecting the regional groundwater aquifer associated with TA-21 based on investigation data. The wells shall be installed according to the requirements in Section X of this Order.

IV.C.2.c.ix MDA A Groundwater Monitoring

The Respondents shall monitor and sample all wells specified below containing alluvial, intermediate, and regional groundwater in accordance with Sections IV.B and IX of this Order and the following requirements:

1. Groundwater samples shall be obtained from Los Alamos Canyon monitoring wells LAO-1.6(g), LAO-2, LAO-3A, LAO-4.5C, LAO-5, LAO-6, LAO-6A, LAUZ-1, LAUZ-2, LADP-3, R-9i, R-5, R-7, R-8, R-9, TW-3, and any wells installed in the future determined by the Department to be required and at the frequency described in Section XII of this Order. As described in Section IV.B.1.e.viii, TW-3 shall be plugged and abandoned according to the procedures in Section X.D. Groundwater shall be monitored from TW-3 until the well is properly abandoned.

2. The groundwater sampling shall be conducted in accordance with Section IX.B of this Order.

3. Groundwater samples shall be collected from the Los Alamos Canyon monitoring wells for submittal to a laboratory for analysis of general chemistry parameters as described in Section IX.B of this Order, radionuclides, perchlorate, TAL metals, total uranium, cyanide, VOCs, SVOCs, HE, and for other analytes specified by the Department.

4. As described in Section IV.B.1.d.vii, Paragraph 7, a long-term groundwater monitoring and sampling work plan shall be submitted to the Department for approval. The work plan shall include the specifics for conducting groundwater sampling associated with MDA A as part of the Los Alamos/Pueblo Canyon watershed prior to implementation of the groundwater-sampling program.

IV.C.2.c.x MDA A Investigation Report

The Respondents shall submit to the Department for approval an investigation report that presents the results of the field activities, summarizes the data collected, and presents the recommendations and conclusions for MDA A. The investigation report shall be prepared in accordance with Section XI.C of this Order and submitted by the date specified in Section XII of this Order.

IV.C.2.d MDA B Investigation

IV.C.2.d.i MDA B Investigation Work Plan

The Respondents shall submit to the Department for approval a work plan for the investigation of contamination at MDA B that meets the requirements of this Section (IV.C.2.d). The work plan shall be prepared in accordance with Section XI.B of this Order, and shall be submitted by the date specified in Section XII of this Order. The work plan shall address investigations of the disposal units; migration pathways and the connections to potential receptors including groundwater; and the nature and extent of contamination in soil, rock, sediments, groundwater (where present), and soil vapor (if detected) at MDA B, including monitoring and reporting. The work plan shall propose the frequency for submitting periodic monitoring reports.

Upon Department approval, the Respondents shall implement the work plan. Upon Department approval, the work plan shall be incorporated herein by reference and become an enforceable part of this Order.

IV.C.2.d.ii MDA B Survey of Disposal Units

The Respondents shall conduct a survey of the disposal units at MDA B. The Respondents shall determine the dimensions and total depth of each disposal trench, absorption bed, shaft, pit, and other unit; and the base profile, topography, low elevation point, and down-slope end of the base of each disposal trench, shaft, pit, and absorption bed.

The dimensions and base elevations of each trench, absorption bed, pit, shaft, and other unit shall be determined using as-built construction drawings and boring logs. If unavailable, ground penetrating radar, magnetic surveys, or other methods shall be used. The methods used to evaluate the disposal units shall be approved by the Department prior to implementation. The survey shall be completed prior to implementation of the drilling explorations under Section IV.C.2.d.iii.

IV.C.2.d.iii MDA B Drilling Explorations

The Respondents shall conduct subsurface explorations in order to obtain sufficient data to characterize the extent of contamination, and to characterize fracture density, fracture orientation, and fracture fill material or the absence of fracture fill material at MDA B. The fracture characterization of the rock formations underlying MDA B shall be completed utilizing data acquired from outcrops, cores, and downhole geophysical and video log data. A discussion of the sampling methods and potential locations for collecting rock fracture data shall be included within the required characterization work plan for MDA B. The Department, prior to field investigation

and data collection activities, shall approve the methods and locations for the fracture investigation activities.

The subsurface investigation activities at MDA B shall, at a minimum, meet the following requirements:

1. A minimum of eight borings shall be advanced using hollow-stem auger drilling methods where practical or other drilling methods approved by the Department. Two of the borings shall be advanced to the base of the Cerro Toledo interval. All borings shall be drilled in accordance with Section X.B of this Order. The Department, prior to drilling, shall approve the location of the borings and the drilling method.

2. Each borehole shall be characterized using geophysical logging techniques approved by the Department.

3. A monitoring well shall be installed if groundwater (perched or regional) is encountered during drilling activities or if geophysical results indicate possible zone(s) of saturation. The wells shall be constructed in accordance with Section X of this Order.

4. Vapor monitoring wells shall be installed in the borings if vapor-phase contamination is detected during drilling activities.

All borings not completed as monitoring wells (vapor or groundwater monitoring wells) shall be properly plugged and abandoned. Documentation of proper well abandonment shall be submitted to the Department within 30 days of abandonment.

IV.C.2.d.iv MDA B Soil and Rock Sampling

The Respondents shall, at a minimum, conduct soil and rock sampling during subsurface explorations activities at MDA B in accordance with the following requirements:

1. Soil samples shall be collected continuously for the first 40 ft and at ten-ft intervals thereafter.

2. Samples shall be collected and screened in accordance with the methods described in Section IX.B of this Order.

3. A minimum of three core samples from the tuff overlying the Cerro Toledo shall be collected and submitted for laboratory permeability testing in accordance with Section IX.B of this Order.

4. Field screening and laboratory sample selection shall be biased toward evidence of contamination, lithologic contacts, fractures, fracture fill material, surge beds, and other higher permeability units identified during investigation activities. The samples shall be collected and screened in accordance with the methods described in Section IX.B of this Order.

5. Sediment, soil, and rock samples shall, at a minimum, be obtained from each boring at the intervals described in Paragraph 1 above and from the bedrock directly below the base elevation of each absorption bed or shaft. A sample also shall be obtained at the maximum depth of each boring.

6. A minimum of four samples shall be selected from each boring for submittal to a laboratory for analysis of VOCs, SVOCs, HE, pH, PCBs, dioxins, furans, nitrates, perchlorate, TAL metals, total uranium, cyanide, and radionuclides. The sample exhibiting the highest field screening detection; the sample obtained from the maximum depth in each boring that displays field screening evidence of contamination; the sample located immediately below the base of any pit, tank, or other structure; and the sample from the total boring depth shall be submitted for laboratory analysis. The Department may require that additional samples, collected from the borings, be submitted for laboratory analyses.

IV.C.2.d.v MDA B Sediment Sampling

All TA-21 outfalls shall be investigated in accordance with Section IV.A.4 of this Order. The characterization of the drainages shall be included in the work plan prepared to fulfill the requirements of Section IV.A.4 of this Order.

IV.C.2.d.vi MDA B Vapor Monitoring

The Respondents shall determine if vapor-phase contamination is present beneath the site. If vapor-phase contamination is detected, the Respondents shall install vapor monitoring wells in the borings and conduct vapor monitoring and sampling as outlined in Section IX.B of this Order. In addition, the Respondents shall submit a vapor monitoring and sampling work plan for approval by the Department prior to well construction. If vapor-phase contamination is detected, the Respondents shall, at a minimum, collect vapor samples from discrete zones in each vapor monitoring well or boring at depths approved by the Department. These data will be used to evaluate the need for additional monitoring and investigation.

IV.C.2.d.vii MDA B Intermediate Groundwater Well Installation

If intermediate zone groundwater is encountered or if geophysical or other evidence suggests the presence of intermediate perched groundwater during the required subsurface investigations for MDA B, intermediate groundwater monitoring well(s) will be required by the Department. The minimum depth of the subsurface investigations for MDA B will be the base of the Cerro Toledo interval. If groundwater is detected, these monitoring wells shall target all potential intermediate perched water bearing intervals identified during subsurface explorations at MDA B. If required, the Respondents shall include the well(s) in the TA-21 monitoring and sampling plan.

IV.C.2.d.viii MDA B Regional Groundwater Well Installation

The Respondents shall install regional groundwater monitoring wells if the Department determines the need for additional wells intersecting the regional groundwater aquifer associated with TA-21 based on investigation data. The wells shall be installed according to the requirements in Section X of this Order.

IV.C.2.d.ix MDA B Groundwater Monitoring

The Respondents shall monitor and sample all wells specified below containing alluvial, intermediate, and regional groundwater in accordance with Sections IV.B and IX of this Order and the following requirements:

1. Groundwater samples shall be obtained from Los Alamos Canyon monitoring wells LAO-1.2, LAO-1.8, LAO-1.6(g), LAO-2, LAO-3A, LAO-4.5C, LAO-5, LAO-6, LAO-6A, LADP-3, R-9i, R-5, R-7, R-8, R-9, TW-3, and any wells installed in the future determined by the Department to be required and at the frequency described in Section XII of this Order. As described in Section IV.B.1.e.viii, TW-3 shall be plugged and abandoned according to the procedures in Section X.D. Groundwater shall be monitored from TW-3 until the well is properly abandoned.

2. The groundwater sampling shall be conducted in accordance with Section IX.B of this Order.

3. Groundwater samples shall be collected from the Los Alamos Canyon monitoring wells for submittal to a laboratory for analysis of general chemistry parameters as described in Section IX.B of this Order, radionuclides, perchlorate, TAL metals, total uranium, cyanide, VOCs, SVOCs, HE, and for other analytes specified by the Department.

4. As described in Section IV.B.1.d.vii, Paragraph 7, a long-term groundwater monitoring and sampling work plan shall be submitted to the Department for approval. The work plan shall include the specifics for conducting groundwater sampling at MDA B as part of the Los Alamos/Pueblo Canyon watershed prior to implementation of the groundwater-sampling program.

IV.C.2.d.x MDA B Investigation Report

The Respondents shall submit to the Department for approval an investigation report that presents the results of the field activities, summarizes the data collected, and presents the recommendations and conclusions for MDA B. The Respondents shall follow the investigation report format outlined in Section XI and the compliance schedule in Section XII.

IV.C.2.e MDA T Investigation

The Respondents shall provide an Investigation Report summarizing the results of past investigation activities conducted at MDA T, in the format described in Section XI of this Order, that includes all data collected for the March 1, 1996 LANL/DOE Sampling and Analysis Plan for Potential Release Site (PRS) 21-016(a,b,c) (EM/ER:96-094). The report shall respond to all comments in the July 29, 1997 Department Request for Supplemental Information, Sampling and Analysis Plan Potential Release Site 21-016(a,b,c) Los Alamos National Laboratory. All additional relevant sediment, groundwater, surface water, and storm water data shall be included in the report.

IV.C.2.e.i MDA T Investigation Work Plan

The Respondents shall submit to the Department for approval a work plan for the investigation of

contamination at MDA T that meets the requirements of this Section (IV.C.2.e). The work plan shall be prepared in accordance with Section XI.B of this Order, and shall be submitted by the date specified in Section XII of this Order. The work plan shall address investigations of the disposal units; migration pathways and the connections to potential receptors including groundwater; and the nature and extent of contamination in soil, rock, sediments, groundwater (where present), and soil vapor (if detected) at MDA T, including monitoring and reporting. The work plan shall propose the frequency for submitting periodic monitoring reports.

Upon Department approval, the Respondents shall implement the work plan. Upon Department approval, the work plan shall be incorporated herein by reference and become an enforceable part of this Order.

IV.C.2.e.ii MDA T Survey of Disposal Units

The Respondents shall conduct a survey of the disposal units at MDA T. The Respondents shall determine the dimensions and total depth of each disposal trench, absorption bed, shaft, pit, and other unit, and the base profile, topography, low elevation point, and down-slope end of the base of each disposal trench, shaft, pit, and absorption bed.

The dimensions and base elevations of each trench, absorption bed, pit, shaft, and other unit shall be determined using as-built construction drawings and boring logs. If unavailable, ground penetrating radar, magnetic surveys, or other methods shall be used. The methods used to evaluate the pits and shafts shall be approved by the Department prior to implementation. The survey shall be completed prior to implementation of the drilling explorations under Section IV.C.2.e.iii.

IV.C.2.e.iii MDA T Drilling Explorations

The Respondents shall conduct subsurface explorations in order to obtain sufficient data to characterize the extent of contamination, and to characterize fracture density, fracture orientation, and fracture fill material or the absence of fracture fill material at MDA T. The fracture characterization of the rock formations underlying MDA T shall be completed utilizing data acquired from outcrops, cores, and downhole geophysical and video log data. A discussion of the sampling methods and potential locations for collecting rock fracture data shall be included within the required Investigation Work Plan for MDA T. The Department, prior to field investigation and data collection activities, shall approve the methods and locations for the fracture investigation activities.

The following are minimum requirements for completing subsurface investigation activities at MDA T:

1. A minimum of eleven borings shall be advanced using hollow-stem auger drilling methods, where practicable, or other drilling methods approved by the Department. Three of the borings shall be advanced to the base of the Cerro Toledo interval. All borings shall be drilled in accordance with Section X.B of this Order. The Department shall approve the locations of the borings and the drilling methods prior to drilling.

2. Each borehole shall be characterized using geophysical logging techniques approved by the Department.

3. A monitoring well(s) shall be installed if groundwater (perched or regional) is encountered during drilling activities or if geophysical results indicate possible zone(s) of saturation. The wells shall be constructed in accordance with Section X of this Order.

4. Vapor monitoring wells shall be installed in the borings if vapor-phase contamination is detected during drilling activities.

All borings not completed as monitoring wells (vapor or groundwater monitoring wells) shall be properly plugged and abandoned. Documentation of proper well abandonment shall be submitted to the Department within 30 days of abandonment.

IV.C.2.e.iv MDA T Soil and Rock Sampling

The Respondents shall, at a minimum, conduct soil and rock sampling during subsurface exploration activities at MDA T in accordance with the following requirements:

1. Soil samples shall be collected continuously for the first 40 ft and at ten-ft intervals thereafter.

2. Samples shall be collected and screened in accordance with the methods described in Section IX.B of this Order.

3. A minimum of three core samples from the tuff overlying the Cerro Toledo shall be collected and submitted for laboratory permeability testing in accordance with Section IX.B of this Order.

4. Field screening and laboratory sample selection shall be biased towards evidence of contamination, lithologic contacts, fractures, fracture fill material, surge beds, and other higher permeability units identified during investigation activities. The samples shall be collected and screened in accordance with the methods described in Section IX.B of this Order.

5. Soil and rock samples shall, at a minimum, be obtained from each boring at the intervals described in Paragraph 1 above and from the bedrock directly below the base elevation of each absorption bed or shaft. A sample also shall be obtained at the maximum depth of each boring.

6. A minimum of four samples shall be selected from each boring for submittal to a laboratory for analysis of VOCs, SVOCs, HE, pH, PCBs, dioxins, furans, nitrates, perchlorate, TAL metals, total uranium, cyanide, and radionuclides. The sample exhibiting the highest field screening detection; the sample obtained from the maximum depth in each boring that displays field screening evidence of contamination; the sample located immediately below the base of any pit, tank, or other structure; and the sample from the total boring depth shall

be submitted for laboratory analysis. The Department may require that additional samples, collected from the borings, be submitted for laboratory analyses.

IV.C.2.e.v MDA T Sediment Sampling

All TA-21 outfalls shall be investigated in accordance with Section IV.A.4 of this Order. The characterization of the drainages shall be included in the work plan prepared to fulfill the requirements of Section IV.A.4 of this Order.

IV.C.2.e.vi MDA T Vapor Monitoring and Sampling

The Respondents shall determine if vapor-phase contamination is present beneath the site. If vapor-phase contamination is detected, the Respondents shall install vapor monitoring wells in the borings and conduct vapor monitoring and sampling as outlined in Section IX.B of this Order. In addition, the Respondents shall submit a vapor monitoring and sampling work plan for approval by the Department prior to well construction. If vapor-phase contamination is detected, the Respondents shall, at a minimum, collect vapor samples from discrete zones in each vapor monitoring well or boring at depths approved by the Department. These data will be used to evaluate the need for additional monitoring and investigation.

IV.C.2.e.vii MDA T Intermediate Groundwater Well Installation

If intermediate zone groundwater is encountered or if geophysical or other evidence suggests the presence of intermediate perched groundwater during the required subsurface investigations for MDA T, intermediate groundwater monitoring well(s) will be required by the Department. The minimum depth of the subsurface investigations for MDA T will be the base of the Cerro Toledo interval. If groundwater is detected, these monitoring wells shall target all potential intermediate perched water bearing intervals identified during subsurface explorations at MDA T. If required, the Respondents shall include the well(s) in the TA-21 monitoring and sampling plan.

IV.C.2.e.viii MDA T Regional Groundwater Well Installation

The Respondents shall install regional groundwater monitoring wells if the Department determines the need for additional wells intersecting the regional groundwater aquifer associated with TA-21 based on investigation data. The wells shall be installed according to the requirements in Section X of this Order.

IV.C.2.e.ix MDA T Groundwater Monitoring

The Respondents shall monitor and sample all wells specified below containing alluvial, intermediate, and regional groundwater in accordance with Sections IV.B and IX of this Order and the following requirements:

1. Groundwater samples shall be obtained from Los Alamos Canyon monitoring wells LAO-1.6(g), LAO-2, LAO-3A, LAO-4.5C, LAO-5, LAO-6, LAO-6A, LAUZ-1, LAUZ-2, LADP-3, R-9i, R-5, R-7, R-8, R-9, TW-3, and any wells installed in the future determined by the Department to be required and at the frequency described in Section XII of this Order. As

described in Section IV.B.1.e.viii, TW-3 shall be plugged and abandoned according to the procedures in Section X.D. Groundwater shall be monitored from TW-3 until the well is properly abandoned.

2. The groundwater sampling shall be conducted in accordance with Section IX.B of this Order.

3. Groundwater samples shall be collected from the Los Alamos Canyon monitoring wells for submittal to a laboratory for analysis of general chemistry parameters as described in Section IX.B of this Order, radionuclides, perchlorate, TAL metals, total uranium, cyanide, VOCs, SVOCs, HE, and for other analytes specified by the Department.

4. As described in Section IV.B.1.d.vii, Paragraph 7, a long-term groundwater monitoring and sampling work plan shall be submitted to the Department for approval. The work plan shall include the specifics for conducting groundwater sampling at MDA T as part of the Los Alamos/Pueblo Canyon watershed prior to implementation of the groundwater-sampling program.

IV.C.2.e.x MDA T Investigation Report

The Respondents shall submit to the Department for approval an investigation report that presents the results of the field activities, summarizes the data collected, and presents the recommendations and conclusions for MDA T. The Respondents shall follow the investigation report format outlined in Section XI.C and the compliance schedule in Section XII.

IV.C.2.f MDA U Investigation

The Respondents shall submit to the Department an Investigation Report summarizing the results of prior investigation activities conducted at MDA U in the format described in Section XI of this Order, containing all of the data collected during implementation of the September 28, 1998 LANL/DOE Sampling and Analysis Plan for Potential Release Site (PRS) 21-017(a,b,c) (LA/UR:98-3856). All additional relevant sediment, groundwater, surface water, and storm water data shall be included in the Investigation Report.

IV.C.2.f.i MDA U Investigation Work Plan

The Respondents shall submit to the Department for approval a work plan for the investigation of contamination in MDA U that meets the requirements of this Section (IV.C.2.f). The work plan shall be prepared in accordance with Section XI.B of this Order, and shall be submitted by the date specified in Section XII of this Order. The work plan shall address investigations of the disposal units; migration pathways and the connections to potential receptors including groundwater; and the nature and extent of contamination in soil, rock, sediments, groundwater (where present), and soil vapor (if detected) at MDA U, including monitoring and reporting. The work plan shall propose the frequency for submitting periodic monitoring reports.

Upon Department approval, the Respondents shall implement the work plan. Upon Department approval, the work plan shall be incorporated herein by reference and become an enforceable part of this Order.

IV.C.2.f.ii MDA U Survey of Disposal Units

The Respondents shall conduct a survey of the disposal units at MDA U. The Respondents shall determine the dimensions and total depth of each disposal trench, absorption bed, shaft, pit, and other unit, and the base profile, topography, low elevation point, and down-slope end of the base of each disposal trench, shaft, pit, and absorption bed.

The dimensions and base elevations of each trench, absorption bed, pit, shaft, and other unit shall be determined using as-built construction drawings and boring logs. If unavailable, ground penetrating radar, magnetic surveys, or other methods shall be used. The methods used to evaluate the pits and shafts shall be approved by the Department prior to implementation. The survey shall be completed prior to implementation of the drilling explorations under Section IV.C.2.f.iii.

IV.C.2.f.iii MDA U Drilling Explorations

The Respondents shall conduct subsurface explorations in order to obtain sufficient data to characterize the extent of contamination, and to characterize fracture density, fracture orientation, and fracture fill material or the absence of fracture fill material at MDA U. The fracture characterization of the rock formations underlying MDA U shall be completed utilizing data acquired from outcrops, cores, and downhole geophysical and video log data. A discussion of the sampling methods and potential locations for collecting rock fracture data shall be included within the required Investigation Work Plan for MDA U. The Department, prior to field investigation and data collection activities, shall approve the methods and locations for the fracture investigation activities.

The following are minimum requirements for completing subsurface investigation activities at MDA U:

1. A minimum of twelve borings shall be advanced, using hollow-stem auger drilling methods where practical or by other drilling methods approved by the Department. Three of the borings shall be advanced to the base of the Cerro Toledo interval. All borings shall be drilled in accordance with Section X.B of this Order. The Department, prior to drilling, shall approve the location of the borings and the drilling method.

2. Each borehole shall be characterized using geophysical logging techniques approved by the Department.

3. A monitoring well(s) shall be installed if groundwater (perched or regional) is encountered during drilling activities or if geophysical results indicate possible zone(s) of saturation. The wells shall be constructed in accordance with Section X of this Order.

4. Vapor monitoring wells shall be installed in the borings if vapor-phase contamination is detected during drilling activities.

5. All borings not completed as monitoring wells (vapor or groundwater monitoring wells) shall be properly plugged and abandoned. Documentation of proper well abandonment shall be submitted to the Department within 30 days of abandonment.

IV.C.2.f.iv MDA U Soil and Rock Sampling

The Respondents shall, at a minimum, conduct soil and rock sampling during subsurface explorations activities at MDA U in accordance with the following requirements:

1. Soil samples shall be collected continuously for the first 40 ft and at ten-ft intervals there after.

2. Samples shall be collected and screened in accordance with the methods described in Section IX.B of this Order.

3. A minimum of one core sample from the tuff overlying the Cerro Toledo shall be collected and submitted for laboratory permeability testing in accordance with Section IX.B of this Order.

4. Field screening and laboratory sample selection shall be biased toward evidence of contamination, lithologic contacts, fractures, fracture fill material, surge beds, and other higher permeability units identified during investigation activities. The samples shall be collected and screened in accordance with the methods described in Section IX.B of this Order.

5. Sediment, soil, and rock samples shall, at a minimum, be obtained from each boring at the intervals described in Paragraph 1 above and from the bedrock directly below the base elevation of each absorption bed or shaft. A sample also shall be obtained at the maximum depth of each boring.

6. A minimum of four samples shall be selected from each boring for submittal to a laboratory for analysis of VOCs, SVOCs, HE, pH, PCBs, dioxins, furans, nitrates, perchlorate, TAL metals, total uranium, cyanide, and radionuclides. The sample exhibiting the highest field screening detection; the sample obtained from the maximum depth in each boring that displays field screening evidence of contamination; the sample located immediately below the base of any pit, tank, or other structure; and the sample from the total boring depth shall be submitted for laboratory analysis. The Department may require that additional samples, collected from the borings, be submitted for laboratory analyses.

IV.C.2.f.v MDA U Sediment Sampling

All TA-21 outfalls shall be investigated in accordance with Section IV.A.4 of this Order. The characterization of the drainages shall be included in the work plan prepared to fulfill the requirements of Section IV.A.4 of this Order.

IV.C.2.f.vi MDA U Vapor Monitoring

The Respondents shall determine if vapor-phase contamination is present beneath the site. If vapor-phase contamination is detected, the Respondents shall install vapor monitoring wells in the borings and conduct vapor monitoring and sampling as outlined in Section IX.B of this Order. In addition, the Respondents shall submit a vapor monitoring and sampling work plan for approval by the

Department prior to well construction. If vapor-phase contamination is detected, the Respondents shall, at a minimum, collect vapor samples from discrete zones in each vapor monitoring well or boring at depths approved by the Department. These data will be used to evaluate the need for additional monitoring and investigation.

IV.C.2.f.vii MDA U Intermediate Groundwater Well Installation

If intermediate zone groundwater is encountered or if geophysical or other evidence suggests the presence of intermediate perched groundwater during the required subsurface investigations for MDA U, intermediate groundwater monitoring well(s) will be required by the Department. The minimum depth of the subsurface investigations for MDA U will be the base of the Cerro Toledo interval. If groundwater is detected, these monitoring wells shall target all potential intermediate perched water bearing intervals identified during subsurface explorations at MDA U. If required, the Respondents shall include the well(s) in the TA-21 monitoring and sampling plan.

IV.C.2.f.viii MDA U Regional Groundwater Well Installation

The Respondents shall install regional groundwater monitoring wells if the Department determines the need for additional wells intersecting the regional groundwater aquifer associated with TA-21 based on investigation data. The wells shall be installed according to the requirements in Section X of this Order.

IV.C.2.f.ix MDA U Groundwater Monitoring

The Respondents shall monitor and sample all wells specified below containing alluvial, intermediate, and regional groundwater in accordance with Sections IV.B and IX of this Order.

1. Groundwater samples shall be obtained from Los Alamos Canyon monitoring wells LAO-1.6(g), LAO-2, LAO-3A, LAO-4.5C, LAO-5, LAO-6, LAO-6A, LAUZ-2, LADP-3, R-9i, R-5, R-7, R-8, R-9, TW-3, and any wells installed in the future determined by the Department to be required and at the frequency described in Section XII of this Order. As described in Section IV.B.1.e.viii, TW-3 shall be plugged and abandoned according to the procedures in Section X.D. Groundwater shall be monitored from TW-3 until the well is properly abandoned.

2. The groundwater sampling shall be conducted in accordance with Section IX.B of this Order.

3. Groundwater samples shall be collected from the Los Alamos Canyon monitoring wells for submittal to a laboratory for analysis of general chemistry parameters as described in Section VI.B of this Order, radionuclides, perchlorate, TAL metals, total uranium, cyanide, VOCs, SVOCs, HE, and for other analytes specified by the Department.

4. As described in Section IV.B.1.d.vii, Paragraph 7, a long-term groundwater monitoring and sampling work plan shall be submitted to the Department for approval. The work plan shall include the specifics for conducting groundwater sampling at MDA U as part of the Los Alamos/Pueblo Canyon watershed prior to implementation of the groundwater-sampling program.

IV.C.2.f.x MDA U Investigation Report

The Respondents shall submit to the Department for approval an investigation report that presents the results of the field activities, summarizes the data collected, and presents the recommendations and conclusions for MDA U. The investigation report shall be prepared in accordance with Section XI.C of this Order and shall be submitted by the date specified in Section XII.

IV.C.2.g MDA V Investigation

The Respondents shall provide a report in the format described in Section XI of this Order for the "hot" demonstration interim measure for the Non-Traditional In-Situ Vitrification (NTISV) demonstration at MDA V performed in April 2000. The report will be due to the Department by December 2002. The report shall include an evaluation of the effectiveness of NTISV as a possible remedy for sites at the Facility. All additional relevant sediment, groundwater, surface water, and storm water data shall be included in the report.

IV.C.2.g.i MDA V Investigation Work Plan

The Respondents shall submit to the Department for approval a work plan for the investigation of contamination in MDA V that meets the requirements of this Section (IV.C.2.g). The work plan shall be prepared in accordance with Section XI.B of this Order, and shall be submitted by the date specified in Section XII of this Order. The work plan shall address investigations of the disposal units; migration pathways and the connections to potential receptors including groundwater; and the nature and extent of contamination in soil, rock, sediments, groundwater (where present), and soil vapor (if detected) at MDA V, including monitoring and reporting. The work plan shall propose the frequency for submitting periodic monitoring reports.

Upon Department approval, the Respondents shall implement the work plan. Upon Department approval, the work plan shall be incorporated herein by reference and become an enforceable part of this Order.

IV.C.2.g.ii MDA V Survey of Disposal Units

The Respondents shall conduct a survey of the disposal units at MDA V. The Respondents shall determine the dimensions and total depth of each disposal trench, absorption bed, shaft, pit, and other unit, and the base profile, topography, low elevation point, and down-slope end of the base of each disposal trench, shaft, pit, and absorption bed.

The dimensions and base elevations of each trench, absorption bed, pit, shaft, and other unit shall be determined using as-built construction drawings and boring logs. If unavailable, ground penetrating radar, magnetic surveys, or other methods shall be used. The methods used to evaluate the pits and shafts shall be approved by the Department prior to implementation. The survey shall be completed prior to implementation of the drilling explorations under Section IV.C.2.g.iii of this Order.

IV.C.2.g.iii MDA V Drilling Explorations

The Respondents shall conduct subsurface explorations in order to obtain sufficient data to characterize the extent of contamination, and to characterize fracture density, fracture orientation, and fracture fill material or the absence of fracture fill material at MDA V. The fracture characterization of the rock formations underlying MDA V shall be completed utilizing data acquired from outcrops, cores, and downhole geophysical and video log data. A discussion of the sampling methods and potential locations for collecting rock fracture data shall be included within the required Investigation Work Plan for MDA V. The Department, prior to field investigation and data collection activities, shall approve the methods and locations for the fracture investigation activities.

The following are the minimum requirements for completing subsurface investigation activities at MDA V:

1. A minimum of fifteen borings shall be advanced using hollow-stem auger drilling methods, where practicable, or other drilling methods approved by the Department. Three of the borings shall be advanced to the base of the Cerro Toledo interval. All borings shall be drilled in accordance with Section X.B of this Order. The Department shall approve the location of the borings and the drilling method prior to drilling.

2. Each borehole shall be advanced using geophysical logging techniques approved by the Department.

3. A monitoring well(s) shall be installed if groundwater (perched or regional) is encountered during drilling activities or if geophysical results indicate possible zone(s) of saturation. The wells shall be constructed in accordance with Section X of this Order.

4. Vapor monitoring wells shall be installed in the borings if vapor-phase contamination is detected during drilling activities.

5. All borings not completed as monitoring wells (vapor or groundwater monitoring wells) shall be properly plugged and abandoned. Documentation of proper well abandonment shall be submitted to the Department within 30 days of abandonment.

IV.C.2.g.iv MDA V Soil and Rock Sampling

The Respondents shall conduct soil and rock sampling during subsurface explorations activities at MDA V in accordance with, at a minimum, the following requirements:

1. Soil samples shall be collected continuously for the first 40 ft and at ten-ft intervals thereafter.

2. Samples shall be collected and screened in accordance with the methods described in Section IX.B of this Order.

3. A minimum of one core sample from the tuff overlying the Cerro Toledo shall be collected and submitted for permeability testing in accordance with Section IX.B of this Order.

4. Field screening and confirmatory sample collection shall be biased toward evidence of contamination, lithologic contacts, fractures, fracture fill material, surge beds, and other higher permeability units identified during investigation activities. The samples shall be collected and screened in accordance with the methods described in Section IX.B of this Order.

5. Sediment, soil, and rock samples shall, at a minimum, be obtained from each boring at the intervals described in Paragraph 1 above and from the bedrock directly below the base elevation of each absorption bed or shaft. A sample also shall be obtained at the maximum depth of each boring.

6. A minimum of four samples shall be selected from each boring for submittal to a laboratory for analysis of VOCs, SVOCs, HE, pH, PCBs, dioxins, furans, nitrates, perchlorate, TAL metals, total uranium, cyanide, and radionuclides. The sample exhibiting the highest field screening detection; the sample obtained from the maximum depth in each boring that displays field screening evidence of contamination; the sample located immediately below the base of any pit, tank, or other structure; and the sample from the total boring depth shall be submitted for laboratory analysis. The Department may require that additional samples, collected from the borings be submitted for laboratory analyses.

IV.C.2.g.v MDA V Sediment Sampling

All TA-21 outfalls shall be investigated in accordance with Section IV.A.4 of this Order. The characterization of the drainages shall be included in the work plan prepared to fulfill the requirements of Section IV.A.4 of this Order.

IV.C.2.g.vi MDA V Vapor Monitoring

The Respondents shall determine if vapor-phase contamination is present beneath the site. If vapor-phase contamination is detected, the Respondents shall install vapor monitoring wells in the borings and conduct vapor monitoring and sampling as outlined in Section IX.B of this Order. In addition, the Respondents shall submit a vapor monitoring and sampling workplan for approval by the Department prior to well construction. If vapor-phase contamination is detected, the Respondents shall, at a minimum, collect vapor samples from discrete zones in each vapor monitoring well or boring at depths approved by the Department. These data will be used to evaluate the need for additional monitoring and investigation.

IV.C.2.g.vii MDA V Intermediate Groundwater Well Installation

If intermediate zone groundwater is encountered or if geophysical or other evidence suggests the presence of intermediate perched groundwater during the required subsurface investigations for MDA V, intermediate groundwater monitoring well(s) will be required by the Department. The minimum depth of the subsurface investigations for MDA V will be the base of the Cerro Toledo interval. If groundwater is identified, these monitoring wells shall target all potential intermediate perched water bearing intervals identified during subsurface explorations at MDA V. If required, the Respondents shall include the well(s) in the TA-21 monitoring and sampling plan.

IV.C.2.g.viii MDA V Regional Groundwater Well Installation

The Respondents shall install regional groundwater monitoring wells if the Department determines the need for additional wells intersecting the regional groundwater associated with TA-21 based on investigation data. The wells shall be installed according to the requirements in Section X of this Order.

IV.C.2.g.ix MDA V Groundwater Monitoring

The Respondents shall monitor and sample all wells specified below containing alluvial, intermediate, and regional groundwater in accordance with Sections IV.B and IX of this Order and the following requirements:

1. Groundwater samples shall be obtained from Los Alamos Canyon monitoring wells LAO-1.2, LAO-1.8, LAO-1.6(g), LAO-2, LAO-3A, LAO-4.5C, LAO-5, LAO-6, LAO-6A, LADP-3, R-9i, R-5, R-7, R-8, R-9, TW-3, and any wells installed in the future determined by the Department to be required and at the frequency described in Section XII of this Order. As described in Section IV.B.1.e.viii, TW-3 shall be plugged and abandoned according to the procedures in Section X.D. Groundwater shall be monitored from TW-3 until the well is properly abandoned.

2. The groundwater sampling shall be conducted in accordance with Section IX.B of this Order.

3. Groundwater samples shall be collected from the Los Alamos Canyon monitoring wells for submittal to a laboratory for analysis of general chemistry parameters as described in Section IX.B of this Order, radionuclides, perchlorate, TAL metals, total uranium, cyanide, VOCs, SVOCs, HE, and for other analytes specified by the Department.

IV.C.2.g.x MDA V Investigation Report

The Respondents shall submit to the Department for approval an investigation report that presents the results of the field activities, summarizes the data collected, and presents the recommendations and conclusions for MDA V. The investigation report shall be prepared in accordance with Section XI.C of this Order and submitted by the date specified in Section XII of this Order.

IV.C.3 Technical Area 50: MDA C

IV.C.3.a Background

MDA C is SWMU 50-009 and is located within TA-50 at the head of Ten Site Canyon. TA-50 is bound on the north by Effluent and Mortandad Canyons, on the east by the upper reaches of Ten Site Canyon (a tributary of Mortandad Canyon), on the south by Two Mile Canyon and on the west by TA-55. The elevation of TA-50 is approximately 7,250 ft above mean sea level and the mesa top is approximately 100 to 200 ft above the adjacent canyon bottoms. The uppermost geology of the mesa consists of surface soil to depths less than three ft underlain by Unit 3 of the Tshirege Member of the Bandelier Tuff. TA-50 lies between two major north-south trending faults. The Rendija fault zone is located approximately 600 ft east of the TA-50 boundary and the Guaje Mountain fault zone

is located approximately 1,900 ft west of TA-50. Between the faults, the Bandelier Tuff is deformed by fractures and micrograbens with up to several feet of displacement. The density of the fractures increases near the faults. The tuff is dissected by cooling joints in addition to the fractures.

The operations at TA-50 include a Radioactive Wastewater Treatment facility, a Waste Reduction Characterization facility, several container storage areas, SWMUs, and MDA C. The wastewater treatment plant has been in operation since 1963 and discharges treated effluent under a Clean Water Act NPDES permit. The treated water discharges to Effluent Canyon, a tributary to Mortandad Canyon.

MDA C (SWMU 50-009) is an inactive 11.8-acre landfill consisting of six disposal pits, a chemical disposal pit, and 107 shafts. A large volume of hazardous, radioactive, and mixed waste was disposed in the landfill between 1948 and 1974. Records, which were provided to the Department by the Respondents, of the content and disposal history of the waste placed in MDA C are incomplete.

Preliminary investigation data collected by the Respondents indicate that tritium and VOCs are present in the vadose zone. The vertical and horizontal extent of contamination is not defined. High concentrations of radionuclides, including tritium at concentrations greater than 1,000,000 picocuries per liter (pCi/l), were detected in the vadose zone beneath the site at depths greater than 90 ft bgs. In addition, VOCs were detected beneath MDA C at concentrations up to 12.9 parts per million of vapor (ppmv) at depths of 200 ft bgs.

IV.C.3.b Historical Investigation

The Respondents shall conduct an investigation of contaminants that may have been discharged or released at MDA C. The investigation shall include the known or suspected source of any groundwater contaminants, and a review of existing data and other information acquired during previous investigations. In conducting the investigation, the Respondents shall review and confirm the construction details and historical use of all existing and demolished TA buildings and other structures; pits, shafts, trenches, landfills, surface impoundments, and other SWMUs; wastewater treatment, conveyance, and disposal systems; subsurface utility corridors; and other possible sources of discharges or releases of contaminants. The Respondents shall also review all investigation borings, excavations, sampling events, and other sources of information on contamination. The Respondents shall submit to the Department a historical investigation report for MDA C, which shall be included as an appendix to the MDA C Investigation Work Plan under Section IV.C.3.c.i. The report shall contain, at a minimum, the following information:

1. A description of the location, construction details, operational history, and present status of each pit, shaft, or other structure at MDA C. All such locations shall be depicted in one or more figures.

2. A description of the known or suspected disposal history of each pit, shaft, or other structure at MDA C listed under Paragraph 1. This description shall include all known and suspected materials disposed, discharged or released, the volume of each discharge or release, and the contaminants present in each discharge or release. The Respondents shall report whether the disposal history is incomplete or unknown.

3. A description of each previous investigation of the sources, extent, or characteristics of contamination at MDA C, regardless of whether or not such investigation was completed.

4. A summary of any results and the conclusions of each previous investigation described in Paragraph 3, including the known or suspected dates of waste disposal, the suspected dates of contaminant releases, and the circumstances related to the contaminant releases.

5. A description of the location, construction details, history, and present status of each investigation well, boring, and excavation at MDA C. All such locations shall be depicted in one or more figures. A site map encompassing TA-50 and pertinent regional investigation locations shall be included in the description.

6. A description of the sample collection methods and the types of field and laboratory analyses performed on each sample obtained from each media during the previous investigations.

7. Tables summarizing the data collected from each investigation well, boring, and excavation. The results shall present only analyte and radionuclide detections and data quality exceptions reported by the analytical laboratory that may mask analyte and radionuclide detections.

8. A summary of data quality exceptions and interpretations of all compromised data.

9. A summary of all contradictory investigation results and the rationale for acceptance or rejection of selected investigation results.

10. A list of general chemistry, metals, and radionuclide background concentrations and documentation of the methods used for establishing the background values.

The summary shall include references to historical documents within the summary text citing the document title, page number, and table or figure number. The full reference citations shall be presented as a separate section in the summary document using the standard USGS format for reference citations. The Facility project leader for corrective action at TA-50 shall meet with representatives designated by the Department to discuss the content and presentation of the information required in this section (IV.C.3.b). The Respondents are responsible for providing complete information with regard to the available data and the need for additional data at each unit. The Department shall evaluate the information and request changes as necessary. The Department's evaluation and approval will address the Respondents' general approach to site characterization and plan for acquiring additional data required to complete the site investigation at MDA C.

In addition to the above requirements, the Respondents shall submit a report summarizing the results of their surface radiological survey conducted at MDA C in 1994. The report shall be prepared in accordance with the reporting requirements listed in Section XI of this Order.

IV.C.3.c MDA C Investigation

IV.C.3.c.i MDA C Investigation Work Plan

The Respondents shall submit to the Department for approval a work plan for the investigation of contamination at MDA C that meets the requirements of this Section (IV.C.3.c). The work plan shall be prepared in accordance with Section XI.B of this Order, and shall be submitted by the date specified in Section XII of this Order. The work plan shall address investigations of the disposal units; migration pathways and the connections to potential receptors including groundwater; and the nature and extent of contamination in soil, rock, sediments, groundwater (where present) and soil vapor at MDA C, including monitoring and reporting. The work plan shall propose the frequency for submitting periodic monitoring reports.

Upon Department approval, the Respondents shall implement the work plan. Upon Department approval, the work plan shall be incorporated herein by reference and become an enforceable part of this Order.

IV.C.3.c.ii MDA C Survey of Disposal Units

The Respondents shall conduct a survey of the disposal units at MDA C. The Respondents shall determine the dimensions and total depth of each disposal shaft and pit, and the base profile, topography, low elevation point, and down-slope end of the base of each shaft and disposal pit.

The dimensions and base elevations of each pit and shaft shall be determined using as-built construction drawings and boring logs. If unavailable, ground penetrating radar, magnetic surveys, or other methods shall be used. The methods used to evaluate the pits and shafts shall be approved by the Department prior to implementation. The survey shall be completed prior to implementation of the drilling explorations under Section IV.C.3.c.iii.

IV.C.3.c.iii MDA C Drilling Explorations

The Respondents shall conduct subsurface investigations to characterize the extent of contamination, and to characterize fracture density, fracture orientation, and fracture fill material at MDA C. The fracture characterization shall be completed utilizing data acquired from outcrops, cores, and down hole geophysical and video data. The methods and locations for collecting rock fracture data shall be approved by the Department prior to data collection.

The following are minimum requirements for completing subsurface explorations of the pit and shaft areas at MDA C:

1. A minimum of one boring shall be advanced at the following locations: 1) directly adjacent to the down-slope end of each pit; 2) at the lowest base elevation point of each disposal pit; 3) at the corners of each disposal pit, at 100-ft intervals along the sides of disposal pits 1 through 6; 4) at 70 ft intervals along the sides of the chemical pit; 5) at the ends of each shaft row; 6) at 50-ft intervals along each shaft row; and 7) adjacent to the location of the strontium-90 disposal shaft. Where practical, boring locations may be combined to address more than one of the requirements listed above.

2. Angled borings shall be advanced beneath all pits where access for drilling of vertical borings is restricted.

3. The Department must approve all borehole locations prior to the start of drilling activities.

4. The borings shall be advanced using hollow-stem auger drilling methods, where practicable, or other drilling methods approved by the Department.

5. The borings shall be drilled to minimum depths of 20 ft below the base of the pits and a minimum of 20 ft below the base of the deepest shafts in a shaft row or shaft field.

6. The borings shall be advanced a minimum of 25 ft below the deepest detected vapor-phase, soil, rock, or groundwater contamination as detected by field screening or previous investigations, whichever is deeper.

7. Each borehole shall be characterized using geophysical logging techniques approved by the Department.

8. A general design for vapor monitoring well construction shall be submitted to the Department for approval prior to the start of subsurface explorations at MDA C.

9. Each boring shall be completed as a vapor monitoring well. The screened intervals or sample port locations and methods and materials used to construct each vapor monitoring well shall be based upon information obtained during drilling activities and open-hole vapor sampling field screening results, and shall be approved by the Department prior to well construction.

10. At a minimum, two borings shall be advanced at MDA C to evaluate the presence of intermediate perched groundwater and vapor-phase contamination at depth beneath the site. The boring locations, depth of the boring, the drilling and sampling program and the well design shall be approved by the Department prior to the start of drilling activities.

11. At a minimum, one TA-50-specific well shall be installed that intersects the regional aquifer at a location approved by the Department. The well shall be located generally east or southeast of MDA C.

IV.C.3.c.iv MDA C Soil and Rock Sampling

The following are minimum requirements for completing soil and rock sampling during subsurface drilling explorations at MDA C:

1. Soil and rock samples shall, at a minimum, be obtained from each boring at ten-ft intervals, from the bedrock directly below the base elevation of each pit or shaft, and from the maximum depth of each boring.

2. The samples shall be collected and screened in accordance with the methods described in Section IX.B of this Order.

3. One core shall be collected from each stratigraphic unit for permeability testing in accordance with Section IX.B of this Order.

4. A minimum of two samples per 100 ft of drilling depth shall be selected from each boring for laboratory analysis. The samples submitted for laboratory analyses shall be analyzed for VOCs, SVOCs, pH, HE compounds, PCBs, dioxins, furans, nitrates, perchlorate, TAL metals, total uranium, cyanide, and radionuclides. The selection of the samples shall include those locations outlined in Paragraphs 5 through 9 below.

5. The samples displaying the greatest field screening evidence of contamination shall be selected for submittal to the analytical laboratory for analysis of the analytes listed in Paragraph 4 above.

6. If field-screening evidence of contamination is not observed in a boring, the sample obtained from the bedrock directly below the base elevation of each pit or shaft shall be submitted for chemical analysis of the analytes listed in Paragraph 4 above.

7. The sample obtained from the maximum depth of each boring also shall be submitted to an analytical laboratory for analysis of the analytes listed in Paragraph 4 above.

8. The sample obtained from the maximum depth in each boring that displays field screening evidence of contamination shall be submitted to an analytical laboratory for analysis of the analytes listed in Paragraph 4 above.

9. Samples obtained from high permeability units such as surge beds, fracture zones, and pumice beds shall be submitted to an analytical laboratory for analysis of the analytes listed in Paragraph 4 above.

IV.C.3.c.v MDA C Vapor Monitoring

The Respondents shall, at a minimum, collect vapor samples from discrete zones in each vapor monitoring well or boring, at depths approved by the Department for field and laboratory analyses in accordance with Section IX.B of this Order. The following minimum requirements shall be fulfilled at MDA C:

1. Vapor samples shall be collected from all newly drilled borings during site investigation activities.

2. An investigation vapor monitoring and sampling work plan shall be prepared in accordance with the format described in Section XI.B of this Order and submitted by the Respondents to the Department for approval.

3. Vapor sampling shall be conducted at MDA C in each existing and newly constructed vapor well and boring.

4. Samples of subsurface vapors shall be collected by the Respondents from vapor monitoring points at discrete zones selected based on investigation and monitoring results. The monitoring points must be approved by the Department prior to sample collection.

5. Based on the results of the investigation vapor monitoring, a long-term subsurface vapor monitoring and sampling program work plan shall be submitted to the Department for approval prior to implementation of a long-term vapor monitoring and sampling program at MDA C.

IV.C.3.c.vi MDA C Intermediate Groundwater Well Installation

The Respondents shall construct a minimum of one intermediate depth groundwater monitoring well at MDA C if evidence of perched groundwater is observed during the drilling of the two borings drilled to evaluate for the presence of intermediate perched groundwater or during drilling of the regional groundwater monitoring well.

1. The borings shall be drilled to a minimum depth of 800 ft below the ground surface.

2. Vapor samples and groundwater samples (if encountered) shall be collected from each boring prior to well construction or borehole abandonment.

3. A monitoring well design plan shall be submitted to the Department for approval prior to construction of the intermediate well(s).

4. The Department may impose specific conditions for well construction, require the boring to be extended to the regional aquifer, or require the drilling of additional borings that intersect the intermediate perched zones or regional aquifer based on the sampling results.

IV.C.3.c.vii MDA C Regional Groundwater Well Installation

The Respondents shall, at a minimum, construct one monitoring well associated with MDA C and TA-50 intersecting the regional aquifer in accordance with Section X of this Order.

1. The borings shall be monitored for the presence of intermediate perched groundwater and vapor-phase contaminants prior to well construction.

2. Based on the results of vapor monitoring, the Department may require that the Respondents construct the wells to accommodate vapor monitoring in addition to groundwater monitoring and sampling.

IV.C.3.c.viii MDA C Groundwater Monitoring

The Respondents shall monitor and sample all wells containing alluvial, intermediate perched, and/or regional groundwater in accordance with the requirements of Sections IV.A and IX of this Order and in accordance with the following requirements:

1. Groundwater samples shall be collected from each saturated zone intersecting the monitoring wells for submittal to a laboratory for analysis of general chemistry parameters as described in Section IX.B of this document, includingVOCs, SVOCs, HE compounds, perchlorate, TAL metals, total uranium, cyanide, and radionuclides and for any other analytes specified by the Department.

2. A groundwater monitoring and sampling work plan shall be submitted to the Department for approval prior to implementation of the groundwater sampling program at MDA C.

3. As described in Section IV.B.2.b.v, Paragraph 5, a long-term groundwater monitoring and sampling work plan shall be submitted to the Department for approval. The work plan shall include the specifics for conducting groundwater sampling at MDA C as part of the Mortandad Canyon watershed groundwater monitoring program prior to implementation of the groundwater-sampling program.

IV.C.3.c.ix MDA C Investigation Report

The Respondents shall submit to the Department for approval an investigation report that presents the results of the field activities, summarizes the data collected, and presents the recommendations and conclusions for MDA C. The investigation report shall be prepared in accordance with Section XI.C of this Order and submitted by the date specified in Section XII of this Order.

IV.C.4 Technical Area 49

IV.C.4.a Background

TA-49 (formerly Operable Unit 1144), also known as Frijoles Mesa Site, is located on the southern-central boundary of the Facility at an elevation of approximately 7,140 ft. TA-49 occupies approximately 1,280 acres and is bounded by Bandelier National Monument on the south and west and TAs-16, 37, 15, and 39 on the north and east. Water Canyon is located along the northern boundary of TA-49, which also forms the southern boundaries of TA-15 and TA-37. Water Canyon heads in the Sierra de Los Valles and runs eastward to White Rock Canyon. Ancho Canyon originates within TA-49 and runs eastward to White Rock Canyon. Surface water flow within both Water and Ancho Canyons is ephemeral near TA-49.

Native soil cover of varying thickness are underlain by a distinct clay layer at the soil/rock interface; followed by (from youngest to oldest) the Tshirege Member of the Bandelier Tuff; Otowi Member of the Bandelier Tuff, including the Guaje Pumice bed; interbedded Puye Formation and Tschicoma Formation; the Totavi Lentil; and an undetermined thickness of the Santa Fe Group. A pyroclastic surge bed (60 to 80 beneath the surface) provides a useful site-wide marker, and is a potential contaminant migration pathway due to high permeability relative to the surrounding tuff. The surge bed is very near to, and in some cases intersects, experimental shafts. A 140-ft offset in the pre-Bandelier Tuff surface along the projection of the Guaje Mountain fault, in the northeastern portion of TA-49 (near well DT-5A), may influence the vadose and saturated zone hydrology as well as infiltration pathways at TA-49. The depth to the regional aquifer at TA-49 is approximately 1,000 ft below ground surface.

TA-49 has been used since the mid-1940s as a buffer zone for activities at adjacent firing sites (TA-15 and TA-39) and is currently used for this purpose. Underground hydronuclear and related experiments were conducted at TA-49 through August 1961. TA-49 contains 20 SWMUs: four underground shaft areas (Areas 1-4, including Areas 2A and 2B); a central control area (Area 5) to monitor underground experiments; a crafts area, an open burning/landfill operation (Area 6); an

underground calibration chamber (Area 10); a radiochemistry and small scale shot area (Area 11); and the Bottle House and Cable Test Pull Facility (Area 12). Areas 8 and 9 were never created. For the purpose of this Order, MDA AB will be referred to as Areas 2, 2A, and 2B, and 49-001(g). The Department is aware that during fiscal year 2000, MDA AB was incorporated into consolidated unit 49-001(a)-99 which includes Areas 1, 2, 2A, 2B, 3, and 4, and 49-001(g), an area of surface soil contamination. The Department will require investigation of MDA AB (Areas 2, 2A, 2B, and 49-001(g)) independent of Areas 1, 3, and 4. This section of the Order (IV.C.4) addresses all SWMUs grouped into the consolidated unit 49-001(a)-99 and Areas 11 and 12 located within the boundaries of TA-49.

MDA AB (SWMUs 49-001(b, c, d, and g)) consists of SWMUs that are contiguous, related to the same operation, have the same contaminants and contaminant origin, and therefore are grouped together as one area. Activities conducted at MDA AB included nuclear device safety tests and HE detonations conducted in 37 shafts at depths ranging from 30 to 78 ft. Materials released at MDA AB include HE, uranium, plutonium-239, americium-241, tritium, lead, and beryllium. The majority of the inventory released at MDA AB is present in the shafts at depths ranging from 50 to 78 ft.

Area 1 (SWMU 49-001(a)) was developed for containment studies in shafts, and later used for down hole studies involving uranium-238 and plutonium. Area 3 (SWMU 49-001(e)) was used exclusively for development of confinement and sample recovery techniques that were subsequently used at Areas 1, 2 (including 2A and 2B), and 4. Contaminants of concern include uranium-tracers, uranium-235 and 238, plutonium-239, and neptunium-239 tracers. Area 4 (SWMU 49-001(f)) was used for containment experiments. Tritium, beryllium, and lead contamination have been detected at Area 4.

Area 11 is the location of the former radiochemistry laboratory (Building 49-15) and associated leach field (SWMU 49-003), and a small-scale shot area (AOC C-49-008(c)). Area 11 was used during the period from 1959 to 1961 for activities related to the hydronuclear program. Activities conducted at Area 11 consisted of radiochemistry operations and small-scale shot experiments involving HE detonations (some containing uranium-238 tracers, neptunium-239, and lead) in shallow shafts. The Respondents' records indicate that Building 49-15 was demolished in 1971. There are no records indicating whether the leach field and drain lines were removed.

Area 12 (AOC C-49-008(d)) was used for confinement experiments in 1960 and 1961. The experiments consisted of HE detonations in sealed metal "bottles". The bottles (up to five ft in diameter and 16 ft in length) were placed in a ten-ft diameter, 30-ft deep shaft located within the Bottle House structure. Approximately 26 experiments were conducted at Area 12 involving irradiated uranium tracers and uranium-238. After containment experiments concluded in 1961, Area 12 structures were used to support operations at the Cable Test Pull Facility located across the access road from the Bottle House.

IV.C.4.b Historical Investigation

The Respondents shall conduct an investigation of contaminants that may have been discharged or released at MDA AB (Areas 2, 2A, and 2B), Experimental Shaft Areas (Areas 1, 3, and 4), Radiochemistry and Small Shot Area (Area 11), and the Bottle House (Area 12) at TA-49 during historical operations at the Facility. The investigation shall include a review of existing data and

other information acquired during previous investigations. In conducting the investigation, the Respondents shall review and confirm the construction details and historical use of all existing and demolished TA buildings and other structures; pits, shafts, trenches, landfills, surface impoundments, and other SWMUs; wastewater treatment, conveyance, and disposal systems; subsurface utility corridors; and other possible sources of discharges or releases of contaminants. The Respondents shall also review all investigation borings, excavations, sampling events, and other sources of information on contamination. The Respondents shall submit to the Department a historical investigation report for MDA AB, Areas 1, 3, 4, 11, and 12, which shall be included as an appendix to the MDA AB, Areas 1, 3, 4, 11, and 12 Investigation Work Plan under Section IV.C.4.c.i. The report shall contain, at a minimum, the following information:

1. A description of the location, construction details, operational history, and present status of each such pit, shaft, or other structure at MDA AB, Areas 1, 3, 4, 11, and 12. The Respondents shall depict all such locations in one or more figures.

2. A description of the known disposal history of each pit, shaft, or other structure listed under Paragraph 1. This description shall include all known and suspected material disposed, discharged, or released; the volume of each discharge or release; and the contaminants present in each discharge or release. The Respondents shall report whether the disposal history is incomplete or unknown.

3. A description of each previous investigation of the sources, extent, or characteristics of contamination at MDA AB, Areas 1, 3, 4, 11, and 12, regardless of whether or not such investigation was completed.

4. A summary of any results and conclusions of each previous investigation described in Paragraph 3, including the known or suspected dates of waste disposal, the suspected dates of contaminant releases, and the circumstances related to the contaminant releases.

5. A description of the location, construction details, history, and present status of each investigation well, boring, and excavation at MDA AB, Areas 1, 3, 4, 11, and 12. The Respondents shall depict all such locations in one or more figures. A site map encompassing the entire TA and pertinent regional investigation locations shall be included in the description.

6. An evaluation of the condition and well completion information, including well logs, for Deep Test Well No. 5A (DT-5A), Deep Test Well No. 9 (DT-9), and Deep Test Well No. 10 (DT-10).

7. A description of the sample collection methods and the types of field and laboratory analyses performed on each sample obtained from each media during the previous investigations.

8. Tables summarizing the data collected from each investigation well, boring, and excavation. The results shall present only analyte and radionuclide detections and data quality exceptions reported by the analytical laboratory that may mask analyte and radionuclide detections.

9. A summary of data quality exceptions and interpretations of all compromised data.

10. A summary of all contradictory or anomalous investigation results and the rationale for acceptance or rejection of the data.

11. A list of general chemistry, metals, and radionuclide background concentrations and documentation of the methods used for establishing the background values.

The summaries shall include references to historical documents within the summary text citing the document title, page number, and table or figure number. The full reference citations shall be presented as a separate Section in each summary document using the standard USGS format for reference citations. The Facility project leader for TA-49 corrective action activities shall meet with Department representatives to discuss the content and presentation of the information required in this Section. The Respondents are responsible for providing complete information with regard to the available data and the need for additional data at each unit. The Department shall evaluate the information and request changes as necessary. The Department's evaluation and approval will address the Respondents' general approach to site investigation and plan for acquiring additional data required to complete the site investigations at TA-49.

IV.C.4.c Technical Area 49 Investigation

IV.C.4.c.i Technical Area 49 Investigation Work Plan

The Respondents shall submit to the Department for approval a supplemental work plan for the completion of the investigation of contamination at TA-49 that meets the requirements of this Section (IV.C.4.c). The supplemental work plan shall provide for the completion of the RCRA Facility Investigation (RFI) Work Plan for Operable Unit 1144 (LA-UR-92-900) for MDA AB (Areas 2, 2A, and 2B), dated May 1992, which is incorporated herein by reference and made an enforceable part of this Order. The supplemental work plan shall be prepared in accordance with Section XI.B of this Order, and shall be submitted by the date specified in Section XII of this Order. The supplemental work plan shall address investigations of the sources of contamination, and the nature and extent of contamination in soils, sediments, surface water, and groundwater at TA-49, including monitoring and reporting. It shall also provide for investigation of Areas 1, 3, 4, 11, and 12 in TA-49. The supplemental work plan shall propose the frequency for submitting periodic monitoring reports.

Upon Department approval, the Respondents shall implement the supplemental work plan. The supplemental work plan shall be incorporated herein by reference and become an enforceable part of this Order.

IV.C.4.c.ii Technical Area 49 Survey of Disposal Units

The Respondents shall conduct a survey of the disposal units at TA-49. The Respondents shall determine the dimensions and total depth of each disposal shaft, pit or other unit, and the base profile, topography, low elevation point, and down-slope end of the base of each disposal pit, shaft, and other unit.

The dimensions and base elevations of each pit, shaft, and other unit shall be determined using as-built construction drawings and boring logs. If unavailable, ground penetrating radar, magnetic surveys, or other methods shall be used. The methods used to evaluate the pits, shafts, and other units shall be approved by the Department prior to implementation. The survey shall be completed prior to implementation of the drilling explorations under Section IV.C.4.c.iii.

IV.C.4.c.iii Technical Area 49 Drilling Explorations

The Respondents shall conduct subsurface explorations at TA-49 in order to acquire data to delineate the extent of contamination and to characterize fracture density, fracture orientation, fracture fill material, and the extent, density, and orientation of fractures created by Facility testing activities. The subsurface conditions shall be characterized by utilizing data acquired from cores, drill cuttings, down hole geophysical logs, video logs, and by evaluating samples of soils, rock, subsurface vapor, and groundwater (where present) by field screening and laboratory chemical analysis. The following are minimum requirements for completing subsurface explorations at MDA AB and Areas 1, 3, 4, 11, and 12:

1. Two borings shall be advanced at MDA AB. One boring shall intersect stratigraphic Unit 5 of the Tshirege Member of the Bandelier Tuff (surge bed) that occurs at a depth of approximately 60 to 80 ft bgs. Unit 5 shall be characterized to evaluate its potential as a migration pathway. One boring shall be installed to a minimum depth of 900 ft to evaluate for the presence of intermediate perched groundwater, to characterize the high permeability zones observed at depths of 285 to 300 ft during the previous drilling (CH-2 and DT-5A), and to assess the potential of the contact between the Tshirege and Otowi formations to act as a hydraulic barrier.

2. Four borings shall be advanced a maximum distance of 25 ft from the perimeter of each of the experimental shaft areas at Areas 1, 3, and 4. Each boring shall be installed to depths of 50 ft below the deepest shaft.

3. Two borings shall be advanced at the Small Shot Area at Area 11. One boring shall intersect stratigraphic Unit 5 of the Tshirege Member of the Bandelier Tuff (surge bed) that occurs at a depth of 60 to 80 ft below the ground surface. The other boring shall be installed to a minimum depth of 35 ft.

4. Vapor samples shall be collected from each boring advanced at the Small Shot Area at Area 11 and analyzed for tritium and VOCs. If contaminants are detected the Respondents shall install a vapor monitoring well in each boring.

5. Four borings shall be advanced at the Area 11 leach field in accordance with the requirements of Section IX of this Order. The Respondents shall collect samples continuously in each borehole during drilling.

6. The former locations of sumps or drains associated with the radiochemistry building at Area 11 shall be located. If located, discrete samples shall be collected from directly below the

base elevation of the structure and ten ft below the base elevation of the structure in the native soil.

7. Five borings shall be advanced within the footprint of the radiochemistry building at Area 11 to a depth of ten ft and in accordance with the requirements of Section IX of this Order.

8. Surface samples shall be collected (0 to 12 inches) on a 25-ft center grid pattern over the Area 11 small shot area and radiochemistry building footprint.

9. Two borings shall be advanced at Area 12. One boring shall be installed within ten ft from the Bottle House building. Each boring shall be advanced to depths of 50 ft below the base of the deepest shaft. One boring shall be installed beneath the location of the former Cable Test Pull facility to an approximate depth of 25 ft.

10. Surface samples shall be collected (0 to 12 inches) at Area 12 on a grid pattern approved by the Department.

11. Vapor samples shall be collected from each boring installed at the Bottle House at Area 12 and analyzed for tritium and VOCs.

12. Vapor monitoring wells shall be installed in borings if vapor-phase contamination is detected during drilling activities.

13. A monitoring well shall be installed if groundwater (perched or regional) is encountered during drilling activities or if geophysical results indicate possible zones of saturation. The wells shall be constructed in accordance with Section X of this Order.

14. All borings not completed as vapor or groundwater monitoring wells shall be properly plugged and abandoned. Documentation of proper well abandonment shall be submitted to the Department within 30 days of abandonment.

15. The Department must approve all borehole locations prior to the start of drilling activities.

16. The borings shall be advanced using hollow-stem auger drilling methods, where practicable, or other drilling methods approved by the Department.

17. The borings shall be advanced a minimum of 20 ft below the deepest detected soil, rock, vapor, or groundwater contamination as detected by field screening or during previous investigations.

18. Each borehole shall be characterized using geophysical logging techniques approved by the Department prior to data collection. At the Small Shot Area at Area 11, the deep borehole shall be characterized using geophysical logging techniques approved by the Department.

IV.C.4.c.iv Technical Area 49 Soil and Rock Sampling

Soil and rock sampling shall be conducted in accordance with the requirements of Section IX.B. of this Order. The following are minimum requirements for completing soil and rock sampling during subsurface drilling explorations at MDA AB and Areas 1, 3, 4, 11, and 12:

1. At MDA AB and Areas 1, 3, and 4, soil samples shall be collected in each boring at ten-ft intervals. At Area 11 and Area 12, soil samples shall be collected in each boring at five-ft intervals.

2. Samples shall be collected and screened in accordance with the methods specified in Section IX.B of this Order.

3. At MDA AB and Areas 1, 3, and 4, a minimum of one core sample collected from each boring shall be collected and submitted for laboratory permeability testing. At Area 11, cores shall be obtained from selected borings, if deemed appropriate and at depths approved by the Department. Permeability testing shall be performed in accordance with Section IX.B of this Order.

4. Field screening and laboratory sample selection shall be biased toward evidence of contamination, lithologic contacts, fractures, fracture fill material, surge beds, and other higher permeability units identified during investigation activities. The samples shall be collected and screened in accordance with the methods described in Section IX.B of this Order.

5. Soil and rock samples shall, at a minimum, be obtained from the intervals described in Paragraph 1 above and from the bedrock at the base elevation of each shaft or pit. A sample also shall be obtained from the maximum depth of each boring.

6. At MDA AB and Areas 1, 3, and 4, a minimum of four samples shall be selected from each boring for submittal to a laboratory for analysis of HE compounds, perchlorate, TAL metals, total uranium, cyanide, and radionuclides. The sample exhibiting the highest field screening detection; the sample obtained from the maximum depth in each boring that displays field screening evidence of contamination; the sample located at the base of any pit, shaft, tank, or other structure; and the sample obtained from the maximum boring depth shall be submitted for laboratory analysis.

7. At Area 11, a minimum of two samples shall be selected from each boring for laboratory analysis of HE compounds, perchlorate, TAL metals, total uranium, cyanide, radionuclides, VOCs, and SVOCs. At all locations, the sample exhibiting the highest field screening detection; the sample obtained from the maximum depth in each boring that displays field screening evidence of contamination; the sample located at the base of any pit, shaft, tank, or other structure; and the sample from the total boring depth shall be submitted for laboratory analysis.

8. At the Bottle House at Area 12, a minimum of two samples shall be selected from the borings for submittal to a laboratory for analysis of HE compounds, perchlorate, TAL

metals, total uranium, cyanide, radionuclides, VOCs, and SVOCs. A minimum of two samples shall be selected from the boring located at the Cable Test Pull Facility for submittal to a laboratory for analysis of VOCs, SVOCs, and diesel and oil range organics. The sample exhibiting the highest field screening detection; the sample obtained from the maximum depth in each boring that displays field screening evidence of contamination; the sample located immediately below the base elevation of any shaft, pit, tank, or other structure; and the sample obtained from the maximum boring depth shall be submitted for laboratory analysis.

IV.C.4.c.v Technical Area 49 Vapor Monitoring

The Respondents shall determine if vapor-phase contamination is present beneath MDA AB and Areas 1, 3, 4, and 12. If vapor-phase contamination is detected, the Respondents shall install vapor-monitoring wells in the borings and conduct vapor monitoring and sampling as outlined in Section IX.B. In addition, the Respondents shall submit a vapor monitoring and sampling work plan for approval by the Department prior to well construction. If vapor-phase contamination is detected, the Respondents shall, at a minimum, collect vapor samples from discrete zones in each vapor monitoring well or boring at depths approved by the Department. These data will be used to evaluate the need for additional monitoring and investigation.

In addition, the Respondents shall continue the moisture monitoring and reporting at MDA AB, as required by the Respondents' *Stabilization Plan for Installing Best Management Practices at Potential Release Sites 49-001(b, c, d, and g)*, dated June 1998 or other approved monitoring plan.

IV.C.4.c.vi Technical Area 49 Intermediate Groundwater Well Installation

The Respondents shall install one groundwater monitoring well that intersects intermediate perched groundwater, if such groundwater is present beneath the site. This well shall be installed within the boundaries of TA-49 and downgradient from MDA AB at a location approved by the Department.

IV.C.4.c.vii Technical Area 49 Regional Groundwater Well Installation

The Respondents shall install regional aquifer well R-30 at the approximate location proposed in the HWP in accordance with the schedule set forth in Section XII of this Order.

IV.C.4.c.viii Technical Area 49 Groundwater Monitoring

The Respondents shall monitor and sample all wells associated with MDA AB containing alluvial, intermediate, and regional groundwater in accordance with Sections IV.A and IX of this Order

1. Groundwater samples shall be collected from each saturated zone intersecting the alluvial aquifer from wells Beta Hole, WCO-1, WCO-2, WCO-3, and all alluvial wells installed in the future.

2. Groundwater samples shall be collected from each zone intersecting the intermediate perched water from well CdV-37-2 and all intermediate wells installed in the future.

3. Groundwater samples shall be collected from each saturated zone intersecting the regional aquifer wells CdV-37-2, DT-5A, DT-9, DT-10, and all regional wells installed in the future.

4. Samples shall be submitted to a laboratory for analysis of general chemistry parameters as described in Section IX of this document and for VOCs, SVOCs, HE compounds, perchlorate, TAL metals, total uranium, cyanide, and radionuclides and for other analytes specified by the Department.

5. A groundwater monitoring and sampling work plan shall be submitted to the Department for approval prior to implementation of the groundwater sampling program at MDA AB.

6. As described in Section IV.B.3.b.iv, Paragraph 5, a long-term groundwater monitoring and sampling work plan shall be submitted to the Department for approval. The work plan shall include the specifics for conducting groundwater sampling in Water Canyon/Cañon de Valle watershed prior to implementation of the groundwater sampling program.

The groundwater monitoring requirements outlined in this section (IV.C.4.c.viii) shall be used to capture all other current groundwater monitoring requirements in this Order for TA-49 (Areas 1, 3, 4, 11, and 12).

IV.C.4.c.ix Technical Area 49 Investigation Report

The Respondents shall submit to the Department for approval an investigation report that presents the results of the field activities, summarizes the data collected, and presents the recommendations and conclusions for MDA AB and Areas 1, 3, 4, 11, and 12. The investigation report shall be prepared in accordance with Section XI.C of this Order and submitted by the date specified in Section XII of this Order.

IV.C.5 Technical Area 10

IV.C.5.a Background

Former TA-10, commonly known as the Bayo Canyon site, is located in Bayo Canyon adjacent to the western boundary of TA-74 and approximately four miles west of the intersection of Bayo and Los Alamos Canyons. Bayo Canyon is situated between Otowi and Kwage mesas and is a tributary of Los Alamos Canyon. Bayo Canyon's intermittent surface water flow in the canyon stream channel is associated exclusively with storm events. A total of 27 SWMUs have been identified at former TA-10, however, this section (IV.C.5) addresses SWMUs 10-002(a and b), 10-003(a-o), 10-004(b), and 10-007.

The Bayo Canyon site consists of the following: 1) solid and liquid waste disposal pits; 2) liquid waste disposal tanks, leach fields and associated drain lines (referred to as the "liquid waste disposal complex"); 3) a solid waste landfill; and 4) a sanitary septic tank. The disposal areas received waste containing strontium-90, uranium, barium, cadmium, plutonium, benzene, carbon tetrachloride, unspecified acids, VOCs, inorganics (including metals), and other radionuclides. The piping, tanks, and other structures and surrounding soils at the "liquid waste disposal complex" were removed in 1963. The resulting excavation was then used as a landfill.

The Respondents conducted open-detonation explosive tests and radiochemical operations related to the development of nuclear weapons at the Bayo Canyon site from 1943 to 1961. In 1963, operational structures at the site were reportedly decontaminated and demolished, and the land was subsequently transferred to Los Alamos County.

Radiochemical operations were conducted at the TA-10 Radiochemistry Laboratory (Lab), Building TA-10-1. The Lab was located in Bayo Canyon northwest of the Bayo Sewage Treatment Facility. Radiation sources for blast diagnostics were prepared at the Lab. The process included separation of lanthanum-140 from a solution containing barium-140 that produced strontium-90 as a byproduct. Separation, precipitation, and encapsulation activities were performed at the Lab from 1944 to 1950. Precipitation and encapsulation work was continued at the TA-10 Lab until 1961. The explosive detonation work dispersed uranium isotopes, lanthanum, and strontium-90 outward from shot pads up to 350 to 650 ft away via aerosols and solid debris. Routine post-shot surveys to a radius of approximately five miles detected lanthanum-140 contamination near State Road 4 and Otowi and Kwage mesas. Post-shot contaminants were washed off the pads with water. Periodic radiation levels measured around the pads ranged from tenths of Roentgens to several Roentgens per hour.

Liquid releases at TA-10 were apparently restricted to operations at the pad areas (wash-off water), the Lab (sanitary and laboratory waste), and the personnel building (sanitary waste). Waste streams that may have contained strontium-90 were discharged from the Lab via acid-waste lines to holding tanks, pits, and a leach field located in "the liquid waste disposal complex." The disposal pits were designed to drain excess liquids through outlet pipes located at or near the base of the pits. Liquid wastes from the storage tanks were periodically discharged to the Bayo Canyon stream channel. It is estimated that approximately 117 Curies of strontium-90 were generated during site operations. Sanitary waste generated at the Lab was delivered to the liquid waste disposal complex or leach field via a septic tank and drain lines. The canyon-bottom alluvium and underlying units transmitted liquid wastes during times of active effluent release. Groundwater monitoring has not been conducted at this site.

Sanitary liquid waste generated at the personnel building (TA-10-10), located approximately 980 ft west of the Lab was discharged to a 1,060-gallon septic tank that discharged to a pit. Liquid overflow from the pit flowed to a drain line that discharged to an intermittent stream channel. The buildings, sewer systems, disposal complex, and surface debris (approximately a 2,500-ft radius from the detonation control buildings) at the site were decommissioned and removed for disposal at TA-54 between 1960 and 1963. The highest levels of radionuclide contamination were detected during the excavation of the disposal complex. The disposal complex was excavated to a depth of approximately 20 ft below ground surface. Measurements of up to 35 millirad per hour (mrad/hr) were obtained during excavation activities and measurements of 1.5 mrad/hr were obtained at the base of the excavation.

Three boreholes were drilled in the vicinity of the Lab as part of a subsurface investigation conducted in 1973. The results of radionuclide screening obtained from two of the three holes detected elevated levels of strontium-90 (20 and 3.3 picocuries per gram (pCi/g)) at depths of approximately five ft below ground surface. In 1974, 11 more borings were drilled in the vicinity of the 1973 boreholes. Soil samples obtained from the borings were analyzed for gross alpha and beta. Gross beta was detected in samples collected from each of the borings at levels greater than the

assumed background for Pajarito Plateau canyon sediments in 1974 of 4 pCi/g. Detected gross beta levels ranged from 1.0 pCi/g to 24,000 pCi/g. The maximum detected level at the total boring depths of approximately 30 ft below ground surface was 1,510 pCi/g.

A survey was performed at the Bayo Canyon site in 1977. The survey included sampling of surface and subsurface soils and sediments. It was performed at and near the Lab, at the firing sites, and the natural drainage from the firing sites located approximately 600 ft east of the Lab. Elevated levels (maximum level of 132 pCi/g) of strontium-90 were detected in the subsurface near the Lab during this survey.

IV.C.5.b Historical Investigation

The Respondents shall conduct an investigation of contaminants that may have been discharged or released at SWMUs 10-002(a and b), 10-003(a-o), 10-004(b), and 10-007 during historical operations at the Facility. The investigation shall include a review of existing data and other information acquired during previous investigations. In conducting the investigation, the Respondents shall review and confirm the construction details and historical use of all existing and demolished former TA-10 buildings and other structures; pits, shafts, trenches, landfills, surface impoundments, and other SWMUs; wastewater treatment, conveyance, and disposal systems; subsurface utility corridors; and other possible sources of discharges or releases of contaminants. The Respondents shall also review all investigation borings, excavations, sampling events, and other sources of information on contamination. The Respondents shall submit to the Department a historical investigation report for, SWMUs 10-002(a and b), 10-003(a-o), 10-004(b), and 10-007, which shall be included as an appendix to the Investigation Work Plan under Section IV.C.5.c.i. The report shall contain, at a minimum, the following information:

1. A list of all past or present SWMUs, AOCs, pit, leachfield, and other sites in or bordering the Bayo Canyon site that may have contributed contaminants to the canyon drainages.

2. A list of all past or present outfalls, NPDES-permitted discharges, and other discharge locations that may have contributed contaminants to the canyon drainages.

3. A description of the location, construction details, operational history, and present status of each such SWMU, AOC, pit, leachfield, and other site listed under Paragraph 1 and each outfall, NPDES discharge, and other discharge location listed under Paragraph 2. The Respondents shall depict all such locations in one or more figures.

4. A description of the known disposal history of each SWMU, AOC, pit, leachfield, and other site listed under Paragraph 1 and each outfall, NPDES discharge, and other discharge location listed under Paragraph 2. This description shall include all known and suspected material disposed, discharged, or released; the volume of each discharge or release; the flow rate of each discharge or release; and the contaminants present in each discharge or release. The Respondents shall report whether the disposal history is incomplete or unknown.

5. A description of each previous investigation of the sources, extent, or characteristics of contamination at the Bayo Canyon site, regardless of whether or not such investigation was

completed.

6. A summary of any results and conclusions of each previous investigation described in Paragraph 5, including the known or suspected dates of waste disposal, including the known or suspected dates of each release of contamination, and the circumstances related to the release of contamination.

7. A description of the location, construction details, history, and present status of each investigation well, boring, and excavation at SWMUs 10-002(a and b), 10-003(a-o), 10-004(b), and 10-007. The Respondents shall depict all such locations in one or more figures. A site map encompassing the entire TA and pertinent regional investigation locations shall be included in the description.

8. A description of the sample collection methods and the types of field and laboratory analyses performed on each sample obtained from each media during the previous investigations.

9. Tables summarizing the data collected from each investigation well, boring, and excavation. The results shall present only analyte and radionuclide detections and data quality exceptions reported by the analytical laboratory that may mask analyte and radionuclide detections.

10. A summary of data quality exceptions and interpretations of all compromised data.

11. A summary of all contradictory investigation results and the rational for acceptance or rejection of selected investigation results.

12. A list of general chemistry, metals, and radionuclide background concentrations and documentation of the methods used for establishing the background values.

The summaries shall include references to historical documents within the summary text citing the document title, page number, and table or figure number. The full reference citations shall be presented as a separate section in each summary document using the standard USGS format for reference citations. The Facility project leader for corrective action at TA-10 shall meet with Department representatives to discuss the content and presentation of the information required in the investigation work plans and reports. The Respondents shall provide complete data and information, to the extent it is available, and shall identify the need for any additional data at each SWMU. The Department shall evaluate the information and request changes as necessary. The Respondents shall submit new or updated information to the Department as soon as it becomes available.

IV.C.5.c Technical Area 10 Investigation

IV.C.5.c.i Technical Area 10 Investigation Work Plan

The Respondents shall submit to the Department for approval a work plan for the investigation of contamination at TA-10 that meets the requirements of this Section (IV.C.5.c). The work plan shall be prepared in accordance with Section XI.B of this Order, and shall be submitted by the date specified in Section XII of this Order. The work plan shall address investigations of the disposal

units; migration pathways and the connections to potential receptors including groundwater; and the nature and extent of contamination in soil, rock, sediments, groundwater (where present), and soil vapor at TA-10, including monitoring and reporting. The work plan shall propose the frequency for submitting periodic monitoring reports.

Upon Department approval, the Respondents shall implement the work plan. Upon Department approval, the work plan shall be incorporated herein by reference and become an enforceable part of this Order.

IV.C.5.c.ii Technical Area 10 Survey of Disposal Units

The Respondents shall conduct a survey of the disposal units at TA-10. The Respondents shall determine the dimensions and total depth of each disposal shaft, pit, and other unit, and the base profile, topography, low elevation point, and down-slope end of the base of each disposal shaft, pit, and other unit.

The dimensions and base elevations of each pit, shaft, and other unit shall be determined using as-built construction drawings and boring logs. If unavailable, ground penetrating radar, magnetic surveys, or other methods shall be used. The methods used to evaluate the pits, shafts, and other units shall be approved by the Department prior to implementation. The survey shall be completed prior to implementation of the drilling explorations under Section IV.C.5.c.iii.

IV.C.5.c.iii Technical Area 10 Drilling Explorations

The Respondents shall conduct subsurface explorations in order to acquire data to characterize the following:

1. The type and concentrations of contaminants present at, and off site from, each SWMU and/or AOC; and

2. The presence of subsurface moisture and the extent of any zones of saturation in the canyon alluvium or bedrock above the regional aquifer.

Prior to the implementation of drilling explorations, the Respondents shall determine the locations, dimensions, remaining structures, and total depths of facility-related features at each SWMU and AOC, and the types of contaminants released from each SWMU and AOC. The dimensions and base elevations of each unit shall be determined using as-built construction drawings and boring logs. If unavailable, ground penetrating radar, magnetic surveys or other methods shall be used. The methods used to evaluate the dimensions of each SWMU or AOC unit shall be approved by the Department prior to implementation.

The characterization shall be completed utilizing data acquired from samples, drill cuttings, cores, and down-hole geophysical data. The subsurface conditions shall be characterized by evaluating samples of soil, rock, sediments, and groundwater (where present) for field screening and laboratory chemical analysis. The methods and locations for collecting data shall be approved by the Department prior to data collection. The following are minimum requirements for completing subsurface explorations:

1. The exact location of former SWMU 10-002(b) shall be identified and a minimum of ten borings shall be advanced to depths of 25 ft bgs in the vicinity of the former disposal pit.

2. Ten borings shall be advanced to depths of 30 ft bgs in the vicinity of the leach field [formerly SWMU 10-003(n)].

3. The presence or absence of drain lines at former SWMU 10-004(b) shall be determined. If present, the drain lines shall be removed, and samples shall be collected from the excavation at 20-ft intervals for field screening and laboratory analyses. If the drain line is not excavated, borings shall be advanced at 25-ft intervals along the entire length of the drain line to depths of five ft below the base of the drain line trench.

4. The drilling activities shall be conducted in accordance with Section X of this Order.

5. The boring locations shall be approved by the Department prior to the start of drilling activities. The borings shall be advanced using hollow-stem auger drilling methods, where practicable, or other drilling methods approved by the Department.

6. At a minimum, two borings shall be advanced to first water to evaluate for the presence of perched groundwater at depth beneath the site.

IV.C.5.c.iv Technical Area 10 Soil and Rock Sampling

The following are minimum requirements for completing soil and rock sampling during subsurface drilling explorations:

1. Soil and rock samples shall, at a minimum, be obtained from each boring at five-ft intervals and from the native material directly below the base of each SWMU or AOC structure or excavation. A sample also shall be obtained at the maximum depth of each boring.

2. The samples shall be collected and screened in accordance with the methods described in Section IX.B of this Order.

3. A minimum of two cores shall be obtained from selected borings, at depths approved by the Department, for permeability testing in accordance with Section IX.B of this Order.

4. A minimum of two samples shall be selected from each boring for submittal to a laboratory for analysis of VOCs, SVOCs, HE, perchlorate, TAL metals, total uranium, cyanide, and radionuclides.

5. The sample displaying the greatest field screening evidence of VOC or radionuclide concentrations shall be selected for submittal to the analytical laboratory for chemical analysis listed in Paragraph 4 above.

6. If field screening evidence of contamination is not observed in a boring, the sample obtained from the native material located directly below the limits of the original construction excavation shall be submitted for the chemical analyses listed in Paragraph 4 above.

7. The sample obtained from the maximum depth of each boring also shall be submitted to an analytical laboratory for the analyses listed in Paragraph 4 above.

8. All borings not completed as monitoring wells shall be properly plugged and abandoned in accordance with Section X of this Order. The Respondents shall provide a status report describing the details of borehole abandonment to the Department within 30 days of completion of abandonment activities.

9. Remove the landfill material at SWMU 10-007 for disposal at an approved landfill. Collect samples from the limits of the excavation at locations specified by the Department.

IV.C.5.c.v Technical Area 10 Groundwater Well Installation

The Respondents shall, at a minimum, construct intermediate zone, and regional groundwater monitoring wells as follows:

1. Two borings shall be advanced to depths intersecting the first significant presence of intermediate zone perched groundwater downgradient of the former liquid waste treatment facility at locations approved by the Department. The respondents shall construct monitoring wells in the borings in accordance with Section X of this Order if groundwater is observed in zones above the regional aquifer.

2. One well shall be installed intersecting the regional aquifer at a location approved by the Department.

3. Core and groundwater samples shall be collected from the boring prior to well construction. The core samples shall be collected to evaluate hydraulic parameters, K_d, and for potential contaminants.

The Department may impose specific conditions for well construction, require the intermediate borings to be extended to the regional aquifer, or require the drilling of additional borings that intersect the intermediate perched zones or regional aquifer based on the sampling and/or geophysical logging results.

IV.C.5.c.vi Technical Area 10 Groundwater Monitoring

The Respondents shall monitor and sample the intermediate perched and regional groundwater in accordance with Section IX of this Order.

1. Groundwater samples shall be collected from each saturated zone intersecting the newly–installed monitoring wells.

2. Groundwater samples shall be submitted to a laboratory for analysis of general chemistry parameters as described in Section IX.B of this Order, radionuclides, perchlorate, TAL metals, total uranium, cyanide, VOCs, SVOCs, and for other analytes specified by the Department.

3. As described in Section IV.B.1.d.vii, Paragraph 7, a long-term groundwater monitoring and sampling work plan shall be submitted to the Department for approval. The work plan shall include the specifics for conducting groundwater sampling at TA-10 as part of the Los Alamos/Pueblo Canyon watershed prior to implementation of the groundwater-sampling program.

The Respondents shall complete the work at TA-10 in accordance with the schedule provided in Section XII of this Order. The Respondents shall report results from the monitoring and sampling plan in accordance with the requirements outlined in Section XI of this Order.

IV.C.5.c.vii Technical Area 10 Investigation Report

The Respondents shall submit to the Department for approval an investigation report that presents the results of the field activities, summarizes the data collected, and presents the recommendations and conclusions for TA-10. The investigation report shall be prepared in accordance with Section XI.C of this Order and submitted by the date specified in Section XII of this Order.

V. INVESTIGATION FOR OTHER SWMUS AND AOCS

V.A INTRODUCTION

This section (V) provides requirements for investigation of all SWMUs and AOCs not addressed in Sections IV and VI of this Order, including any additional SWMUs or AOCs that may be discovered after the issuance of this Order.

V.B AGGREGATE AREAS

Within 180 days of the effective date of this Order, the Respondents shall submit to the Department a list of all Aggregate Areas identifying each SWMU and AOC located within each Aggregate Area, including all SWMUs and AOCs listed in the Facility Operating Permit. The Respondents shall identify each unit as a SWMU or an AOC. The list shall be revised upon the discovery of additional SWMUs or AOCs.

V.C NEWLY IDENTIFIED SWMUS AND AOCS

Within fifteen (15) days after the discovery of any newly identified or suspected SWMU or AOC, the Respondents shall notify the Department in writing of such discovery and submit a revised list of Aggregate Areas. The notification shall include, at a minimum, the location of the SWMU or AOC and all available information pertaining to the nature of any release of contaminants from the SWMU or AOC, including the contaminants released, the magnitude of the release, and the media affected by the release.

Within sixty (60) days after submitting such notification, the Respondents shall submit to the Department for approval a SWMU Assessment Report (SAR) for each newly identified or suspected SWMU or AOC. At a minimum, the SAR shall provide the following information:

1. Location of each unit on a topographic map of appropriate scale;

2. Designation of type and function of each unit;

3. General dimensions, capacities, and structural description of each unit (including any available plans/drawings);

4. Dates of operation for each unit;

5. Identification of all wastes that have been managed at or in each unit, to the extent available. Include any available data on hazardous constituents and radionuclides in the wastes; and

6. All available information pertaining to any release of contaminants from each unit, including groundwater data, soil analyses, air sampling or monitoring data, and surface water data.

Based on the results of the SAR, the Department will determine the need for further investigations at the SWMUs or AOCs covered in the SAR, including the need for an investigation report under Section V.E.3.

V.D NEWLY DISCOVERED RELEASES FROM SWMUS OR AOCS

Within fifteen (15) days after the discovery of any previously unknown release of a contaminant from a SWMU or AOC, the Respondents shall notify the Department in writing of such discovery. The Department will determine whether further investigation of the release of contaminants is needed, including the need for an investigation report under Section V.E.3.

V.E SITE INVESTIGATIONS

V.E.1 Investigation Work Plan

The Department may determine that further investigation is needed at any of the SWMUs or AOCs listed in the Facility Operating Permit or identified under Sections V.C or V.D. If the Department makes such a determination, it will notify the Respondents in writing. The Respondents shall submit to the Department for approval an investigation work plan or plans for those SWMUs and AOCs needing further investigation. An individual work plan may cover several SWMUs or AOCs within an Aggregate Area. The work plans shall be prepared in accordance with Section XI.B of this Order and shall be submitted by the date specified for the appropriate Aggregate Area in Section XII of this Order.

If the Department determines that further investigation of a newly discovered SWMU or AOC is required, the Facility's Operating Permit will be modified to include the newly discovered SWMU or AOC on the list of SWMUs requiring further investigation, in accordance with 20.4.1.901 NMAC and 20.4.1.900 NMAC (incorporating 40 C.F.R. Part 270, Subpart D).

V.E.2 Site Investigation

The Respondents shall perform the site investigations in accordance with the approved investigation work plan. The Respondents shall notify the Department a minimum of twenty (20) business days prior to the commencement of any field activity under the approved investigation work plan.

V.E.3 Investigation Report

The Respondents shall submit to the Department for approval an investigation report that presents the results of field activities, summarizes the data collected, and presents the recommendations and conclusions of the investigation. An individual report may cover several SWMUs or AOCs within an Aggregate Area. The reports shall be prepared in accordance with Section XI.C of this Order and shall be submitted by the date specified in the approved investigation work plan.

V.F CORRECTIVE ACTION

V.F.1 Corrective Measures Evaluation

If the Department requires corrective action at a SWMU or AOC listed in the Facility's Operating Permit or identified in Sections V.B or V.C of this Order, the Respondents shall submit to the Department a corrective measures evaluation, in compliance with the requirements of Section XI of this Order, within 180 days of notification by the Department that a corrective measures evaluation is required. Public participation requirements listed in Section VII.D.7 shall be followed during the remedy selection process.

V.F.2 Corrective Measures Implementation

The Respondents shall implement the remedy chosen in the corrective measures evaluation. The Respondents shall submit a corrective measures completion report to the Department in accordance with a schedule for completion determined by the Department.

V.G INTERIM MEASURES

The Respondents shall prepare a list of sites where interim measures are needed. The list shall be based on current knowledge of site contaminants, contaminant concentrations, potential contaminant migration, and potential unacceptable risk to human health and the environment. The Respondents shall submit the list to the Department within 180 days of the effective date of this Order and shall update the list annually. The first submittal shall be included with the initial Site-wide Stabilization Plan.

V.G.1 Interim Measures Work Plan

If required by the Department, the Respondents shall prepare and submit to the Department for approval an Interim Measures Work Plan. Interim measures will be required, if necessary, to reduce or prevent migration of contaminants or human or environmental exposure to contaminants while long-term corrective action remedies are evaluated and implemented. The Respondents shall include an implementation schedule in the Interim Measures Work Plan.

The Interim Measures Work Plan required by the Department must be approved prior to implementation. If the Department disapproves the Interim Measures Work Plan, the Department will notify the Respondents in writing of the plan's deficiencies and specify a due date for submission of a revised Interim Measures Work Plan.

The Respondents may initiate interim measures without prior approval by the Department by notifying the Department in writing prior to implementation of the interim measures.

V.G.2 Interim Measures Implementation

The Respondents shall implement the interim measures in accordance with the approved Interim Measures Work Plan or with the prior written notification.

Within 90 days of completion of interim measures, the Respondents shall prepare and submit to the Department, an Interim Measures Report summarizing the results of the interim measures, and including copies of all relevant laboratory, monitoring, and other data. The Interim Measures Report format shall follow the requirements described in Section XI of this Order.

V.H AGGREGATE REQUIREMENTS

The Respondents shall submit a list identifying all SWMUs and AOCs located within each aggregate to the Department within 180 days of the effective date of this Order. The Respondents shall identify each unit as a SWMU or an AOC. The Respondents shall submit a work plan to the Department for approval to investigate each aggregate in accordance with the schedule provided in Section XII of this Order. Upon review of the work plans, the Department will determine the submittal dates for the aggregate-specific investigation reports. The Respondents shall follow the protocol for site investigation, monitoring, and reporting established in this Order.

VI. ON-GOING INVESTIGATIONS

VI.A INTRODUCTION

This section (VI) provides for the continuing investigation of several TAs, MDAs, SWMUs, and AOCs for which investigations have already begun under various authorities. This section also provides for the implementation of corrective measures at some of these sites. Additional investigations or corrective measures at any of these sites may be required.

VI.B SWMU 3-010(A)

VI.B.1 Background

SWMU 3-010(a) is located at TA-3. The SWMU was created as a result of disposing used vacuum oil from the pump repair area at Building TA-3-30. The oil contained radionuclides, benzene, toluene, ethylbenzene, xylene, and metals, including mercury. The disposal site was used from 1950 to 1957. It was approximately 40 ft long by 15 ft wide and is located on a moderately steep hillside on the west side of Building TA-3-30. The drainage from the hillside flows into a tributary of Two-Mile Canyon. A recreational footpath runs through the tributary west of the site.

Contaminated soil was removed in 1994 during corrective measures activities. Confirmatory samples collected following the soil removal and fill replacement revealed the presence of VOCs. A Phase II RFI was performed to determine the extent of the VOC and tritium contamination. Groundwater was encountered at approximately 23 ft bgs during drilling activities and a well was installed in one of the boreholes. Water samples were collected from the well, which showed VOCs above SALs and tritium. The Respondents also collected water samples from a seep located in the tributary. Metals (lead and mercury) were detected in several of those water samples.

In a supplemental information request for the RFI Report addendum, the Department required the Respondents to further determine the extent of the groundwater contamination, groundwater source, groundwater flow direction, and any connection between the shallow groundwater and deeper zones. The Respondents are also required to determine if there is another source causing or contributing to the contaminated groundwater.

The Department considers this site to be a high priority because groundwater has been contaminated, the extent of groundwater contamination is unknown, and other possible sources of contamination have not been investigated.

VI.B.2 SWMU 3-010(a) Continued Investigation

The Respondents shall continue the investigation of SWMU 3-010(a). The investigation shall identify and characterize all sources of groundwater contamination; fully characterize the vertical and lateral extent of groundwater contamination; determine the groundwater source and groundwater flow rates; and determine whether there is any connection between the alluvial aquifer and the intermediate or regional aquifer.

The Respondents shall submit to the Department for approval an investigation work plan for SWMU 3-010(a). The work plan shall be prepared in accordance with Section XI.B of this Order, and shall be submitted by the date specified in Section XII of this Order.

Upon Department approval, the Respondents shall implement the investigation work plan. Upon Department approval, the work plan shall be incorporated herein by reference and become an enforceable part of this Order.

The Respondents shall submit to the Department for approval an investigation report that presents the results of field activities, summarizes the data collected, and presents recommendations and conclusions of the investigation for SWMU 3-010(a). The investigation report shall be prepared in accordance with Section XI.C of this Order and shall be submitted by the date specified in Section XII of this Order.

VI.C SWMU 16-003(O)

VI.C.1 Background

SWMU 16-003(o) is the former outfall associated with Building TA-16-340 at TA-16. Building 16-340 is the largest of approximately five structures that operated to produce plastic-bonded explosive powders in 1951 and 1952. The operations in the building ceased in October 1999. The interior drain lines feed six HE sumps that originally discharged to the outfall and into a short tributary of Cañon de Valle. Between 1951 and 1988, all HE-contaminated wastewater that was discharged was untreated. In the early 1980s, a 250-ft long weir-type discharge aerator (also known as the "fish ladder") was fitted to the outfall to allow aeration of solvents before final discharge to the drainage. In 1989, a distiller was installed in Building 16-340 to help trap solvents before discharge to the outfall. In 1998, the six sumps were sealed off from discharging to the outfall and fitted with water-level detectors and alarms. HE-contaminated wastewater is now pumped from the sumps as needed and treated at the High Explosives Wastewater Treatment Plant. The use of the outfall was discontinued and the outfall was plugged on July 20, 1998.

Historically, Building 16-340 was the largest user by volume of solvents at TA-16. Contaminants identified at the site are HE (including HMX, RDX and TNT), VOCs, SVOCs, barium, and uranium. Soil, sediment, and sump water samples obtained between 1970 and 1985 contained low concentrations of HE.

The Department considers this site to be a high priority because of its potential impacts to the vadose zone and groundwater. The extent of VOCs, HE, uranium and metals contamination in sediments and groundwater is unknown. Contaminants may have migrated beyond the SWMU boundaries, given the duration of historical discharge. The ecological risk is also unknown.

VI.C.2 SWMU 16-003(o) Continued Investigation

The Respondents shall continue the investigation of SWMU 16-003(o). The investigation shall fully characterize the vertical and lateral extent of sediment and groundwater contamination.

The Respondents shall submit to the Department for approval an investigation work plan for SWMU 16-003(o). The work plan shall be prepared in accordance with Section XI.B of this Order, and shall be submitted by the date specified in Section XII of this Order.

Upon Department approval, the Respondents shall implement the investigation work plan. Upon Department approval, the work plan shall be incorporated herein by reference and become an enforceable part of this Order.

The Respondents shall submit to the Department for approval an investigation report that presents the results of field activities, summarizes the data collected, and presents recommendations and conclusions for SWMU 16-003(o). The investigation report shall be prepared in accordance with Section XI.C of this Order and shall be submitted by the date specified in Section XII of this Order.

VI.D SWMU 16-008(A)

VI.D.1 Background

SWMU 16-008(a) is an inactive, unlined pond approximately 200 ft in diameter located at TA-16 and is part of the consolidated SWMU 16-008(a)-99. TA-16 is bordered by Bandelier National Monument, along State Road 4 to the south and Santa Fe National Forest along State Road 501 to the west. To the north and east it is bordered by TAs-8, 9, 15, and 49. The pond received liquid waste from the HE sumps and drainlines at process Buildings TA-16-89, 90, and 91. The discharge occurred from as early as 1949 and lasted into the mid-1950s. The waste potentially contained HE, barium, uranium, VOCs, and machining oils.

Beginning in 1986, several sediment and water samples were collected from within the pond. The analytical results indicated the presence of some metals above their respective SALs. No data has been collected from the tuff below the pond floor. Several 10 to 15-ft boreholes were drilled around the pond as part of the RFI for the TA-16-260 outfall. In addition, an intermediate depth (140 ft deep) borehole was installed east of the pond to investigate possible contamination of the vadose zone and groundwater flow pathways within the vadose zone as part of the RFI. Solid HE has been removed from locations within the pond perimeter.

The Department considers this site to be a medium priority because analytical results indicate there are not high levels of contaminants in the sediment. Contamination present in the sediment is likely not migrating because the pond is dry, and the site is not accessible to the public. There is, however, a potential for an unacceptable ecological risk from contaminants at the site and the extent of groundwater contamination is not known.

VI.D.2 SWMU 16-008(a) Continued Investigation

The Respondents shall continue the investigation of SWMU 16-008(a). The investigation shall fully characterize the vertical and lateral extent of groundwater contamination.

The Respondents shall submit to the Department for approval an investigation work plan for SWMU 16-008(a). The work plan shall be prepared in accordance with Section XI.B of this Order, and shall be submitted by the date specified in Section XII of this Order.

Upon Department approval, the Respondents shall implement the investigation work plan. Upon Department approval, the work plan shall be incorporated herein by reference and become an enforceable part of this Order.

The Respondents shall submit to the Department for approval an investigation report that presents the results of field activities, summarizes the data collected, and presents recommendations and conclusions for SWMU 16-008(a). The investigation report shall be prepared in accordance with Section XI.C of this Order and shall be submitted by the date specified in Section XII of this Order.

VI.E SWMU 16-018 (MDA P) AND TA-16-387

VI.E.1 Background

MDA P is located in TA-16 and consists of SWMU 16-018. TA-16 is bordered by Bandelier National Monument, along State Road 4 to the south and Santa Fe National Forest along State Road 501 to the west. To the north and east it is bordered by TAs-8, 9, 15, and 49. The SWMUs incorporated into MDA P closure activities include the former barium nitrate pile (SWMU 16-016(c)), the TA-16-386 flash pad (SWMU 16-010(a)), the TA-16-387 flash pad (SWMU 16-010(b)), and the septic tank drain field and outfall (SWMU 16-006(e)).

MDA P operated from the early 1950s until 1984 as a disposal site for debris originating from the burning of HE and HE-contaminated material at TA-16. MDA P is a waste pile subject to 40 C.F.R. § 264.91 through § 264.100 groundwater monitoring requirements and subject to 40 C.F.R. Part 264 Subpart G Closure and Postclosure Care requirements. In 1995, the Respondents submitted a closure plan to the Department for MDA P. The closure plan proposed that MDA P would be clean closed in accordance with 20.4.1.265 NMAC. The Respondents are currently in the process of implementing the approved closure plan.

The Department considers this site to be a high priority. Confirmatory sampling is required in order to perform an ecological risk assessment.

VI.E.2 SWMU 16-018 (MDA P) and TA-16-387 Continued Investigation

The Respondents shall continue the investigation and closure of MDA P and the closure of the TA-16-367 flash pad. The investigation shall fully characterize the vertical and lateral extent of groundwater contamination, including contamination through fracture flow at MDA P.

The Respondents shall submit to the Department for approval a storm water and groundwater monitoring plan for MDA P. The work plan shall be prepared in accordance with Section XI.B of this Order and shall be submitted by the date specified in Section XII of this Order.

Upon Department approval, the Respondents shall implement the storm water and groundwater monitoring plan. Upon Department approval, the storm water and groundwater monitoring plan shall be incorporated herein by reference and become an enforceable part of this Order.

The Respondents shall submit to the Department for approval an investigation report that presents

the results of field activities, summarizes the data collected, and presents recommendations and conclusions for the closure of MDA P. The report shall also include the results of the VCA activities for SWMU 16-016(c)-99. The investigation report shall be prepared in accordance with Section XI.C of this Order and shall be submitted by the date specified in Section XII of this Order.

VI.F SWMUS 16-021(C) AND 16-003(K)

VI.F.1 Background

SWMUs 16-021(c) and 16-003(k) consist of the outfall and drainage associated with sumps and drain lines from an active HE machining building (TA-16-260). Building 260 has operated since 1951 and has processed large quantities of HE. Machine turnings and HE wash water are routed to 13 sumps located along the east side of the building. From 1951 to November 1996, these sumps discharged to the outfall. The outfall was permitted under a NPDES permit from the 1970s to 1998. At one time, discharge to the outfall was reported to be as high as several million gallons per year.

The TA-16-260 drainage runs for approximately 600 ft north from the outfall to its confluence with Cañon de Valle. The hydrogeology and contaminant pathways at the site are complex and presumably controlled by fractures and other preferential flow pathways. In 1995 and 1996, the Respondents conducted an interim action at Building 260, which consisted of installing storm water controls to minimize road runoff onto the site. In 2000 to 2001, the Respondents conducted an interim measure to remove the predominant source of contamination around the outfall, former pond area, and drainage to Cañon de Valle. A CMS and Phase III RFI have been in progress since the Fall of 1999. A CMS addendum was later submitted by the Respondents to the Department to address intermediate and regional aquifer contamination. A regional aquifer well, CdV-R-15-3, was installed in 2000 about 1.5 miles east of Building 260. Regional aquifer well CdV-R-37-2 was installed in 2001 to the southeast of this SWMU. Hydrogeologic investigations and bench and pilot remediation studies are ongoing. Coordination continues with the Respondents and the Department on a site-specific ecological risk assessment of Cañon de Valle that began in May 2001.

The primary contaminants at these SWMUs are HE (RDX, HMX, TNT) and barium. Soil, sediments, the alluvial groundwater system, and regional groundwater are contaminated. Also present above background levels are cadmium, copper, lead, nickel, vanadium, uranium, zinc, anthracene, phthalates, and major cations such as calcium and magnesium. RDX was detected in the outfall area, prior to the implementation of interim measures, at concentrations as high as 200,000 ppm. Barium concentrations detected in sediment samples obtained from Cañon de Valle ranged up to 40,000 ppm and concentrations detected in the soil in the outfall area, prior to the interim measures, ranged up to 33,000 ppm. Excavation to remove the highest concentrations of HE and barium in soil from the former pond area and drainage was completed in Summer 2000. Since excavation activities were completed, RDX has been detected in soil samples obtained from Cañon de Valle soils at concentrations less than 50 ppb.

RDX has been detected in surface water samples obtained in Cañon de Valle at concentrations greater than 800 ppb. Barium concentrations detected in surface water samples obtained from Cañon de Valle range up to seven ppm. The EPA health advisory for RDX is two ppb and the WQCC standard for barium is one ppm.

The Department considers this site to be a high priority because of the volumes of contaminated water that were discharged from the outfall and because HE has impacted the alluvial, intermediate, and regional groundwater. In addition, barium levels are high in surface water, sediment, and soil.

VI.F.2 SWMUs 16-021(c) and 16-003(k) Continued Investigation

The Respondents shall continue the investigation of SWMUs 16-021(c) and 16-003(k), and implement appropriate corrective measures. The investigation shall fully characterize the vertical and lateral extent of groundwater contamination in the alluvial, intermediate, and regional zones;and shall fully characterize the extent of soil and sediment contamination.

The Respondents shall submit to the Department for approval an investigation work plan for SWMUs 16-021(c) and 16-003(k) as an addendum to the CMS Plan. The work plan shall include the installation of intermediate monitoring wells in accordance with Section X of this Order. The work plan shall be prepared in accordance with Section XI.B of this Order and shall be submitted by the date specified in Section XII of this Order.

Upon Department approval, the Respondents shall implement the investigation work plan. Upon Department approval, the work plan shall be incorporated herein by reference and become an enforceable part of this Order.

The Respondents shall submit to the Department for approval an investigation report that presents the results of field activities, summarizes the data collected, and presents recommendations and conclusions for the investigation. The investigation report shall be prepared in accordance with Section XI.C of this Order and shall be submitted by the date specified in Section XII of this Order.

The Respondents shall submit to the Department for approval an interim measures report in accordance with Section VII.A of this Order. The Interim Measures Report shall be submitted by the date specified in Section XII of this Order.

The Respondents shall submit to the Department for approval a Phase III RFI Report that includes a risk assessment. The Phase III RFI Report shall be submitted by the date specified in Section XII of this Order.

The Respondents shall submit to the Department for approval a CMS Report addressing surface water and alluvial groundwater, and a CMS Report addressing intermediate and regional groundwater. The reports shall be submitted by the dates specified in Section XII of this Order.

The Respondents shall conduct corrective measures evaluation and implementation in accordance with Sections VII.C and VII.D of this Order to address contamination in surface water and alluvial, intermediate, and regional groundwater.

VI.G SWMU 21-011(K)

VI.G.1 Background

SWMU 21-011(k) was an outfall for treated industrial wastewater from Buildings TA-21-35 and TA-21-257, the former industrial wastewater treatment plants at TA-21. The SWMU consists of a drain line from two wastewater treatment tanks that discharged to an outfall ditch, which channeled wastewater to the canyon rim and down the hillside into DP Canyon.

TA-21 is the former plutonium processing area at the Facility. Plutonium processing operations began at TA-21 in 1945 and reportedly ceased in 1978. Building TA-21-35 was the first wastewater treatment plant, which began operation in 1952 and operated until 1967. TA-21-257 began operation in 1967. Both facilities treated wastes from the mesa top areas referred to as DP West and DP East. The wastes consisted of liquids remaining after plutonium extraction and processing of radioactive materials for nuclear weapons and space rocket research projects. The treatment process mixed raw waste with lime, ferric sulfate, and coagulant agents. The waste was then pumped to a flocculator and on to a settling tank. The effluent was allowed to settle and then was discharged through a pressure filter and sampled. After settling, the effluent was pumped to holding tanks (TA-21-112 and TA-21-113) and then discharged through the effluent pipe to DP Canyon. The discharged wastewater contained radioactive and chemical constituents.

DOE investigated SWMU 21-011(k) in 1988. The Respondents investigated the SWMU in 1992 and 1993. Results of the Environmental Restoration (ER) Project investigation were reported in the 1995 Final Draft OU 1106 Addendum to Phase 1B, 1C Report.

In 1996 and 1997, an interim action was performed, during which an estimated 390 cubic yards of soil were removed and transported to MDA G for disposal. Following removal activities, storm water controls were installed in 1997 and later upgraded in August of 1999. The Respondents routinely inspect and maintain the storm water controls at the site. In March 2001, an in-situ gamma survey and additional waste characterization sampling were conducted. The results of the survey and sampling will be formally submitted to the Department in the corrective measures plan.

Because SWMU 21-011(k) is the most likely source of contamination in DP Canyon and the detected concentrations of contaminants of concern are relatively high, the Department considers this site to be a high priority. Additional soil and tuff removal or site stabilization are needed in the vicinity of the former outfall and possibly in DP Canyon bottom. Although the outfall area itself is fenced and access is restricted, there is public access to DP Canyon, which contains contaminants from the 21-011(k) outfall.

VI.G.2 SWMU 21-011(k) Continued Investigation

The Respondents shall continue the investigation of SWMU 21-011(k), and implement appropriate corrective measures.

The Respondents shall submit to the Department for approval a corrective measures implementation plan for SWMU 21-011(k) in accordance with Section VII.D.2 of this Order. The plan shall be submitted by the date specified in Section XII of this Order.

Upon Department approval, the Respondents shall implement the corrective measures implementation plan in accordance with Section VII.D of this Order. Upon Department approval, the corrective measures implementation plan shall be incorporated herein by reference and become an enforceable part of this Order.

The Respondents shall submit to the Department for approval a remedy completion report for SWMU 21-011(k). The remedy completion report shall be submitted by the date specified in Section XII of this Order.

VI.H SWMU 21-024(I)

VI.H.1 Background

SWMU 21-024(i) is an inactive septic system that operated from approximately 1945 to 1965, serving Buildings TA-21-152, TA-21-166, and TA-21-167. This SWMU is made up of a concrete septic tank (structure TA-21-181), six-inch vitrified clay pipe inlet and outlet drain lines, and the associated outfall. The septic system routed wastewater from Building TA-21-209, through a septic tank and on to an outfall located southeast of the building. Building TA-21-152 was used for weapons and non-weapons research and, based on engineering drawings, is believed not to have had any floor drains. The bathrooms in the building were connected directly to the septic tank. Buildings TA-21-166 and TA-21-167 housed air conditioning and heating equipment for certain laboratories located in Building TA-21-152.

SWMU 21-024(i) has been divided into three main areas: 1) the tank and influent/effluent lines (Area 1); 2) the outfall area on the mesa top between the septic tank outlet line and the mesa edge (Area 2); and 3) the bench area beneath the mesa top and above Los Alamos Canyon (Area 3).

Reconnaissance sampling was conducted in 1988 and during the Phase I RFI activities in 1992 and 1993. In 1997, during Phase II RFI activities, it was discovered that the contents of the septic tank were not removed when the system was abandoned in place in 1965. Based on previous investigation results, the contaminants were determined to include metals, radionuclides, PCBs, and VOCs. The Respondents submitted a VCA to the Department for contaminant source reduction. The Department determined that a VCA was not appropriate for the site because contaminant source removal would not be a final remedy. The Respondents submitted an interim action plan to the Department. The Department required that the septic tank and its contents be removed. The interim action was implemented to remove the contaminant source from the hillside and plug the septic line while disposal options for the septic tank contents were explored.

A means of disposal for the septic tank contents has been proposed. The Respondents are planning to remove the contents of the tank, remove the tank itself, and the inlet and outlet pipe, and to perform confirmatory sampling under the interim action plan. A corrective measures plan will be submitted to the Department for review and approval. The corrective measures plan will include all existing data for the site and describe any additional cleanup required following removal of the tank, drain lines, and the outfall.

The Department considers this site a high priority because contamination in the tank sludge and tank cleaning water consists of VOCs, radionuclides (mainly tritium), and PCBs. In addition, contaminated soil in the vicinity of the septic system has the potential to pose an unacceptable risk to human health and the environment.

VI.H.2 SWMU 21-024(i) Continued Investigation

The Respondents shall continue the investigation of SWMU 21-024(i), and implement appropriate corrective measures.

The Respondents shall submit to the Department for approval a corrective measures plan in accordance with Section VII.D.2 of this Order for removal and proper disposal of the septic tank and its contents at SWMU 21-024(i). The plan shall be submitted by the date specified in Section XII of this Order.

Upon Department approval, the Respondents shall implement the corrective measures plan in accordance with Section VII.D of this Order. Upon Department approval, the corrective measures implementation plan shall be incorporated herein by reference and become an enforceable part of this Order.

The Respondents shall submit to the Department for approval a remedy completion report for SWMU 21-024(i). The remedy completion report shall be submitted by the date specified in Section XII of this Order.

VI.I TA-35 (MIDDLE MORTANDAD/TEN SITE AGGREGATE AREA)

VI.I.1 Background

TA-35 is located on a finger mesa between Mortandad Canyon and Ten Site Canyon. There are approximately 300 designated structures located at TA-35. Facility operations date back to the 1950s. The historical operations at TA-35 include development of lanthanum-140 for weapons research. Experiments with various other radionuclides (e.g. tritium, plutonium) were also conducted here. Radioactive wastewater associated with these activities was processed at TA-35. Three nuclear fission reactors (LAPRE-I, LAPRE-II, LAMPRE) were developed and operated at TA-35. A tritium facility was also housed in the basement of Building TA-35-2. Radioactive materials work was phased out by the 1970s and research activities shifted to laser technology, optics, robotics, and nuclear safeguards. These activities continue at present.

Releases of contaminants to the environment from TA-35 have occurred from outfalls, air stack emissions, cooling water, and septic system discharges. The wastewater treatment facility operated from 1951 until 1963 and discharged potentially contaminated effluent into Ten Site Canyon. Potential contaminant releases occurred from accidental spills or from leaks in pipelines, structures, and container storage areas. Documented large volume releases include an oil spill at SWMU 35-015(a) and leaks from wastewater storage tanks at SWMU 35-003(d) that released radioactively contaminated wastewater into Ten Site canyon. Potential contaminants include metals, PCBs, VOCs, and radionuclides.

TA-35 is divided into subareas for an aggregate investigation. The sites located within the Pratt Canyon subarea include holding tanks and associated structures (SWMUs 35-003(d, l, and q)), cooling water outfall, a septic system, and Pratt Canyon itself. SWMUs 35-003(d, l and q) are the major contributors to the contamination in Pratt Canyon. Potential contaminants include radionuclides (strontium-90, americium-241, cesium-137, and isotopic plutonium), metals, organics, and PCBs.

Sites associated with the Ten Site Canyon subarea include sewage lagoons and filter beds (SWMUs 35-010 (a-e)). These lagoons received liquid wastes from TA-35, 50, 55, 48, and 64. The lagoons primarily received sanitary waste but also received waste from photo-processing and industrial drains. The potential contaminants include solvents, radionuclides, and other chemicals from the industrial wastelines.

The Department considers remediation of TA-35 to be a high priority based on the presence of potential contaminants, past releases of potential contaminants in the canyon, and the potential for transport of these contaminants downstream within the canyon system.

The Respondents are preparing a SAP integrating most of the TA-35 sites into one aggregate. Implementation of the aggregate SAP should provide data to help prioritize the remediation of the subareas. Remediation will be based on the risk to human health and the environment.

VI.I.2 TA-35 Continued Investigation

The Respondents shall continue the investigation of TA-35 (Middle Mortandad/Ten Site Aggregate Area), and implement appropriate corrective measures.

The Respondents shall submit to the Department for approval an Aggregate Area SAP for the entire TA-35 Aggregate Area in accordance with Section XI.B of this Order. The plan shall be submitted by the date specified in Section XII of this Order.

The Respondents shall submit an addendum to the Aggregate Area SAP for Middle Mortandad/Ten Site Aggregate Area in accordance with Section XI.B of this Order. The addendum shall cover investigation for the remaining SWMUs and AOCs in the Aggregate Area not covered by the SAP. The addendum shall be submitted by the date specified in Section XII of this Order.

The Respondents shall submit to the Department for approval an investigation report for the Middle Mortandad/Ten Site Aggregate Area in accordance with Section XI.C of this Order. The remedy completion report shall be submitted by the date specified in Section XII of this Order.

VI.J TA-49: AREAS, 5, 6, AND 10

VI.J.1 Background

SWMU 49-006 and AOCs C-49-005(b) and C-49-008(a) are also known as Area 5 at TA-49. AOC C-49-008(b) is part of Area 6, along with SWMU 49-004. AOC C-49-002 and SWMU 49-005(a) are also known as Area 10. TA-49 was formally created in 1959 but has been used since the mid-1940s as a buffer zone for activities at adjacent firing sites (TA-15 and TA-39). It is currently used

for this purpose. Underground hydronuclear and related experiments were conducted at the site through August 1961. Areas 5, 6, and 10 were used to support hydronuclear testing conducted at Areas 1, 2, 2A, 2B, 3, and 4 also located at TA-49. Area 5 was used as a central control area to monitor underground experiments. Area 6 was a crafts area used for general support activities, an open burning operation, and a landfill operation. Area 10 was an underground calibration chamber and a small landfill that received construction debris from decommissioning activities conducted in the 1980s.

The Department considers Areas 5, 6, and 10 to be a medium priority because nature and extent of surface and subsurface contamination and potential migration pathways have not been adequately investigated.

VI.J.2 TA-49, Areas, 5, 6, and 10 Continued Investigation

The Respondents shall continue the investigation of TA-49, Areas 5, 6, and 10. The investigation shall fully characterize the vertical and lateral extent of surface and subsurface contamination.

The Respondents shall submit to the Department for approval an investigation work plan for TA-49, Areas 5, 6, and 10. The work plan shall be prepared in accordance with Section XI.B of this Order, and shall be submitted by the date specified in Section XII of this Order.

Upon Department approval, the Respondents shall implement the investigation work plan. Upon Department approval, the work plan shall be incorporated herein by reference and become an enforceable part of this Order.

The Respondents shall submit to the Department for approval an investigation report that presents the results of field activities, summarizes the data collected, and presents recommendations and conclusions for the investigation of TA-49, Areas 5, 6, and 10. The investigation report shall be prepared in accordance with Section XI.C of this Order and shall be submitted by the date specified in Section XII of this Order.

VI.K SWMUS 53-002(A AND B)

VI.K.1 Background

SWMU 53-002(a) is comprised of two impoundments (northeast and northwest) constructed in 1969, each measuring 210 ft by 210 ft by six ft deep. The impoundments were surface retention structures that received sanitary, radioactive, and industrial wastewater from various TA-53 facilities. After their construction, the impoundments were occasionally filled to capacity and overflow was discharged to a drainage channel that flows east into a tributary of Los Alamos Canyon. Liquid waste was either pumped to the impoundments through waste lines or brought to the impoundment by truck.

SWMU 53-002(b) is an impoundment (southern) constructed in 1985 measuring approximately 305 ft by 148 ft by six ft deep. In 1989 the impoundment became a total retention radioactive liquid waste storage impoundment and the northeast and northwest impoundments began receiving sanitary wastewater only. All three impoundments are now inactive.

A SAP for all three impoundments was approved by the Department on August 8, 2000. The southern impoundment has been completely removed, including soils below the liner. The Department has not received a formal report on this activity. Based on informally submitted information provided to the Department, samples in the impoundment sludge detected hot spots of radioactivity, and SVOCs and metals concentrations below SALs. Samples were analyzed for PCBs, but the data have not been submitted to the Department. Sampling was conducted below the liner until samples showed decreasing trends or nondetect concentrations. The Respondents will remove the sludge and liners from the two northern impoundments under this plan.

The Department considers this site to be a low priority because the surface and near surface investigations are nearing completion and the source of contamination has been or will be removed. However, further investigation is necessary in the drainages around the impoundments.

VI.K.2 SWMUs 53-002(a and b) Continued Investigation

The Respondents shall continue the investigation of SWMUs 53-002(a and b). The investigation shall fully characterize the vertical and lateral extent of contamination in the drainages around the impoundments.

The Respondents shall submit to the Department for approval an investigation work plan for SWMUs 53-002(a and b). The work plan shall be prepared in accordance with Section XI.B of this Order and shall be submitted by the date specified in Section XII of this Order.

Upon Department approval, the Respondents shall implement the investigation work plan. Upon Department approval, the work plan shall be incorporated herein by reference and become an enforceable part of this Order.

The Respondents shall submit to the Department for approval an investigation report that presents the results of field activities, summarizes the data collected, and presents recommendations and conclusions for the investigation of SWMUs 53-002(a and b). The investigation report shall be prepared in accordance with Section XI.C of this Order and shall be submitted by the date specified in Section XII of this Order.

VI.L SWMUS 73-001(A-D) AND 73-004(D)

VI.L.1 Background

The Airport Landfill is comprised of five SWMUs: a main landfill (73-001(a)), a waste oil pit (73-001(b)), bunker debris pits (73-001(c)), a debris disposal area (73-001(d)), and a septic system (73-004(d)). DOE began operation at the main landfill in 1943. Trash was collected from the town site and the Facility and burned on the edge of a hanging valley. Intentional burning continued from 1943 until 1965, when Los Alamos County assumed operation of the landfill. The County continued to operate the landfill until June 30, 1973. From 1984 to 1986, the western portion of the landfill was excavated and moved to the debris disposal pit (73-001(d)) to allow for construction of the existing airport hangers and tie-down areas.

Investigation of the Airport Landfill mesa top area tract will be conducted using a phased approach. The first phase will consist of filling data gaps for assessment of the mesa top tract and submitting the results in a Phase I VCM Plan. The Phase I VCM plan will identify any additional characterization or investigation required in order to design a cover for the landfill. Landfill cover design will be conducted under Phase II VCM activities. A Phase II VCM report, which includes cover design and final site recommendations will be submitted to the Department for review and approval prior to capping. A final VCM report will be submitted summarizing activities for both phases and proposing long-term site monitoring plans.

Investigation of the associated drainages will be conducted under the drainage tract investigation. Drainage and landfill tract activities will be conducted simultaneously. The Respondents will submit an interim measures (IM) plan for debris removal in the associated drainages. Results of the drainage debris removal will be detailed in the final IM report and in the final VCM report.

This is considered to be a high priority site because of the large amount of debris in the drainages leading from the mesa top. The debris in the drainages is a violation of WQCC Regulations, 20.6.2.2201 NMAC. In addition, the mesa top landfill area has no cap covering the waste and, although airport management restricts access to the landfill, private planes are parked adjacent to the landfill. Stressed and dead vegetation on the landfill may indicate the generation of subsurface landfill gas.

VI.L.2 SWMUs 73-001(a-d) and 73-004(d) Continued Investigation

The Respondents shall continue the investigation of SWMUs 73-001(a-d) and 73-004(d), and implement appropriate corrective measures.

The Respondents shall submit to the Department for approval a Phase I voluntary corrective measures plan and a Phase II voluntary corrective measures plan in accordance with Section VII.D.2 of this Order. The Phase I voluntary corrective measures plan shall propose a conceptual design of the landfill cover. The Phase II voluntary corrective measures plan shall propose a final design and address the construction of the cover. The plans shall be submitted by the dates specified in Section XII of this Order.

Upon Department approval of each voluntary corrective measures plan, the Respondents shall implement the plan in accordance with Section VII.D of this Order. Upon Department approval, each plan shall be incorporated herein by reference and become an enforceable part of this Order.

The Respondents shall submit to the Department for approval a remedy completion report in accordance with Section VII.E.6.a of this Order. The remedy completion report shall be submitted by the date specified in Section XII.

VI.M SWMU 73-002

VI.M.1 Background

SWMU 73-002 is the ash pile from a former incinerator at TA-73. The incinerator is located adjacent to the Los Alamos County Airport and was originally used to destroy classified documents

from the Facility for a short period of time beginning in 1947. The incinerator was later used to burn municipal trash. The incinerator was only used for a short period of time because it did not function as it was intended. The incinerator equipment and stack have been removed; however, the Department has received no information regarding removal activities. The ash and debris surface disposal area is located on the slope below the canyon rim to the immediate north of the incinerator building. Debris from the concrete staging area located north of the building may have been disposed of in Pueblo Canyon.

Waste characterization data has been collected from the ash pile and have been provided to the Department. Although the waste has been characterized, possible releases to the environment and potential contaminant migration through fractures have not been evaluated. Based on the lack of investigation data, a work plan for investigation and additional characterization will be required by the Department.

The Department considers this site to be a medium priority. Additional assessment work is required because the site is accessible to the public and potential releases of contaminants to the environment, including dioxins and radionuclides, have not been determined.

VI.M.2 SWMU 73-002 Continued Investigation

The Respondents shall continue the investigation of SWMU 73-002. The investigation shall fully characterize the vertical and lateral extent of contamination and the potential for migration of contaminants through fractures.

The Respondents shall submit to the Department for approval an investigation work plan for SWMU 73-002. The work plan shall be prepared in accordance with Section XI.B of this Order, and shall be submitted by the date specified in Section XII of this Order.

Upon Department approval, the Respondents shall implement the investigation work plan. Upon Department approval, the work plan shall be incorporated herein by reference and become an enforceable part of this Order.

The Respondents shall submit to the Department for approval an investigation report that presents the results of field activities, summarizes the data collected, and presents recommendations and conclusions for SWMU 73-002. The investigation report shall be prepared in accordance with Section XI.C of this Order and shall be submitted by the date specified in Section XII of this Order.

VII. CORRECTIVE MEASURES

The Respondents shall implement corrective measures at the Facility, as necessary, in accordance with the requirements of this Section (VII).

The results of the investigations required in this Order, and other information available to the Department, will be used as the basis for determining whether further investigation and corrective measures are necessary at each SWMU, AOC, canyon, or other Facility site. The general procedures for implementing corrective measures are described in this Section (VII).

VII.A EROSION CONTROL AND MONITORING

The Respondents are responsible for controlling erosion at each Facility SWMU, AOC, unit, Aggregate Area, and watershed by implementing an Erosion Control and Monitoring Program. The purpose of the Erosion Control and Monitoring Program shall be to control and limit siltation, sediment transport, contaminant transport, and surface erosion within the Facility and within individual site boundaries. The Respondents shall submit a Site-Wide Stabilization Plan to the Department within one year of the effective date of this Order. The plan shall outline the general approach to erosion control and the Facility-wide erosion control and monitoring program to be implemented at each site. The plan shall address the erosion control measures/interim measure inspection and maintenance schedule and the criteria used to determine the need for erosion control measure maintenance and/or upgrades. The plan shall include a storm water monitoring program to be implemented at each SWMU, AOC, and aggregate area and shall include the frequency of storm water monitoring. Of the approximately 250 high to medium erosion potential sites identified by SOP 2.01, those sites scoring high (erosion matrix score greater than 60) shall be monitored yearly until stabilization has been verified. Medium range scoring sites (erosion matrix score 40-60) shall be monitored on a rotating basis so that all are monitored over a two-year period. All site-specific monitoring shall be conducted at appropriate locations that meet the definition of representative sampling as defined by the Surface Water Assessment DQO Team (2002). All monitoring stations shall be located upstream of the confluence with other surface water(s) of the state (20.6.4 NMAC, 20.6.4.7, RR). Constituents to be monitored at each site shall, at a minimum, be representative of those identified by previous investigations to be present above background levels. All monitoring results shall be submitted as outlined in Section XI.D and Table XII-2. A contingency plan shall be included as part of the stabilization plan to address releases that may be identified during monitoring. The plan shall address geomorphic as well as operational unit erosion control and monitoring.

Erosion controls shall be implemented in accordance with the priorities listed in this section (VII). All sites shall be evaluated in accordance with the Facility's Environment Safety, and Health (ESH) Standard Operating Procedure (SOP) 2.01. Erosion control measures shall be implemented, where necessary, at the high priority sites included in this Order and at all Facility sites, beginning with sites assessed with an erosion matrix score greater than 40, as designated by the LANL ESH SOP 2.01 Erosion Assessment. Erosion controls shall include slope stabilization, surface water runon and runoff control, and sediment transport controls. The Respondents shall implement engineering

controls and best management practices to control surface water and sediment transport within the Facility boundaries. The purpose of the monitoring program shall be to monitor erosion potential, sedimentation rates, and surface water quality. Erosion control and surface water monitoring shall be performed in accordance with the Clean Water Act [U.S. Code Title 33, Chapter 26] requirements, the State of New Mexico Standards for Interstate and Intrastate Surface Waters [20.6.4 NMAC], WQCC Regulations [20.6.2 NMAC], the Department's Surface Water Quality Bureau, and EPA guidance. Erosion control shall be implemented, as necessary, before, during, and after implementation of corrective measures.

VII.B INTERIM MEASURES

VII.B.1 General

The Department will require interim measures, if the Department determines that such measures are necessary, to reduce or prevent migration of contaminants or human or environmental exposure to contaminants while long-term corrective action remedies are evaluated and implemented. Upon making such a determination, the Department will notify the Respondents.

VII.B.2 Interim Measures Work Plan

Within ninety (90) days after receiving notification from the Department that interim measures are required, the Respondents shall submit to the Department for approval an Interim Measures Work Plan that shall include an implementation schedule.

VII.B.3 Approval of Interim Measures Work Plan

If the Department disapproves the Interim Measures Work Plan, the Department will notify the Respondents in writing of the Interim Measures Work Plan's deficiencies and specify a due date for submission of a revised Interim Measures Work Plan. Upon receipt of such notification of disapproval, the Respondents shall submit to the Department, within the specified timeframe, a revised Interim Measures Work Plan that corrects the deficiencies.

VII.B.4 Interim Measures Implementation

The Respondents shall implement the interim measures in accordance with the approved Interim Measures Work Plan and implementation schedule.

VII.B.5 Emergency Interim Measures

The Respondents may determine, during implementation of site investigation activities, that emergency interim measures are necessary to address an immediate threat of harm to human health or the environment. The Respondents shall notify the Department within three (3) days of discovery of the facts giving rise to the threat, and shall propose emergency interim measures to address the threat. If the Department approves the emergency interim measures in writing, the Respondents may implement the emergency interim measures without submitting an interim measures work plan.

VII.B.6 Interim Measure Report

Within ninety (90) days after completion of interim measures, the Respondents shall submit to the Department an IM Report summarizing the results of the interim measures, that shall include copies of the results of all field screening, monitoring, sampling, analysis, and other data generated as part of the interim measures implementation.

VII.C RISK ANALYSIS

VII.C.1 General

The Respondents shall attain the cleanup goals outlined in Section VIII of this Order for all media at each site for which the Department determines, under Section VII.D.1, that corrective action is necessary to protect human health or the environment. The Respondents may propose to demonstrate to the Department that achievement of a cleanup goal at a particular site is technically infeasible. The Respondents shall have the burden of making such demonstration to the Department's satisfaction. If the Respondents propose to demonstrate the technical infeasibility of achievement of a groundwater cleanup goal that is a WQCC standard, the applicable requirements of the WQCC Regulations, 6.2.4103.E and 4103.F NMAC, shall be followed. If the Department approves the technical infeasibility demonstration, the Respondents shall prepare a site-specific risk assessment for that site to identify alternate cleanup goals or, if the WQCC Regulations apply, alternate abatement standards. The risk assessment shall include both a human health risk assessment and an ecological risk assessment.

VII.C.2 Risk Analysis Report

Within ninety (90) days after receiving from the Department a written determination that a technical infeasibility demonstration has been approved, the Respondents shall submit to the Department for approval a Risk Analysis Report for that site. The Respondents shall follow the Risk Analysis Report format outlined in Section XI.E of this Order.

VII.C.2.a Conceptual Site Model

The risk analysis shall include information on the expected fate and transport of contaminants detected at the site including a list of all sources of contamination at the site. Sources that are no longer considered to be releasing contaminants, but represent the point of origination for contaminants transported to other locations, shall be included. The discussion of fate and transport shall address potential migration of each contaminant in each medium, potential breakdown products and their migration, and anticipated pathways of exposure for human and ecological receptors.

For human health risk assessments, the conceptual site model shall include residential land use as the future land use for all risk assessments. Site-specific future land use may be included, provided that written approval to consider a site-specific future land use has been obtained from the Department prior to inclusion in the risk assessment.

Conceptual site models presented for ecological risk assessments shall identify assessment endpoints and measurement receptors for the site. The discussion of the model shall explain how the measurement receptors for the site are protective of the wildlife receptors.

VII.C.2.b Risk Screening Levels

The risk assessment shall include the actual screening values used for each contaminant for comparison to all human health and ecological risk screening levels. The Department's soil screening levels (SSLs) for residential soil shall be used to screen soil for human health. For those contaminants not appearing on the Department's SSL table, the EPA Region 6 soil screening value adjusted to meet the Department's target risk goal of 10^{-5} for total risk for carcinogens shall be used to screen the site for human health risks. Screening for ecological risk shall be conducted using the LANL Ecological Screening Levels (ESLs) if the LANL ESLs have received written approval from the Department. If the LANL ESLs have not been approved by the Department or the LANL ESL database does not contain a screening value for the receptor or contaminant, the Respondents shall use U.S. EPA ecological soil screening levels (ECO-SSLs), or derive a screening level using the methodology in the Department's "Guidance for Assessing Ecological Risks Posed by Chemicals: Screening–Level Ecological Risk Assessment." If no valid toxicological studies exist for a particular receptor or contaminant, the contaminant/receptor combination shall be addressed using qualitative methods. If an approved site-specific risk scenario is used for the human health risk assessment, the Respondents shall include all toxicity information and exposure assessment equations used for the site-specific scenario as well as the sources for that information. Other regulatory levels applicable to screening the site, such as drinking water MCLs and WQCC standards, shall also be included in the risk analysis.

VII.D CORRECTIVE MEASURES EVALUATION

VII.D.1 General

The Department will require corrective measures at a site if the Department determines, based on the Investigation Report and other information available to the Department, that there has been a release of hazardous waste or hazardous waste constituents into the environment at the site and that corrective action is necessary to protect human health or the environment. Upon making such a determination, the Department will notify the Respondents.

VII.D.2 Corrective Measures Evaluation Report

Within 180 days after receiving notification from the Department that a corrective measures evaluation is required, the Respondents shall submit to the Department for approval a Corrective Measures Evaluation Report. The Respondents shall follow the Corrective Measures Evaluation Report format outlined in Section XI.F of this Order. The corrective measures evaluation shall evaluate potential remedial alternatives and shall recommend a preferred remedy that will be protective of human health and the environment and attain the appropriate cleanup goals. The Corrective Measures Evaluation Report shall, at a minimum, comply with Section XI.F of this Order and include the following:

1. A description of the location, status, and current use of the site.

2. A description of the history of site operations and the history of releases of contaminants.

3. A description of site surface conditions.

4. A description of site subsurface conditions.

5. A description of on- and off-site contamination in all affected media.

6. An identification and description of all sources of contaminants.

7. An identification and description of contaminant migration pathways.

8. An identification and description of potential receptors.

9. A description of cleanup standards or other regulatory criteria.

10. An identification and description of a range of remedy alternatives.

11. Remedial alternative pilot or bench scale testing results.

12. A detailed evaluation and rating of each of the remedy alternatives, applying the criteria set forth in Section VII.D.4.

13. An identification of a proposed preferred remedy or remedies.

14. Design criteria of the selected remedy or remedies.

15. A proposed schedule for implementation of the preferred remedy.

VII.D.3 Cleanup Standards

The Respondents shall select corrective measures that are capable of achieving the cleanup standards and goals outlined in Section VIII of this Order or, if the cleanup standards or goals cannot be achieved, approved risk-based cleanup goals established by a risk analysis.

VII.D.4 Remedy Evaluation Criteria

VII.D.4.a Threshold Criteria

The Respondents shall evaluate each of the remedy alternatives for the following threshold criteria. To be selected, the remedy alternative must:

1. Be protective of human health and the environment.

2. Attain media cleanup standards.

3. Control the source or sources of releases so as to reduce or eliminate, to the extent practicable, further releases of contaminants that may pose a threat to human health and the environment.

4. Comply with standards for management of wastes.

VII.D.4.b Remedial Alternative Evaluation Criteria

The Respondents shall evaluate each of the remedy alternatives for the factors described in this Section (VII.D.4.b). These factors shall be balanced in proposing a preferred alternative.

VII.D.4.b.i Long-Term Reliability and Effectiveness

The remedy shall be evaluated for long-term reliability and effectiveness. This factor includes consideration of the magnitude of risks that will remain after implementation of the remedy; the extent of long-term monitoring, or other management that will be required after implementation of the remedy; the uncertainties associated with leaving contaminants in place; and the potential for failure of the remedy. A remedy that reduces risks with little long-term management, and that has proven effective under similar conditions, shall be preferred.

VII.D.4.b.ii Reduction of Toxicity, Mobility, or Volume

The remedy shall be evaluated for its reduction in the toxicity, mobility, and volume of contaminants. A remedy that uses treatment to more completely and permanently reduce the toxicity, mobility, and volume of contaminants shall be preferred.

VII.D.4.b.iii Short-Term Effectiveness

The remedy shall be evaluated for its short-term effectiveness. This factor includes consideration of the short-term reduction in existing risks that the remedy would achieve; the time needed to achieve that reduction; and the short-term risks that might be posed to the community, workers, and the environment during implementation of the remedy. A remedy that quickly reduces short-term risks, without creating significant additional risks, shall be preferred.

VII.D.4.b.iv Implementability

The remedy shall be evaluated for its implementability or the difficulty of implementing the remedy. This factor includes consideration of installation and construction difficulties; operation and maintenance difficulties; difficulties with cleanup technology; permitting and approvals; and the availability of necessary equipment, services, expertise, and storage and disposal capacity. A remedy that can be implemented quickly and easily, and poses fewer and lesser difficulties, shall be preferred.

VII.D.4.b.v Cost

The remedy shall be evaluated for its cost. This factor includes a consideration of both capital costs, and operation and maintenance costs. Capital costs shall include, without limitation, construction and installation costs; equipment costs; land development costs; and indirect costs including engineering costs, legal fees, permitting fees, startup and shakedown costs, and contingency allowances. Operation and maintenance costs shall include, without limitation, operating labor and materials costs; maintenance labor and materials costs; replacement costs; utilities; monitoring and reporting costs; administrative costs; indirect costs; and contingency allowances. All costs shall be

calculated based on their net present value. A remedy that is less costly, but does not sacrifice protection of health and the environment, shall be preferred.

VII.D.5 Approval of Corrective Measures Evaluation Report

If the Department disapproves the Corrective Measures Evaluation Report, the Department will notify the Respondents in writing of the Corrective Measures Evaluation's deficiencies and specify a due date for submission of a revised Corrective Measures Evaluation Report. Upon receipt of such notification of disapproval, the Respondents shall submit to the Department, within the specified time, a revised Corrective Measures Evaluation Report that corrects the deficiencies. If the Department approves the Corrective Measures Evaluation Report, the Department will notify the Respondents in writing.

VII.D.6 Relationship to Corrective Action Requirements

The Corrective Measures Evaluation shall serve as a Corrective Measures Study for the purposes of RCRA compliance. See 55 Fed. Reg. 30875-77 (July 27, 1990) (proposed 40 C.F.R. §§ 264.520-264.524).

VII.D.7 Statement of Basis

Upon approval of the Corrective Measures Evaluation and remedy selection, the Department will select a remedy or remedies for the site. The Department will issue a Statement of Basis for selection of the remedy, and will receive public comment on the remedy. The public comment period will extend for sixty (60) days from the date of the public notice of the Statement of Basis. The Department will select a final remedy and issue a response to public comments within ninety (90) days, or other appropriate time, after the end of the public comment period.

VII.E CORRECTIVE MEASURES IMPLEMENTATION

VII.E.1 General

The Respondents shall implement the final remedy selected by the Department.

VII.E.2 Corrective Measures Implementation Plan

Within ninety (90) days after the Department's selection of a final remedy, or such other time as the Department determines, the Respondents shall submit to the Department for approval a Corrective Measures Implementation Plan outlining the design, construction, operation, maintenance, and performance monitoring for the selected remedy, and a schedule for its implementation. The Corrective Measures Implementation Plan shall, at a minimum, include the following elements:

1. A description of the selected final remedy.

2. A description of the cleanup goals and remediation system objectives.

3. An identification and description of the qualifications of all persons, consultants, and contractors that will be implementing the remedy.

4. Detailed engineering design drawings and systems specifications for all elements of the remedy.

5. A construction work plan.

6. An operation and maintenance plan.

7. The results of any remedy pilot tests.

8. A plan for monitoring the performance of the remedy, including sampling and laboratory analysis of all affected media.

9. A waste management plan.

10. A proposed schedule for submission to the Department of periodic progress reports.

11. A proposed schedule for implementation of the remedy.

VII.E.3 Health and Safety Plan

The Respondents shall conduct all activities in accordance with the Health and Safety Plan as described in the most recent version of the ER Project Installation Work Plan (IWP [LA-UR-00-1336]) during all construction, operation, maintenance, and monitoring activities conducted during corrective measures implementation.

VII.E.4 Community Relations Plan

The Respondents shall involve the public in all corrective measures selections and implementations in accordance with the Public Involvement Plan included in the most recent version of the ER Project IWP (LA-UR-00-1336).

VII.E.5 Progress Reports

The Respondents shall submit to the Department progress reports in accordance with the schedule approved in the Corrective Measures Implementation Plan. The progress reports shall, at a minimum, include the following information:

1. A description of the remedy work completed during the reporting period.

2. A summary of all problems, potential problems, or delays encountered during the reporting period.

3. A description of all actions taken to eliminate or mitigate the problems, potential problems, or delays.

4. A discussion of the remedy work projected for the next reporting period, including all sampling events.

5. Copies of the results of all monitoring, including sampling and analysis, and other data generated during the reporting period.

6. Copies of all waste disposal records generated during the reporting period.

VII.E.6 Remedy Completion

VII.E.6.a Remedy Completion Report

Within ninety (90) days after completion of remedy, the Respondents shall submit to the Department a Remedy Completion Report. The report shall, at a minimum, include the following items:

1. A summary of the work completed.

2. A statement, signed by a registered professional engineer, that the remedy has been completed in full satisfaction of the terms of this Order.

3. As-built drawings and specifications signed and stamped by a registered professional engineer.

4. Copies of the results of all monitoring, including sampling and analysis, and other data generated during the remedy implementation, if not already submitted in a progress report.

5. Copies of all waste disposal records, if not already submitted in a progress report.

6. A certification, signed by a responsible official of both DOE and the University of California, stating: "To the best of my knowledge, after thorough investigation, I certify that the information contained in or accompanying this report is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

VII.E.6.b Certification of Completion

Upon receipt of the Remedy Completion Report, the Department will determine whether the remedy has been completed in full satisfaction of the terms of this Order. The Department may conduct an inspection of the site, or request additional information from the Respondents, to make this determination. If the Department determines that the remedy has not been satisfactorily completed, it will notify the Respondents in writing of the actions that are necessary to complete the remedy. The Respondents shall implement such actions in accordance with the notification. If the Department determines that the remedy has been satisfactorily completed, it will issue to the Respondents a written Certification of Completion of the remedy for that site.

VIII. CLEANUP AND SCREENING LEVELS

The Department has established cleanup levels, methods of calculating cleanup goals, and reporting requirements at sites where corrective action is required in response to the release of contaminants to the environment. The cleanup levels are based on excess lifetime cancer risk levels that are consistent with the EPA's National Oil and Hazardous Substance Pollution Contingency Plan, 40 C.F.R. §300.430(e)(2)(i)(A)(*2*). The EPA recommends a range of 10^{-4} to 10^{-6} lifetime excess cancer risk as acceptable. In general, the Department has selected a target risk level of 10^{-5} for establishing cleanup levels for regulated substances. The Department has generally selected a target hazard index (HI) of one for individual noncarcinogenic chemicals of concern and for contamination involving two or more noncarcinogenic regulated substances. Unless otherwise specifically provided in this Order, the Respondents shall follow the cleanup and screening levels described in this Section (VIII) in implementing the corrective action requirements of this Order. The Respondents shall comply with the adopted and established cleanup and reporting requirements described in this section (VIII).

VIII.A GROUNDWATER

VIII.A.1 Groundwater Cleanup Levels

The New Mexico WQCC has established groundwater cleanup standards for selected contaminants (20.6.2.1101, 20.6.2.3103, and 20.6.2.4103 NMAC). The Department has established groundwater cleanup levels that incorporate the WQCC standards and the EPA MCLs for drinking water contaminants. If both a WQCC standard and an MCL have been established for an individual substance, then the lower of the two levels will be considered the cleanup level for that substance. The Department uses the most recent version of the EPA Region VI Human Health Medium-Specific Screening Level (HHMSSL) for tap water as the target cleanup level if either a WQCC standard or an MCL has not been established for a specific substance.

VIII.A.1.a Groundwater Perchlorate Screening Levels

EPA has established a draft reference dose for perchlorate in drinking water. Currently, the drinking water equivalent level for perchlorate, based on this dose, is one µg/L. The Department has adopted the EPA provisional drinking water reference dose as an interim groundwater screening level. The Department will adopt the EPA drinking water standard for perchlorate as a groundwater cleanup level when the EPA publishes the new drinking water standard. The Department's drinking water screening level for perchlorate will be updated if EPA revises the reference dose for perchlorate in the future. If the Department determines that corrective action is required, site-specific cleanup levels will be established.

VIII.A.2 Groundwater Radionuclide Reporting

The Respondents shall determine the nature and extent of radionuclide contamination and implement groundwater monitoring at sites where radiological contamination is suspected or has been detected. The EPA has published preliminary remediation goals for radionuclides and drinking water

maximum contaminant levels for some radionuclides. The Respondents shall report to the Department all radionuclide concentrations in groundwater exceeding background, and, of those, all radionuclide concentrations exceeding the most current version of the EPA preliminary remediation goals or the maximum contaminant level. The Respondents also shall submit to the Department the results of all investigations and testing for the presence of radionuclides.

VIII.B SOIL

VIII.B.1 Soil Cleanup Levels

The Department has established soil cleanup levels for 133 elements and compounds. In general, the cleanup levels are based on a target total risk of 10^{-5} for carcinogenic substances and a target HI of one for all noncarcinogenic chemicals. The target soil cleanup levels for selected substances are listed in the Department's Technical Background Document for Development of Soil Screening Levels. The Department uses the most recent version of the EPA Region VI HHMSSL for residential soil as the target cleanup level for compounds designated as "n" (noncarcinogen effects), "max" (maximum concentration), and "sat" (soil saturation concentration), or ten times the EPA Region VI HHMSSL for compounds designated "c" (carcinogen effects) if a Department soil cleanup level has not been established for a regulated substance.

VIII.B.1.a Soil Polychlorinated Biphenyls Cleanup Levels

The Department has established soil cleanup levels for PCBs. Soil cleanup levels for PCBs are discussed in the Department's Position Paper "Risk-based Remediation of Polychlorinated Biphenyls at RCRA Corrective Action Sites" (March 2000). The default soil cleanup level for PCBs is one mg/kg.

VIII.B.1.b Soil Perchlorate Cleanup Levels

Currently, a soil cleanup level for perchlorate has not been established by NMED. NMED will determine a soil cleanup level for perchlorate based on the reference dose, which is anticipated to be established by the EPA. The soil cleanup level for perchlorate will be updated if EPA revises the reference dose for perchlorate in the future.

VIII.B.2 Soil Radionuclide Reporting

The Respondents shall determine the nature and extent of radioactive contamination in soil or other solid-phase media and implement monitoring programs at sites where radiological contamination is suspected or has been detected. The Department has not established soil cleanup levels for radionuclides in environmental media; however, the Department requires testing to determine if soil has been affected by radiological contamination. All radionuclides are classified as Class A carcinogens by the EPA, as described in the *April 2001 User's Guide: Radionuclide Carcinogenicity for the HEAST Radionuclide Table* from the EPA Office of Radiation and Indoor Air Radiation Protection Division. Radionuclides have been assigned HEAST slope factors for carcinogenicity and are evaluated by the same methods used for chemical carcinogens. The EPA has developed preliminary remediation goals for radionuclides in soil that correspond to a 10^{-6} excess risk for various scenarios. The Respondents shall report all radionuclide concentrations in soil exceeding

background and the most current EPA preliminary remediation goals for the residential and agricultural scenarios to the Department.

Comparison of individual radionuclide concentrations to the EPA preliminary remediation goals assures that the total excess risk from radionuclides will not exceed the Department total excess risk goal of 10^{-5}. The total risk goal is delineated in Section 1.2.3 *Target Risk and Hazard* of the Department's guidance document NMED-00-008 *Technical Background Document for Development of Soil Screening Levels*. The Respondents shall also submit the results of all investigations and testing for the presence of radionuclides to the Department.

VIII.C SURFACE WATER

VIII.C.1 Surface Water Cleanup Levels

The Respondents shall comply with the surface water quality standards outlined in the Clean Water Act (33 U.S.C.§26), the New Mexico WQCC Regulations (20.6.1 NMAC) and the State of New Mexico Standards for Interstate and Intrastate Surface Waters (20.6.4 NMAC).

VIII.C.1.a Surface Water Perchlorate Cleanup Levels

EPA has established a draft reference dose for perchlorate in drinking water of 0.00003 mg/kg-day. Currently, the drinking water equivalent level for perchlorate, based on this dose, is one µg/L. The Department has adopted the EPA provisional drinking water equivalent level as an interim groundwater cleanup level. EPA anticipates publishing a drinking water standard for perchlorate. The Department will adopt the EPA drinking water standard for perchlorate as a surface water cleanup level when EPA publishes the drinking water standard. The Department's drinking water cleanup level for perchlorate will be updated if EPA revises the reference dose for perchlorate in the future.

VIII.C.2 Surface Water Radionuclide Reporting

The Respondents shall determine the nature and extent of radionuclide contamination and implement surface water monitoring at sites where radiological contamination is suspected or has been detected. EPA has published preliminary remediation goals for radionuclides in groundwater and drinking water maximum contaminant levels for some radionuclides. The Respondents shall report to the Department all radionuclide concentrations in surface water exceeding background and either the EPA preliminary remediation goals or maximum contaminant levels. The Respondents also shall submit the results of all investigations and testing for the presence of radionuclides to the Department.

VIII.D ECOLOGICAL RISK EVALUATION

Ecological risk at each site shall be evaluated in a manner consistent with the Department's Guidance for Assessing Ecological Risks Posed by Chemicals: Screening-Level Ecological Risk Assessment (March 2000) and the Department's Guidance for Assessing Ecological Risks Posed by Radionuclides: Screening-Level Ecological Risk Assessment (April 2000). The Facility ER Project Screening Level Ecological Risk Assessment Methods and database may be substituted for the

above guidance provided that written approval for use of this method and database is obtained from the Department prior to implementation.

VIII.E RISK-BASED VARIANCE FROM CLEANUP STANDARDS OR LEVELS

If attainment of the established cleanup level is demonstrated to be technically infeasible, the Respondents may perform a risk-based evaluation to establish alternative cleanup levels for specific media at individual corrective action units. The risk-based evaluation should be conducted in accordance with the Department's human health risk Position Paper Assessing Human Health Risks Posed by Chemicals: Screening Level Risk Assessment (March 2000) using the equations in the Department's Technical Background Document for Development of Soil Screening Levels. The risk-based evaluation should be developed in accordance with the Department's ecological risk guidance document Guidance for Assessing Ecological Risks Posed by Chemicals: Screening-level Ecological Risk Assessment (March 2000). For groundwater, if the Respondents propose to demonstrate the technical infeasibility of achievement of a groundwater cleanup level that is a WQCC standard, the applicable requirements of the WQCC Regulations, 6.2.4103.E and 4103.F NMAC, shall be followed.

IX. INVESTIGATION AND SAMPLING METHODS AND PROCEDURES

The Respondents shall submit to the Department for approval site-specific work plans for each unit prior to the commencement of field activities where environmental investigation, corrective action, sampling or monitoring is being conducted or proposed. The site-specific work plans shall include the methods to be used to conduct all activities at each site or unit and shall be prepared in accordance with the format described in Section XI of this Order. The Respondents shall provide notification to the Department of corrective action field activities a minimum of fifteen (15) days prior to commencing the activity.

The methods used to conduct investigation, remediation, and monitoring activities shall be sufficient to fulfill the requirements of this Order and provide accurate data for the evaluation of site conditions, the nature and extent of contamination and contaminant migration, and for remedy selection and implementation, where necessary. The methods presented in Section IX.B of this Order are minimum requirements for environmental investigation and sampling, and are not intended to include all methods that may be necessary to fulfill the requirements of this Order. The methods for conducting investigations, corrective actions, and monitoring at the Facility must be determined based on the conditions and contaminants that exist at each site or unit.

IX.A LANL STANDARD OPERATING PROCEDURES

The Respondents maintain SOP manuals for conducting field investigations, monitoring, and sampling activities. The Respondents may implement the investigation, monitoring, and sampling procedures outlined in the most current Facility SOPs for investigation, remediation, and environmental restoration if the SOP has been approved for use by the Department. Use of SOPs does not imply compliance with the methods and procedures described in this Order. The following LANL SOPs have been reviewed and approved by the Department:

- ER-SOP-1.05, Rev. 0 -- Field Quality Control Samples
- ER-SOP-1.08, Rev. 1 – Field Decontamination of Drilling and Sampling Equipment
- ER-SOP-5.03, Rev. 2 – Monitoring Well and RFI Borehole Abandonment
- ER-SOP-6.26, Rev. 1 – Core Barrel Sampling for Subsurface Earth Materials
- ER-SOP-12.01, Rev. 4 – Field Logging, Handling and Documentation of Borehole Materials
- ER-SOP-12.04, Rev. 1 – Physical Processing and Storage of Borehole Samples at the Sample Management Facility

IX.B INVESTIGATION, SAMPLING, AND ANALYSES METHODS

IX.B.1 Introduction and Purpose

The Investigation and Sampling Methods and Procedures Section of this Order provides minimum requirements for field investigations, sample collection, handling and screening procedures, field and laboratory sample analysis, and quality assurance procedures for samples of the medium being investigated or tested at the Facility.

The purpose of this section (IX.B) is to: 1) provide minimum requirements for drilling and sample collection in exploratory borings and other excavations; 2) provide minimum requirements for sampling of the target media; 3) provide minimum requirements for monitoring of groundwater and vadose zone conditions; and 4) identify minimum required screening, analytical, and quality assurance procedures that shall be implemented during field sampling activities and laboratory analyses.

The quality assurance procedures referenced in the previous paragraph include: 1) the Facility investigation data quality objectives; 2) the requirements for QA/QC to be followed during field investigations and by the analytical laboratories; and 3) the methodology for the review and evaluation of the field and laboratory QA/QC results and documentation.

IX.B.2 Field Exploration Activities

Exploratory borings shall be advanced at locations specified in this Order. The Department may require additional exploratory borings to fulfill the requirements of this Order. Any additional boring locations, if required, will be determined or approved by the Department. The depths and locations of all exploratory and monitoring well borings shall be specified in the canyon- or site-specific work plans submitted to the Department for approval prior to the start of the respective field activities. The Department shall approve proposed unit aggregates grouped for the purpose of site investigation, remediation, and/or monitoring activities.

IX.B.2.a Subsurface Features/Utility Geophysical Surveys

The Respondents shall conduct surveys to locate underground utilities, pipelines structures, drums, debris, and other buried features in the shallow subsurface prior to the start of field exploration activities. The methods used to conduct the surveys, such as magnetometer, ground penetrating radar, resistivity, or other methods, shall be selected based on the characteristics of the site and the possible or suspected underground structures. The results of the surveys shall be included in the investigation reports submitted to the Department. The Respondents are responsible for locating and clearing all aboveground and underground utilities or other hazards at any site prior to conducting field work.

IX.B.2.b Drilling and Soil, Rock, and Sediment Sampling

IX.B.2.b.i Drilling

Exploratory and monitoring well borings shall be drilled using the most effective, proven, and practicable method for recovery of undisturbed samples and potential contaminants. The Department shall approve the drilling methods selected for advancement of each boring prior to the start of field

activities. Based on the drilling conditions, the borings shall be advanced using one of the following methods:

- Hollow-stem auger
- Air rotary
- Mud rotary
- Percussion hammer
- Sonic
- Dual wall air rotary
- Direct Push Technology (DPT)
- Cryogenic
- Cable tool

Hollow-stem auger or DPT drilling methods are preferred if vapor-phase or VOC contamination is known or suspected to be present. Air rotary drilling is preferred for borings intersecting the regional aquifer. The type of drilling fluid used, if necessary, shall be approved by the Department prior to the start of drilling activities or prior to use at any unit or unit aggregate.

All drilling equipment shall be in good working condition and capable of performing the assigned task. Drilling rigs and equipment shall be operated by properly trained, experienced, and responsible crews. The Respondents are responsible for ensuring that contaminants from another site or facility are not introduced into the site under investigation due to malfunctioning equipment or poor site maintenance. The drilling equipment shall be properly decontaminated before drilling each boring.

Exploratory borings shall be advanced to unit- and location-specific depths specified or approved by the Department. The Respondents shall propose drilling depths in the site-specific work plans submitted for each subject area. Unless otherwise specified in this Order, the borings shall be advanced to the following minimum depths:

1. In all borings, 25 ft below the deepest detected contamination based on field screening, laboratory analyses, and/or previous investigations at the site.

2. Twenty ft below the base of disposal units if contamination is not detected.

3. Five ft below the base of shallow structures such as piping or building sumps, or other building structures.

4. Five ft below the contact between canyon alluvium and bedrock.

5. One hundred ft below the deepest known intermediate perched groundwater zone.

6. One hundred ft below the top of the regional aquifer.

7. Depths specified by the Department based on regional or unit specific data needs.

The Respondents shall notify the Department as early as practicable if conditions arise or are encountered that do not allow the advancement of borings to the depths specified by the Department so that alternative actions may be discussed. Precautions shall be taken to prevent the migration of contaminants between geologic, hydrologic, or other identifiable zones during drilling and well installation activities. Contaminant zones shall be isolated from other zones encountered in the borings.

The drilling and sampling shall be accomplished under the direction of a qualified engineer or geologist who shall maintain a detailed log of the materials and conditions encountered in each boring. Both sample information and visual observations of the cuttings and core samples shall be recorded on the boring log. Known site features and/or site survey grid markers shall be used as references to locate each boring prior to surveying the location as described in Section IX.B.2.f of this Order. The boring locations shall be measured to the nearest foot, and locations shall be recorded on a scaled site map upon completion of each boring.

Trenching and other exploratory excavation methods shall follow the applicable general procedures outlined in this Order. The particular methods proposed for use by the Respondents for exploratory excavation and sampling at any specific unit shall be included in the site-specific investigation work plan submitted to the Department. The Department shall include any changes or additional requirements for conducting exploratory excavation and sampling activities at the subject unit in its response to the Respondents after review of the investigation work plan.

IX.B.2.b.ii Soil and Rock Sampling

Relatively undisturbed discrete soil and rock samples shall be obtained, where possible, during the advancement of each boring for the purpose of logging, field screening, and analytical testing. Generally, the samples shall be collected at the following intervals and depths:

1. At five-ft intervals, ten-ft intervals, continuously, or as approved by the Department.

2. At the depth immediately below the base of the disposal unit or facility structure.

3. At the maximum depth of each boring.

4. At the depths of contacts or first encounter, observed during drilling, with geologic units of different lithology, structural or textural characteristics, or of relatively higher or lower permeability.

5. Of soil or rock types relatively more likely to sorb or retain contaminants than surrounding lithology.

6. At the depth of the first encounter, during drilling, with shallow or intermediate saturated zones.

7. At intervals suspected of being source or contaminated zones.

8. At the top of the regional aquifer.

9. At other intervals approved or required by the Department.

The sampling interval for the borings may be modified, or samples may be obtained from a specific depth, based on field observations. A decontaminated split-barrel sampler lined with brass sleeves, a coring device, or other method approved by the Department shall be used to obtain samples during the drilling of each boring.

A split barrel sampler lined with brass sleeves or a coring device is the preferred sampling method for borehole soil, rock, and sediment sampling. The following procedures should be followed if a split barrel sampler is used. Upon recovery of the sample, one or more brass sleeves shall be removed from the split barrel sampler and the open ends of the sleeves covered with Teflon tape or foil and sealed with plastic caps fastened to the sleeves with tape for shipment to the analytical laboratory. If brass sleeves are not used, a portion of the sample shall be placed in pre-cleaned, laboratory-prepared sample containers for laboratory chemical analysis. The remaining portions of the sample shall be used for logging and field screening, as described in Sections IX.B.2.c and IX.B.2.d, respectively.

Discrete samples shall be collected for field screening and laboratory analyses. Homogenization of discrete samples collected for analyses other than for VOC and SVOC analyses shall be performed by the analytical laboratory, if necessary. The Respondents may submit site-specific, alternative methods for homogenization of samples in the field to the Department for approval.

Samples to be submitted for laboratory analyses shall be selected based on: 1) the results of the field screening or mobile laboratory analyses; 2) the position of the sample relative to groundwater, suspected releases, or site structures; 3) the sample location relative to former or altered site features or structures; 4) the stratigraphy encountered in the boring; and 5) the specific objectives and requirements of this Order. The proposed number of samples and analytical parameters shall be included as part of the unit-specific work plan submitted to the Department for approval prior to the start of field investigation activities at each unit. The work plans shall allow for flexibility in modifying the project-specific tasks based on information obtained during the course of the investigation. Modifications to site-specific work plan tasks shall be pre-approved in writing by the Department.

IX.B.2.b.iii Sediment Sampling

Sediment samples shall be collected in the same manner as described in Section IX.B.2.b.ii for soil and rock sampling where borings are drilled to explore alluvial subsurface conditions. The sampling device shall be a decontaminated, hand-held stainless steel coring device, shelby tube, thin-wall sampler, or other device approved by the Department where sediment sampling is conducted without the use of the drilling methods described in Section IX.B.2.b.i. The samples shall be transferred to pre-cleaned laboratory prepared containers for submittal to the laboratory. Samples obtained for volatiles analysis shall be collected using shelby tubes, thin-wall samplers, or other device approved by the Department. The ends of the samplers shall be lined with Teflon tape or aluminum foil and sealed with plastic caps fastened to the sleeves with tape for shipment to the analytical laboratory.

The physical characteristics of the sediment (such as mineralogy, ASTM soil classification, AGI [American Geological Institute] rock classification, moisture content, texture, color, presence of stains or odors, and/or field screening results), depth where each sample was obtained, method of sample collection, and other observations shall be recorded in the field log.

IX.B.2.b.iv Drill Cuttings (Investigation Derived Waste)

Drill cuttings, excess sample material and decontamination fluids, and all other investigation derived waste (IDW) shall be contained and characterized using methods based on the boring location, boring depth, drilling method, and type of contaminants suspected or encountered. An IDW management plan shall be included with the unit-specific investigation work plan submitted to the Department for approval prior to the start of field investigations. The Department shall approve the method of containment for drill cuttings prior to the start of drilling activities. Borings not completed as groundwater or vapor monitoring wells shall be properly abandoned in accordance with the methods listed in Section X.D of this Order. Borings completed as groundwater monitoring wells shall be constructed in accordance with the requirements described in Section X.C of this Order.

IX.B.2.c Logging of Soil/Rock and Sediment Samples

Samples obtained from all exploratory borings and excavations shall be visually inspected and the soil or rock type classified in general accordance with ASTM D2487 (Unified Soil Classification System) and D2488, or AGI Methods for soil and rock classification. Detailed logs of each boring shall be completed in the field by a qualified engineer or geologist. Additional information, such as the presence of water-bearing zones and any unusual or noticeable conditions encountered during drilling shall be recorded on the logs. Field boring logs, test pit logs, and field well construction diagrams shall be converted to the format acceptable for use in final reports submitted to the Department. Draft boring logs, test pit logs, and well construction diagrams shall be submitted to the Department for review within thirty (30) days after the completion of each boring or monitoring well.

IX.B.2.d Soil, Rock, and Sediment Sample Field Screening

Samples obtained from borings shall be screened in the field for evidence of the potential presence of contaminants. Field screening results shall be recorded on the exploratory boring and excavation logs. Field screening results are used as a general guideline to determine the nature and extent of possible contamination. In addition, screening results shall be used to aid in the selection of soil, rock, sediment, and vapor-phase samples for laboratory analysis. The Department recognizes that field screening alone will not detect the possible presence or full nature and extent of all contaminants that may be encountered at the site.

The primary screening methods to be used shall include: 1) visual examination; 2) radionuclide screening; 3) headspace vapor screening for VOCs; and 4) metals and isotope screening using X-ray fluorescence. Additional screening for site- or release-specific characteristics such as pH or for specific compounds using field test kits shall be conducted where appropriate.

Radionuclide screening shall target gross alpha, beta, and gamma radiation. The type of instrument (scintillation counter, gas-flow proportional counter, Geiger-Meuller pancake detector, FIDLER probe, multi-channel analyzer, or other instrument) used for field screening during investigation, remediation,

or monitoring activities shall be selected based on the known or suspected radionuclides at the specific site and the media to be screened (soils, rock, liquid, or vapor). The Department shall approve the type of radionuclide screening instrument selected for each site-specific project prior to use. Field screening for alpha and beta radiation shall be conducted as close to the sample as possible. Field screening for gamma radiation shall not be conducted at distances exceeding six inches from the media being screened. A background range will be established for the corresponding radiation measurement at a minimum of 50 (fifty) feet upwind from the site. A minimum of 8-10 readings shall be obtained to determine the background range. This background range shall be recorded and reported. A minimum of three measurements, obtained at a minimum of a one-minute count rate, shall be obtained when screening each sample. The field screening results shall be considered acceptable if there is not greater than a 20 percent variance between the measurements. The instrument(s) shall be checked each day for proper operation and calibration using a National Institute of Standards and Testing traceable source. Field screening of the sample shall be repeated if there is greater than a 20 percent variance between field screening measurements for any sample when the measured values are greater than the background noise established before the field screening.

Headspace vapor screening shall target VOCs and shall be conducted by placing a soil or rock sample in a plastic sample bag or a foil-sealed container allowing space for ambient air. The container shall be sealed and then shaken gently to expose the soil or rock to the air trapped in the container. The sealed container shall be allowed to rest for a minimum of five minutes while vapors equilibrate. Vapors present within the sample bag headspace will then be measured by inserting the probe of the instrument in a small opening in the bag or through the foil. The maximum value and the ambient air temperature shall be recorded on the field boring or test pit log for each sample. The monitoring instruments shall be calibrated each day to the manufacturers standard for instrument operation. A photo-ionization detector (PID) equipped with a 10.6 or higher electron volt (eV) lamp, combustible gas indicator, or other instrument approved by the Department shall be used for VOC field screening. The limitations, precision, and calibration procedures of the instrument to be used for VOC field screening shall be included in the site-specific investigation work plan prepared for each unit.

X-ray fluorescence (XRF) may be used to screen soil, rock, or sediment samples for the presence of metals or isotopes. XRF screening requires proper sample preparation and proper instrument calibration. Sample preparation and instrument calibration procedures shall be documented in the field logs. The methods and procedures for sample preparation and instrument calibration shall be approved by the Department prior to the start of field activities. Field XRF screening results for selected metals may be used in lieu of laboratory analyses upon approval by the Department; however, the results shall, at a minimum, be confirmed by laboratory analyses at a frequency of 20 percent (one sample per every five analyzed by XRF analysis).

Field screening results are site- and boring-specific and the results vary with instrument type, media screened, weather conditions, moisture content, soil or rock type, and type of contaminant. The Respondents shall record on the field logs all conditions capable of influencing the results of field screening. The Respondents shall submit to the Department conditions potentially influencing field screening results as part of the site-specific investigation, remediation, or monitoring reports.

At a minimum, the Respondents shall submit the samples with the greatest apparent degree of contamination, based on field observations and field screening, for laboratory analysis. The

Respondents shall also use the location of the sample relative to groundwater, stratigraphic units or contacts, and the proximity to significant site or subsurface features or structures as a guideline for sample selection. In addition, the Respondents shall submit the samples with no or little apparent contamination, based on field screening, for laboratory analysis if the intention is to confirm that the base (or other depth interval) of a boring or other sample location is not contaminated.

IX.B.2.e Soil, Rock, and Sediment Sample Types

The Respondents shall collect soil, rock, and sediment samples at the frequencies outlined in the site-specific investigation, corrective action, or monitoring work plans for each SWMU, AOC, or other site submitted by the Respondents for approval by the Department. The samples collected shall be representative of the media and site conditions being investigated or monitored. The Respondents shall collect QA/QC samples to monitor the validity of the soil, rock, and sediment sample collection procedures. Field duplicates will be collected at a rate of ten percent. The Respondents shall collect equipment blanks from all sampling apparatus at a frequency of ten percent for chemical analysis. Equipment blanks shall be collected at a frequency of one per day if disposable sampling equipment is used. The Respondents shall collect field blanks at a frequency of one per day for each medium (with the exception of air samples) at each SWMU, AOC, or other site. Reagent blanks shall be used if chemical analytical procedures requiring reagents are employed in the field as part of the investigation or monitoring program. The resulting data will provide information on the variability associated with sample collection, handling, and laboratory analysis operations. The blanks and duplicates shall be submitted for laboratory analyses associated with the project-specific contaminants, data quality concerns, and media being sampled.

IX.B.2.f Sample Point and Structure Location Surveying

The horizontal coordinates and elevation of each surface sampling location; the surface coordinates and elevation of each boring or test pit, the top of each monitoring well casing, and the ground surface at each monitoring well location; and the locations of all other pertinent structures shall be determined by a registered New Mexico professional land surveyor in accordance with the State Plane Coordinate System (NMSA 1978 47-1-49-56 (Repl. Pamp. 1993)). The surveys shall be conducted in accordance with Sections 500.1 through 500.12 of the Regulations and Rules of the Board of Registration for Professional Engineers and Surveyors Minimum Standards for Surveying in New Mexico. Horizontal positions shall be measured to the nearest 0.1-ft, and vertical elevations shall be measured to the nearest 0.01-ft. The Respondents shall prepare site map(s), certified by a registered New Mexico professional land surveyor, presenting all surveyed locations and elevations including relevant site features and structures for submittal with all associated reports to the Department.

IX.B.2.g Subsurface Vapor-phase Monitoring and Sampling

Samples of subsurface vapors shall be collected from vapor monitoring points from both discrete zones, selected based on investigation and field screening results, and as total well subsurface vapor samples where required by the Department.

The Respondents shall, at a minimum, collect vapor samples for field measurement of the following:

- Percent oxygen;

- Organic vapors (using a photo-ionization detector with an 11.7 eV (electron volt) lamp, a combustible vapor indicator or other method approved by the Department);
- Percent carbon dioxide;
- Tritium (gross beta);
- Static subsurface pressure; and
- Other parameters (such as carbon monoxide and hydrogen sulfide) as required by the Department.

The Respondents also shall collect vapor samples for laboratory analysis of the following as required:

- Percent moisture;
- VOCs;
- Tritium; and
- Other analytes required by the Department.

Vapor samples analyzed by the laboratory for percent moisture and VOCs shall be collected using SUMMA canisters or other sample collection method approved by the Department. The samples shall be analyzed for VOC concentrations by EPA Method TO-14 or equivalent VOC analytical method.

Vapor samples also shall be collected using silica gel cartridges in series, or other sample collection method approved by the Department, for tritium analysis using EPA Method 114, liquid scintillation spectrometry (NESHAP Part 61, Appendix B), or equivalent method.

Field vapor measurements, the date and time of each measurement, and the instrument used shall be recorded on a vapor monitoring data sheet. The instruments used for field measurements shall be calibrated daily in accordance with the manufacturers specifications and as described in Section IX.B.4. The methods used to obtain vapor-phase field measurements and samples shall be approved by the Department prior to the start of air monitoring at each Facility site where vapor-phase monitoring is conducted.

IX.B.2.h Groundwater and Surface Water Monitoring

IX.B.2.h.i Groundwater Levels

Groundwater level measurements shall be obtained at intervals required by the Department and after significant seasonal and weather events such as spring snowmelt and at the end of summer monsoon season. Groundwater levels also shall be obtained prior to purging in preparation for a sampling event. Measurement data and the date and time of each measurement shall be recorded on a site monitoring data sheet. The depth to groundwater shall be measured to the nearest 0.01 ft. The depth to groundwater shall be recorded relative to the surveyed well casing rim or other surveyed datum.

Groundwater levels shall be measured in all wells in a given watershed within 24 hours. Facility-wide regional aquifer and intermediate perched zone groundwater level measurements shall be obtained at all well locations within ten (10) calendar days of the commencement of the specified measuring event. The Respondents shall conduct quarterly measuring events, the schedule for which shall be provided in the groundwater monitoring work plans. In addition, groundwater levels shall be measured in alluvial wells in conjunction with the collection of surface water measurements in each watershed.

IX.B.2.h.ii Surface Water Measurements

Stream stage fluctuations and stream flow rates within each watershed shall be measured immediately after significant rain events and during seasonal snowmelt and monsoon events. The seasonal surface water measurements shall be scheduled to coincide with groundwater level measuring events. The specific methods and locations for obtaining surface water measurements shall be approved by the Department.

IX.B.2.i Groundwater and Surface Water Sampling

Groundwater samples shall initially be obtained from newly installed monitoring wells between ten (10) and thirty (30) days after completion of well development. Groundwater monitoring and sampling shall be conducted at an interval approved by the Department after the initial sampling event. All monitoring wells within a watershed shall be sampled within fifteen (15) days of the start of the groundwater sampling event. All regional wells shall be sampled within thirty (30) days of the start of the sampling event. The Respondents shall sample all saturated zones screened to allow entry of groundwater into each monitoring well during each sampling event. All requests for variances from the groundwater sampling schedule shall be submitted to the Department, in writing, thirty (30) days prior to the start of scheduled monitoring and sampling events. Groundwater samples shall be collected from all saturated zones within exploratory borings not intended to be completed as monitoring wells prior to abandonment of the borings.

Surface water samples shall be obtained in conjunction with routine groundwater sampling, where present, at sampling stations and at intervals approved by the Department. All surface water stations within a watershed shall be sampled within 24 hours of the initial sample collection. Surface water samples shall be obtained from a watershed within 24 hours of a rain event that causes a significant increase in runoff and stream flow rates.

Water samples shall be analyzed for one or more of the following general chemistry parameters as required by the Department:

nitrate/nitrite	sulfate	chloride	sodium
Dissolved CO_2	alkalinity	carbonate/bicarbonate	boron
Fluoride	manganese	calcium	silicon/bromide
ferric/ferrous iron	ammonia	potassium	phosphorus/phosphate

Strontium	lithium	magnesium	molybdenum
TKN	total organic carbon	suspended sediment concentration*	
total dissolved solids		stable isotopes (as required by the Department)	

* ASTM Method D3977-97 standard test for determining sediment concentration in water samples.

IX.B.2.i.i Well Purging

All zones in each monitoring well shall be purged by removing groundwater prior to sampling in order to ensure that formation water is being sampled. Purge volumes shall be determined by monitoring, at a minimum, groundwater pH, specific conductance, dissolved oxygen concentrations, turbidity, redox potential, and temperature during purging of volumes and at measurement intervals approved by the Department. The groundwater quality parameters shall be measured using a flow-through cell and instruments approved by the Department. The volume of groundwater purged, the instruments used, and the readings obtained at each interval shall be recorded on the field monitoring log. Water samples may be obtained from the well after the measured parameters of the purge water have stabilized to within ten percent for three consecutive measurements. Well purging may also be conducted in accordance with the Department's Position Paper "Use of Low-Flow and other Non-Traditional Sampling Techniques for RCRA Compliant Groundwater Monitoring" (October 30, 2001). The Respondents may submit, to the Department for approval, a written request for a variance from the described methods of well purging for individual wells no later than ninety (90) days prior to scheduled sampling activities. The Department shall respond to the request, in writing, within sixty (60) days of receipt of the variance request.

IX.B.2.i.ii Groundwater Sample Collection

Groundwater samples shall be obtained from each well after a sufficient amount of water has been removed from the well casing to ensure that the sample is representative of formation water. Groundwater samples shall be obtained using methods approved by the Department within eight hours of the completion of well purging. Sample collection methods shall be documented in the field monitoring reports. The samples shall be transferred to the appropriate, clean, laboratory-prepared containers provided by the analytical laboratory. Sample handling and chain-of-custody procedures are described in Section IX.B.2.j of this Order. Decontamination procedures shall be established for reusable water sampling equipment as described in Section IX.B.3.

All purged groundwater and decontamination water shall be temporarily stored at satellite accumulation areas or transfer stations in labeled 55-gallon drums or other containers approved by the Department until proper characterization and disposal can be arranged. The methods for disposal of purge/decontamination water shall be approved by the Department prior to removal from the temporary storage area. Disposable materials shall be handled as described in Section IX.B.5.

Groundwater samples intended for metals analysis shall be submitted to the laboratory as total metals samples. If required by the Department, the Respondents shall obtain groundwater samples for

dissolved metals analysis to be filtered using disposable in-line filters with a mesh size approved by the Department.

IX.B.2.i.iii Surface Water Sample Collection

Surface water samples shall be obtained at locations and frequencies approved by the Department. The sampling events shall be conducted during time periods that represent seasonal low water levels and seasonal high water levels and at times that coincide with precipitation events that result in significant watershed surface water runoff.

Surface water samples shall be collected using methods approved by the Department. Samples shall be collected in clean laboratory-prepared sampling containers. At a minimum, measurements of surface water pH, specific conductance, dissolved oxygen concentration, and temperature shall be obtained at each sample location in conjunction with sample collection. The methods and instruments used to measure field parameters shall be approved by the Department prior to conducting surface water sampling. The sampling and monitoring techniques used and the measurements obtained shall be recorded in the field monitoring reports. The Respondents shall include a surface water sampling program in the site-specific work plan for each site and as part of a Facility-wide groundwater and surface water sampling work plan. The work plans shall be prepared in accordance with Section XI of this Order.

IX.B.2.i.iv Groundwater and Surface Water Sample Types

Groundwater samples shall be collected from each monitoring well and surface water samples shall be collected at predetermined locations. Field duplicates, field blanks, equipment rinsate blanks, reagent blanks, if necessary, and trip blanks shall be obtained for quality assurance during groundwater and surface water sampling activities. The samples shall be handled as described in Section IX.B.2.j of this Order.

Field duplicate surface water and groundwater samples shall be obtained at a frequency of ten percent. At a minimum, one duplicate sample per sampling event shall always be obtained.

Field blanks shall be obtained at a minimum frequency of one per day per site or unit. Field blanks shall be generated by filling sample containers in the field with deionized water and submitting the samples, along with the groundwater or surface water samples, to the analytical laboratory for the appropriate analyses.

Equipment rinsate blanks shall be obtained for chemical analysis at the rate of ten percent or a minimum of one rinsate blank per sampling day. Equipment rinsate blanks shall be collected at a rate of one per sampling day if disposable sampling apparatus is used. Rinseate samples shall be generated by rinsing deionized water through unused or decontaminated sampling equipment. The rinsate sample then shall be placed in the appropriate sample container and submitted with the groundwater or surface water samples to the analytical laboratory for the appropriate analyses.

Reagent blanks shall be obtained at a frequency of 20 percent or a minimum of one per day per unit if chemical analyses requiring the use of chemical reagents are conducted in the field during water sampling activities.

Trip blanks shall accompany laboratory sample bottles and shipping and storage containers intended for VOC analyses. Trip blanks shall consist of a sample of analyte-free deionized water prepared by the laboratory and placed in an appropriate sample container. The trip blank shall be prepared by the analytical laboratory prior to the sampling event and shall be kept with the shipping containers and placed with other water samples obtained from the site each day. Trip blanks shall be analyzed at a frequency of one for each shipping container of samples.

IX.B.2.j Sample Handling

At a minimum, the following procedures shall be used at all times when collecting samples during investigation, corrective action, and monitoring activities:

1. Neoprene, nitrile, or other protective gloves shall be worn when collecting samples. New disposable gloves shall be used to collect each sample.

2. All samples collected of each medium for chemical analysis shall be transferred into clean sample containers supplied by the project analytical laboratory with the exception of soil, rock, and sediment samples obtained in brass sleeves or in Encore™ samplers. Upon recovery of the sample collected using split barrel samplers with brass sleeves, the brass sleeves shall be removed from the split barrel sampler and the open ends of the sleeves shall be lined with Teflon tape or foil and sealed with plastic caps. The caps shall be fastened to the sleeve with tape for storage and shipment to the analytical laboratory. The sample depth and the top of the sample shall be clearly marked. Sample container volumes and preservation methods shall be in accordance with EPA SW-846 and established industry practices for use by accredited analytical laboratories. Sufficient sample volume shall be obtained for the laboratory to complete the method-specific QC analyses on a laboratory-batch basis.

3. Sample labels and documentation shall be completed for each sample following procedures approved by the Department. Immediately after the samples are collected, they shall be stored in a cooler with ice or other appropriate storage method until they are delivered to the analytical laboratory. Standard chain-of-custody procedures, as described in Section IX.B.6.b of this Order, shall be followed for all samples collected. All samples shall be submitted to the laboratory soon enough to allow the laboratory to conduct the analyses within the method holding times. At a minimum, all samples shall be submitted to the laboratory within 48 hours after their collection.

Shipment procedures shall include the following:

1. Individual sample containers shall be packed to prevent breakage and transported in a sealed cooler with ice or other suitable coolant or other EPA or industry-wide accepted method. The drainage hole at the bottom of the cooler shall be sealed and secured in case of sample container leakage. Temperature blanks shall be included with each shipping container.

2. Each cooler or other container shall be delivered directly to the analytical laboratory.

3. Glass bottles shall be separated in the shipping container by cushioning material to prevent breakage.

4. Plastic containers shall be protected from possible puncture during shipping using cushioning material.

5. Samples contaminated with radionuclides shall be packaged and handled in accordance with Nuclear Regulatory Commission requirements outlined in 10 C.F.R. Part 71 and U.S. Department of Transportation requirements outlined in 40 C.F.R. Parts 170-189.

6. The chain-of-custody form and sample request form shall be shipped inside the sealed storage container to be delivered to the laboratory.

7. Chain-of-custody seals shall be used to seal the sample-shipping container in conformance with EPA protocol.

8. Signed and dated chain-of-custody seals shall be applied to each cooler prior to transport of samples from the site.

IX.B.2.k In-situ Testing

In-situ permeability tests, remediation system pilot tests, stream flow tests, and other tests conducted to evaluate site and subsurface conditions shall be designed to accommodate specific site conditions and to achieve the test objectives. The testing methods shall be approved by the Department prior to implementation. The tests shall be conducted in order to appropriately represent site conditions and in accordance with USGS, ASTM or other methods generally accepted by the industry. Detailed logs of all relevant site conditions and measurements shall be maintained during the testing events. A summary of the general test results, including unexpected or unusual test results and equipment failures or testing limitations shall be reported to the Department within thirty (30) days of completion of the test. The summary shall be presented in a format acceptable to the Department and in general accordance with the report formats outlined in Section XI of this Order. A formal report summarizing the results of each test shall be submitted to the Department within one hundred and twenty (120) days of completion of each test.

IX.B.3 Decontamination Procedures

The objective of the decontamination procedures is to minimize the potential for cross-contamination. A designated decontamination area shall be established for decontamination of drilling equipment, reusable sampling equipment and well materials. The drilling rig shall be decontaminated prior to entering the site or unit. Drilling equipment or other exploration equipment that may come in contact with the borehole shall be decontaminated by steam cleaning, by hot-water pressure washing, or by other method approved by the Department prior to drilling each new boring.

Sampling or measurement equipment, including but not limited to, stainless steel sampling tools, split-barrel or core samplers, well developing or purging equipment, groundwater quality measurement instruments, and water level measurement instruments, shall be decontaminated in accordance with the following procedures or other methods approved by the Department before each sampling attempt or measurement:

1. Brush equipment with a wire or other suitable brush, if necessary or practicable, to remove large particulate matter.

2. Rinse with potable tap water.

3. Wash with nonphosphate detergent or other detergent approved by the Department (examples include Fantastik™, Liqui-Nox®) followed by a tap water rinse.

4. Rinse with 0.1 M nitric acid (to remove trace metals, if necessary) followed by a tap water rinse.

5. Rinse with methanol (to remove organic compounds, if necessary) followed by a tap water rinse.

6. Rinse with potable tap water.

7. Double rinse with deionized water.

All decontamination solutions shall be collected and stored temporarily as described in Section IX.B.5 of this Order. Decontamination procedures and the cleaning agents used shall be documented in the daily field log.

IX.B.4 Field Equipment Calibration Procedures

Field equipment requiring calibration shall be calibrated to known standards, in accordance with the manufacturers' recommended schedules and procedures. At a minimum, calibration checks shall be conducted daily, or at other intervals approved by the Department, and the instruments shall be recalibrated, if necessary. Calibration measurements shall be recorded in the daily field logs. If field equipment becomes inoperable, its use shall be discontinued until the necessary repairs are made. In the interim, a properly calibrated replacement instrument shall will be used.

IX.B.5 Collection and Management of Investigation Derived Waste

Investigation derived waste (IDW) includes general refuse, drill cuttings, excess sample material, water (decontamination, development and purge), and disposable equipment generated during the course of investigation, corrective action, or monitoring activities. All IDW shall be properly characterized and disposed of in accordance with all Federal, State, and local rules and regulations for storage, labeling, handling, transport, and disposal of waste. The Respondents shall submit an IDW management and disposal plan to the Department for approval prior to disposal of any IDW produced during investigation, corrective action, or monitoring activities. The Respondents may submit a request to the Department to dispose of IDW on a case-by-case basis prior to submittal of the IDW management and disposal plan.

All water generated during sampling and decontamination activities shall be temporarily stored at satellite accumulation areas or transfer stations in labeled 55-gallon drums or other containers approved by the Department until proper characterization and disposal can be arranged. The IDW may be characterized for disposal based on the known or suspected contaminants potentially present in the

waste. The methods for waste characterization and disposal of IDW shall be approved by the Department prior to removal from the temporary storage area.

IX.B.6 Documentation of Field Activities

IX.B.6.a General

Daily field activities, including observations and field procedures, shall be recorded on appropriate forms. The original field forms shall be maintained at the Facility. Copies of the completed forms shall be maintained in a bound and sequentially numbered field file for reference during field activities. Indelible ink shall be used to record all field activities. Photographic documentation of field activities shall be performed, as appropriate. The daily record of field activities shall include the following:

- Site or unit designation;
- Date;
- Time of arrival and departure;
- Field investigation team members including subcontractors and visitors;
- Weather conditions;
- Daily activities and times conducted;
- Observations;
- Record of samples collected with sample designations and locations specified;
- Photographic log;
- Field monitoring data, including health and safety monitoring;
- Equipment used and calibration records, if appropriate;
- List of additional data sheets and maps completed;
- An inventory of the waste generated and the method of storage or disposal; and
- Signature of personnel completing the field record.

IX.B.6.b Sample Custody

All samples collected for analysis shall be recorded in the field report or data sheets. Chain-of-custody forms shall be completed at the end of each sampling day, prior to the transfer of samples off site, and shall accompany the samples during shipment to the laboratory. A signed and dated custody seal shall be affixed to the lid of the shipping container. Upon receipt of the samples at the laboratory, the custody seals will be broken, the chain-of-custody form shall be signed as received by the laboratory,

and the conditions of the samples shall be recorded on the form. The original chain-of-custody form shall remain with the laboratory and copies shall be returned to the relinquishing party. The Respondents shall maintain copies of all chain-of-custody forms generated as part of sampling activities. Copies of the chain-of-custody records shall be included with all draft and final laboratory reports submitted to the Department for review.

IX.C CHEMICAL ANALYSES

The Respondents shall submit all samples for laboratory analysis to accredited contract laboratories. The laboratories shall use the most recent standard EPA and industry-accepted analytical methods for chemical and radiological analyses for target analytes as the testing methods for each medium sampled. Chemical analyses shall be performed in accordance with the most recent EPA standard analytical methodologies and extraction methods. In addition, the Respondents shall use the most recent EPA and accepted industry-wide standard, accurate, and dependable methods for detecting the presence of radionuclides.

The Respondents shall submit a list of analytes and analytical methods to the Department for approval as part of each site-specific investigation, corrective action, or monitoring work plan. The detection limits for each method shall be less than applicable background, screening, and regulatory cleanup levels. The preferred method detection limits are a maximum of 20 percent of the cleanup, screening, or background levels. Analyses conducted with detection limits that are greater than applicable background, screening,and regulatory cleanup levels shall be considered data quality exceptions and the reasons for the elevated detection limits shall be reported to the Department. These data cannot be used for statistical analyses. All analytical data (non-detects, estimated blanks, and detedts) shall be included in the electronic copy of the investigation report in Microsoft™ Excel format with qualifiers as attached from the analytical laboratory. The radiochemical data will include the activity concentration and the associated minimum detectable concentration, even when the results are less than zero (negative). The summary tables will include only detects of the data based on the corresponding qualifiers. The Respondents will not censor the data based on detection limits, quantitation limits, or measurement uncertainty.

IX.C.1 Laboratory QA/QC Requirements

The following requirements for laboratory QA/QC procedures shall be considered the minimum QA/QC standards for the laboratories employed by the Respondents that provide analytical services for environmental investigation, corrective action, and monitoring activities conducted at the Facility. The Respondents shall provide the names of the contract analytical laboratories and copies of the laboratory quality assurance manuals to the Department within forty-five (45) days of awarding a contract for analytical services to any contract laboratory.

IX.C.1.a Quality Assurance Procedures

Contract analytical laboratories shall maintain internal quality assurance programs in accordance with EPA and industry-wide accepted practices and procedures. At a minimum, the laboratories shall use a combination of standards, blanks, surrogates, duplicates, matrix spike/matrix spike duplicates (MS/MSD), blank spike/blank spike duplicates (BS/BSD), and laboratory control samples to demonstrate analytical QA/QC. The laboratories shall establish control limits for individual chemicals

or groups of chemicals based on the long-term performance of the test methods. In addition, the laboratories shall establish internal QA/QC that meets EPA's laboratory certification requirements. The specific procedures to be completed are identified in the following sections.

IX.C.1.b Equipment Calibration Procedures and Frequency

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

IX.C.1.c Laboratory QA/QC Samples

Analytical procedures shall be evaluated by analyzing radiogenic National Institute of Standards and Technology (NIST) traceable source standards, reagent or method blanks, surrogates, MS/MSDs, BS/BSDs, and laboratory duplicates, as appropriate for each method. The laboratory QA/QC samples and frequency of analysis to be completed shall be documented in the cited EPA or DOE test methodologies. At a minimum, the laboratory shall analyze laboratory blanks, MS/MSDs, BS/BSDs, and laboratory duplicates at a frequency of one in twenty for all batch runs requiring EPA test methods and at a frequency of one in ten for non-EPA test methods. Laboratory batch QA/QC samples shall be specific to the project. For radionuclides, the instrument shall be calibrated to the appropriate radiogenic source standard and blanks shall be analyzed at a frequency of once per batch.

IX.C.1.d Laboratory Deliverables

The analytical data package shall be prepared in accordance with EPA-established Level III analytical support protocol. The following shall be provided in the analytical laboratory reports submitted to the Department electronically and in hard (paper) copy for this project:

1. Transmittal letter, including information about the receipt of samples, the testing methodology performed, any deviations from the required procedures, any problems encountered in the analysis of the samples, any data quality exceptions, and any corrective actions taken by the laboratory relative to the quality of the data contained in the report.

2. Sample analytical results, including sampling date; date of sample extraction or preparation; date of sample analysis; dilution factors and test method identification; soil, rock, or sediment sample results in consistent units (mg/kg) or micrograms per kilogram in dry-weight basis; water sample results in consistent units (milligrams per liter or micrograms per liter (μg/L)); vapor sample results in consistent units (ppm or ppmv); radionuclide results in consistent units (pCi/L or pCi/g); and detection limits for undetected analytes. Results shall be reported for all field samples, including field duplicates and blanks, submitted for analysis.

3. Method blank results, including reporting limits for undetected analytes.

4. Surrogate recovery results and corresponding control limits for samples and method blanks (organic analyses only).

5. MS/MSD and/or BS/BSD spike concentrations, percent recoveries, relative percent differences (RPDs), and corresponding control limits.

6. Laboratory duplicate results for inorganic analyses, including relative percent differences and corresponding control limits.

7. Radiogenic NIST traceable source standard calibration references.

8. Sample chain-of-custody documentation.

9. Holding times and conditions.

10. Conformance with required analytical protocol(s).

11. Instrument calibration.

12. Blanks.

13. Detection/quantitation limits.

14. Recoveries of surrogates.

15. Variability for duplicate analyses.

16. Completeness.

17. Data report formats.

18. The following data deliverables for organic compounds shall be required from the laboratory:

- A cover letter referencing the procedure used and discussing any analytical problems, deviations, and modifications, including signature from authority representative certifying to the quality and authenticity of data as reported;

- Report of sample collection, extraction, and analysis dates, including sample holding conditions;

- Tabulated results for samples in units as specified, including data qualification in conformance with EPA protocol, and definition of data descriptor codes;

- Reconstructed ion chromatograms for gas chromatograph/mass spectrometry (GC/MS) analyses for each sample and standard calibration;

- Selected ion chromatograms and mass spectra of detected target analytes (GC/MS) for each sample and calibration with associated library/reference spectra;

- Gas chromatograph/electron capture device (GC/ECD) and/or gas chromatograph/flame ionization detector (GC/FID) chromatograms for each sample and standard calibration;

- Raw data quantification reports for each sample and calibrations, including areas and retention times for analytes, surrogates, and internal standards;

- A calibration data summary reporting calibration range used and a measure of linearity [include decafluorotriphenylphosphine (DFTPP) and p-bromofluorobenzene (BFB) spectra and compliance with tuning criteria for GC/MS];

- Final extract volumes (and dilutions required), sample size, wet-to-dry weight ratios, and instrument practical detection/quantitation limit for each analyte;

- Analyte concentrations with reporting units identified, including data qualification in conformance with the CLP Statement of Work (SOW) (include definition of data descriptor codes);

- Quantification of analytes in all blank analyses, as well as identification of method blank associated with each sample;

- Recovery assessments and a replicate sample summary, including all surrogate spike recovery data with spike levels/concentrations for each sample and all MS/MSD results (recoveries and spike amounts); and

- Report of tentatively identified compounds with comparison of mass spectra to library/reference spectra,

19. The following data deliverables for inorganic compounds shall be required from the laboratory:

- A cover letter referencing the procedure used and discussing any analytical problems, deviations, and modifications; including signature from authority representative certifying to the quality and authenticity of data as reported;

- Report of sample collection, digestion, and analysis dates, with sample holding conditions;

- Tabulated results for samples in units as specified, including data qualification in conformance with the CLP SOW (including definition of data descriptor codes);

- Results of all method QA/QC checks, including inductively coupled plasma (ICP) Interference Check Sample and ICP serial dilution results;

- Tabulation of instrument and method practical detection/quantitation limits;

- Raw data quantification report for each sample;

- A calibration data summary reporting calibration range used and a measure of linearity, where appropriate;

- Final digestate volumes (and dilutions required), sample size, and wet-to-dry weight ratios;

- Quantification of analytes in all blank analyses, as well as identification of method blank associated with each sample; and

- Recovery assessments and a replicate sample summary, including post-digestate spike analysis; all MS data (including spike concentrations) for each sample, if accomplished; all MS results (recoveries and spike amounts); and laboratory control sample analytical results).

20. The following data deliverables for radionuclides shall be required from the laboratory:

- A cover letter referencing the procedure used and discussing any analytical problems, deviations, and modifications, including signature from authority representative certifying to the quality and authenticity of data as reported;

- Report of sample collection, digestion, and analysis dates, with sample holding conditions;

- Tabulated results for samples in units as specified, including data qualification in conformance with EPA and industry-wide accepted protocol, and definition of data descriptor codes;

- Tabulation of instrument and method practical detection/quantitation limits;

- Chemical separation specificity (alpha spectrometry);

- Target radionuclide list identification (gamma spectrometry);

- Calibration of instruments (verify instrument was calibrated and evaluate shape of high voltage plateaus, efficiency versus energy curves, and quench curves) for initial and continuing gas flow (proportional and other gross counting measurements); liquid scintillation [tritium] (including efficiency quench curves); spectroscopy systems; and Lucas cells and radon flask counting systems;

- Routine calibration verification for gas flow proportional and other gross counting measurements, liquid scintillation, spectroscopy systems, and Lucas cells and radon flask counting systems;

- Blanks (most frequent of one blank per matrix, one blank per batch, or five percent of samples). Plot results of blanks on a QC chart and establish acceptable tolerances based on performances and analytical requirements;

- Calibration sample-specific chemical recovery percentages;

- Laboratory control sample (LCS) results (most frequent of one blank per matrix, one blank per batch, or five percent of samples), aqueous LCS control limits, and solid LCS control limits; and

- Recovery assessments and a replicate sample summary, including all surrogate spike recovery data with spike levels/concentrations for each sample and all MS/MSD results (recoveries and spike amounts).

The Respondents shall present summary tables of these data in the formats described in Section XI of this Order. The raw analytical data, including calibration curves, instrument calibration data, data calculation work sheets, and other laboratory support data for samples from this project, shall be compiled and kept on file at the Facility for reference. The Respondents shall make the data available to the Department upon request.

IX.C.2 Review of Field and Laboratory QA/QC Data

The Respondents shall evaluate the sample data, field, and laboratory QA/QC results for acceptability with respect to the data quality objectives (DQOs). Each group of samples shall be compared with the DQOs and evaluated using data validation guidelines contained in EPA guidance documents, the latest version of SW-846, and industry-accepted QA/QC methods and procedures.

The Respondents shall require the laboratory to notify the Facility project manager of data quality exceptions within 24 hours in order to allow for sample re-analysis, if possible. The Facility project manager shall contact the Department within 24 hours of receipt of laboratory notification of data quality exceptions in order to discuss the implications and determine whether the data will still be considered acceptable or if sample re-analysis or resampling is necessary. The Facility project manager shall summarize the results of the discussion with the Department project leader regarding the data quality exceptions in a memorandum. The Respondents shall submit the memorandum to the Department by fax or electronic mail within one (1) working day of the conclusion of the data quality discussion.

IX.C.3 Blanks, Field Duplicates, Reporting Limits and Holding Times

IX.C.3.a Blanks

The analytical results of field blanks and field rinsate blanks shall be reviewed to evaluate the adequacy of the equipment decontamination procedures and the possibility of cross-contamination caused by decontamination of sampling equipment. The analytical results of trip blanks shall be reviewed to evaluate the possibility for contamination resulting from the laboratory-prepared sample containers or the sample transport containers. The analytical results of laboratory blanks shall be reviewed to evaluate the possibility of contamination caused by the analytical procedures. If contaminants are detected in field or laboratory blanks, the sample data shall be qualified, as appropriate.

IX.C.3.b Field Duplicates

Field duplicates shall consist of two samples either split from the same sample device or collected sequentially. Field duplicate samples shall be collected at a minimum frequency of ten percent of the total number of samples submitted for analysis. RPDs for field duplicates shall be calculated. A precision of no more than 20 percent for duplicates shall be considered acceptable for soil, rock, and sediment sampling conducted at the Facility. The analytical DQO for precision shall be used for water duplicates.

IX.C.3.c Method Reporting Limits

Method reporting limits for sample analyses for each medium shall be established at the lowest level practicable for the method and analyte concentrations and shall not exceed soil, groundwater, surface water, or vapor emissions background levels, cleanup standards, and screening levels. The preferred method detection limits are a maximum of 20 percent of the background, screening, or cleanup levels. Detection limits that exceed established soil, groundwater, surface water, or air emissions cleanup standards, screening levels, or background levels and are reported as "not detected" shall be considered data quality exceptions and an explanation for the exceedance and its acceptability for use shall be provided.

IX.C.3.d Holding Times

The Respondents shall review the sampling, extraction, and analysis dates to confirm that extraction and analyses were completed within the recommended holding times, as specified by EPA protocol. Appropriate data qualifiers shall be noted if holding times were exceeded.

IX.C.4 Representativeness and Comparability

IX.C.4.a Representativeness

Representativeness is a qualitative parameter related to the degree to which the sample data represent the relevant specific characteristics of the media sampled. The Respondents shall implement procedures to assure representative samples are collected and analyzed, such as repeated measurements of the same parameter at the same location over several distinct sampling events. The Respondents shall note any procedures or variations that may affect the collection or analysis of representative samples and shall qualify the data.

IX.C.4.b Comparability

Comparability is a qualitative parameter related to whether similar sample data can be compared. To assure comparability, the Respondents shall report analytical results in appropriate units for comparison with other data (past studies, comparable sites, screening levels, and cleanup standards), and shall implement standard collection and analytical procedures. Any procedure or variation that may affect comparability shall be noted and the data shall be qualified.

IX.C.5 Laboratory Reporting, Documentation, Data Reduction, and Corrective Action

Upon receipt of each laboratory data package, data shall be evaluated against the criteria outlined in the previous sections. Any deviation from the established criteria shall be noted and the data will be qualified. A full review and discussion of analytical data QA/QC and all data qualifiers shall be submitted as appendices or attachments to investigation and monitoring reports prepared in accordance with Section XI of this Order. Data validation procedures for all samples shall include checking the following, when appropriate:

1. Holding times;

2. Detection limits;

3. Field equipment rinsate blanks;

4. Field blanks;

5. Field Duplicates;

6. Trip blanks;

7. Reagent blanks;

8. Laboratory duplicates;

9. Laboratory blanks;

10. Laboratory matrix spikes;

11. Laboratory matrix spike duplicates;

12. Laboratory blank spikes;

13. Laboratory blank spike duplicates;

14. Surrogate recoveries; and

15. Radiogenic source standard calibration data.

If significant quality assurance problems are encountered, appropriate corrective action shall be implemented. All corrective action shall be defensible and the corrected data shall be qualified.

X. MONITORING WELL CONSTRUCTION REQUIREMENTS

X.A TYPES OF MONITORING WELLS

Three types of groundwater monitoring wells are required at the Facility: alluvial, intermediate, and regional wells. Alluvial wells are shallow wells which monitor groundwater in the alluvium located in the canyon bottoms. Intermediate wells monitor perched groundwater beneath the Facility and generally extend from depths of approximately 100 to 700 ft below ground surface. Regional wells monitor the deep regional aquifer beneath the Facility and generally are deeper than 700 ft below ground surface.

The well construction, installation, and completion procedures for these wells differ because each well monitors a different stratigraphic horizon and at different depths. General drilling procedures are presented in Section X.B and monitoring well construction requirements are presented in Section X.C of this Order.

X.B DRILLING METHODS

Groundwater monitoring wells and piezometers must be designed and constructed in a manner which will yield high quality samples, ensure that the well will last the duration of the project, and ensure that the well will not serve as a conduit for contaminants to migrate between different stratigraphic units or aquifers. The design and construction of groundwater monitoring wells shall comply with the guidelines established in various EPA RCRA guidance, including, but not limited to:

- U.S. EPA, *RCRA Groundwater Monitoring: Draft Technical Guidance*, EPA/530-R-93-001, November, 1992;

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

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

A variety of methods are available for drilling monitoring wells. While the selection of the drilling procedure is usually based on the site-specific geologic conditions, the following issues shall also be considered:

- Drilling shall be performed in a manner that preserves the natural properties of the subsurface materials.

- Contamination and cross-contamination of groundwater and aquifer materials during drilling shall be avoided.

- The drilling method shall allow for the collection of representative samples of rock, unconsolidated materials, and soil.

- The drilling method shall allow the Respondents to determine when the appropriate location for the screened interval(s) has been encountered.

- The drilling method shall allow for the proper placement of the filter pack and annular sealants. The borehole diameter shall be at least four inches larger in diameter than the nominal diameter of the well casing and screen to allow adequate space for placement of the filter pack and annular sealants.

- The drilling method shall allow for the collection of representative groundwater samples. Drilling fluids (including air) shall be used only when minimal impact to the surrounding formation and groundwater can be ensured.

A brief description of the different drilling methods that may be appropriate for the construction of monitoring wells at the Facility follows. Many of these methods may be used alone, or in combination, to install monitoring wells at the Facility. While the selection of the specific drilling procedure will usually depend on the site-specific geologic conditions, justification for the method selected must be provided to the Department.

X.B.1 Hollow-Stem Auger

The hollow-stem continuous flight auger consists of a hollow, steel shaft with a continuous, spiraled steel flight welded onto the exterior site of the stem. The stem is connected to an auger bit and, when rotated, transports cuttings to the surface. The hollow stem of the auger allows drill rods, split-spoon core barrels, Shelby tubes, and other samplers to be inserted through the center of the auger so that samples may be retrieved during the drilling operations. The hollow stem also acts to temporarily case the borehole, so that the well screen and casing (riser) may be inserted down through the center of the augers once the desired depth is reached, minimizing the risk of possible collapse of the borehole. A bottom plug or pilot bit can be fastened onto the bottom of the augers to keep out most of the soils and/or water that have a tendency to clog the bottom of the augers during drilling. Drilling without a center plug is acceptable provided that the soil plug, formed in the bottom of the auger, is removed before sampling or installing well casings. The soil plug can be removed by washing out the plug using a side discharge rotary bit, or augering out the plug with a solid-stem auger bit sized to fit inside the hollow-stem auger. In situations where heaving sands are a problem, potable water may be poured into the augers to equalize the pressure so that the inflow of formation materials and water shall be held to a minimum when the bottom plug is removed. The hollow-stem auger method is best suited for drilling shallow overburden wells.

X.B.2 Air Rotary/Air Down-The-Hole Hammer/ODEX

The air rotary method consists of a drill pipe or drill stem coupled to a drill bit that rotates and cuts through soils and rock. The cuttings produced from the rotation of the drilling bit are transported to the surface by compressed air, which is forced down the borehole through the drill pipe and returns to the surface through the annular space (between the drill pipe and the borehole wall). The circulation of the compressed air not only removes the cuttings from the borehole but also helps to

cool the drill bit. The use of air rotary drilling is best suited for hard-rock formations. In soft unconsolidated formations, casing is driven to keep the formation from caving. When using air rotary, the air compressor shall have an in-line organic filter system to filter the air coming from the compressor. The organic filter system shall be inspected regularly to insure that the system is functioning properly. In addition, a cyclone velocity dissipator or similar air containment/dust-suppression system shall be used to funnel the cuttings to one location instead of allowing the cuttings to discharge uncontrolled from the borehole. Air rotary that employs the dual-tube (reverse circulation) drilling system is acceptable because the cuttings are contained within the drill stem and are discharged through a cyclone velocity dissipator to the ground surface.

The injection of air into the borehole during air rotary drilling has the potential to alter the natural properties of the subsurface. This can occur through air-stripping of the VOCs in both soil and groundwater in the vicinity of the borehole, altering the groundwater geochemical parameters (e.g., pH and redox potential), and potentially increasing biodegradation of organic compounds in the aquifer near the borehole. These factors may prevent the well from yielding groundwater samples that are representative of in-situ conditions.

In hard, abrasive, consolidated rock, a down-the-hole hammer may be more appropriate than the air rotary method. In this method, compressed air is used to actuate and operate a pneumatic hammer as well as lift the cuttings to the surface and cool the hammer bit. One drawback of the down-the-hole hammer is that oil is required in the air stream to lubricate the hammer-actuating device, and this oil could potentially contaminate the soil in the vicinity of the borehole and the aquifer.

The ODEX method is a variation of the air rotary method in which a casing-driving technique is used in combination with air rotary drilling. With the ODEX system, the drill bit extends outward and reams a pilot hole large enough for a casing assembly to slide down behind the drill bit assembly. As a result, casing is advanced simultaneously while drilling the hole.

X.B.3 Water Rotary and Mud Rotary

The water and mud rotary drilling methods consist of rotary drilling techniques where water or drilling mud is used as the circulating fluid. In both methods, the circulating fluid is pumped down through the drill pipe and is returned back up the borehole through the annular space. The circulating fluid stabilizes the borehole, cools the drill bit, and carries the drill cuttings up to the surface. While the water and mud rotary drilling techniques are rapid and effective drilling methods, the recognition of water-bearing zones is hampered by the addition of water into the system.

Mud rotary drilling is similar to water rotary drilling with the exception that mud additives are added to the water to change the properties (e.g., density, viscosity, yield point, gel strength, fluid-loss-control effectiveness, and lubricity) of the circulating fluid. Drilling muds provide greater borehole stabilization than water alone. There are several types of mud presently available, including bentonite, barium sulfate, organic polymers, cellulose polymers, and polyacrylamides. While drilling muds enhance the stability of the borehole and allow for drilling in formations not appropriate to other methods, they can adversely affect the hydrologic properties and geochemistry of the aquifer. For example, drilling fluid invasion and the buildup of borehole filter cake may reduce the effective porosity of the aquifer in the vicinity of the borehole. In addition, bentonite drilling muds may affect the pH of groundwater and organic polymer drilling muds have been

observed to facilitate bacterial growth, which reduces the reliability of sampling results. If polymer emulsions are to be used in the drilling program at the Facility, polymer dispersion agents shall be used at the completion of the drilling program to remove the polymers from the boreholes. For example, if EZ Mud® is used as a drilling additive, a dispersant (e.g., BARAFOS® or five percent sodium hypochlorite) shall be used to disperse and chemically breakdown the polymer prior to developing and sampling the well.

X.B.4 Dual-Wall Reverse Circulation

The dual-wall reverse circulation drilling method utilizes a double-wall drill pipe and has the reverse circulation of other conventional rotary drilling methods. The circulating fluid (water or air) is pumped down the borehole between the outer and inner drill pipe, and returns up the inner drill pipe. Cuttings are lifted to the surface through the inner drill pipe. The inner drill pipe rotates the bit, and the outer drill pipe acts as a casing and stabilizes the borehole. Typically, a tri-cone bit is used when drilling through unconsolidated formations and a down-the-hole hammer is used in hard rock.

The dual-wall reverse circulation rotary method is one of the better methods available for obtaining representative and continuous formation samples while drilling. If a roller cone bit is used, the formation that is being drilled is located only a few inches ahead of the double-wall pipe. As a result, the cuttings observed at the surface represent no more than one foot of the formation at any point in time.

When drilling with air, an in-line filter shall be used to remove oil or other impurities from the airstream. However, if a down-the-hole hammer is used, it must be used with caution since it requires oil in the airstream to lubricate the hammer. This could possibly introduce contaminants to the borehole and aquifer.

X.B.5 Resonant Sonic

Resonant sonic drilling is a method that uses a sonic drill head to produce high-frequency, high-force vibrations in a steel drill pipe. The vibrations in the pipe create a cutting action at the bit face, which allows a continuous core of the formation to move into a core barrel. The method requires no drilling fluid, drills very fast (up to one ft/sec in certain formations), drills at any angle through all formations (rock, clay, sand, boulders, permafrost, glacial till), and yields virtually no cuttings in the drilling process. While there are numerous advantages to this process, the primary disadvantage is the cost of the method. This drilling method has been tested by the DOE and used at various DOE facilities.

X.B.6 Cryogenic

Cryogenic drilling is a technique that uses standard air rotary drilling methods, but employs cold nitrogen gas as the circulating fluid instead of compressed air. The use of nitrogen gas as the circulation fluid freezes the borehole wall while drilling, which stabilizes unconsolidated sediments and prevents potential cross-contamination of different water-bearing zones. In addition, the method produces fewer cuttings than liquid based drilling methods, requires minimal equipment modifications to existing drill rigs, and does not add contaminants to the borehole during the drilling process due to the benign nature of nitrogen gas. The method is especially applicable for drilling

through alternating hard (competent) and soft (unconsolidated) formations. This drilling method has been tested by the DOE and proposed for future use at various DOE facilities.

X.C WELL CONSTRUCTION/COMPLETION METHODS

X.C.1 Well Construction Materials

Well construction materials shall be selected based on the goals and objectives of the proposed monitoring program and the geologic conditions at the site. When selecting well construction materials, the primary concern shall be selecting materials that will not contribute foreign constituents or remove contaminants from the groundwater. Other factors to be considered include the tensile strength, compressive strength, and collapse strength of the materials; length of time the monitoring well will be in service; and the material's resistance to chemical and microbiological corrosion. Generally, if the monitoring program requires the analysis of organic constituents, stainless steel or fluoropolymer materials should be used. However, if the monitoring program requires only inorganic constituent analyses, polyvinyl chloride (PVC) materials may be used. PVC should not be used for monitoring wells where organic constituents will be analyzed due to its potential for sorption and leaching of contaminants.

Well screen and casing materials acceptable for the construction of RCRA monitoring wells include stainless steel (304 or 316), rigid PVC (meeting American National Standards Institute/National Sanitation Foundation Standard 14), and fluoropolymer materials (polytetrafluoroethylene, fluorinated ethylene propylene, and polyvinylidene). In addition, there are other materials available for the construction of monitoring wells including acrylonitrile butadiene styrene (ABS), fiberglass-reinforced plastic (FRP), black iron, carbon steel, and galvanized steel, but these materials are not recommended for use in long term monitoring wells due to their low resistance to chemical attack and potential contribution of contamination to the groundwater. However, these materials may be used in the construction of monitoring wells where they will not be in contact with the groundwater that will be sampled (e.g., carbon steel pipe used as surface casing).

X.C.2 Well Construction Techniques

X.C.2.a Single-Cased Wells

The borehole shall be bored, drilled, or augered as close to vertical as possible, and checked with a plumb bob or level. Slanted boreholes shall not be acceptable unless specified in the design. The borehole shall be of sufficient diameter so that well construction can proceed without major difficulties. To assure an adequate size, a minimum two-inch annular space is required between the casing and the borehole wall (or the hollow-stem auger wall). The two-inch annular space around the casing will allow the filter pack, bentonite seal, and annular grout to be placed at an acceptable thickness. Also, the two-inch annular space will allow up to a 1.5-inch outer diameter tremie pipe to be used for placing the filter pack, bentonite seal, and grout at the specified intervals.

It may be necessary to overdrill the borehole so that any soils that have not been removed (or that have fallen into the borehole during augering or drill stem retrieval) will fall to the bottom of the borehole below the depth where the filter pack and well screen are to be placed. Normally, three to five ft is sufficient for overdrilling shallow wells. Deep wells may require deeper overdrilling. The

borehole can also be overdrilled to allow for an extra space for a well sump to be installed. If the borehole is overdrilled deeper than desired, it can be backfilled to the designated depth with bentonite pellets or the filter pack.

The well casings (riser assembly) should be secured to the well screen by flush-jointed threads and placed into the borehole and plumbed by the use of centralizers, a plumb bob, or a level. No lubricating oils or grease shall be used on casing threads. Teflon tape can be used to wrap the threads to insure a tight fit and minimize leakage. No glue of any type shall be used to secure casing joints. Teflon "O" rings can also be used to ensure a tight fit and minimize leakage. "O" rings made of materials other than Teflon are not acceptable if the well will be sampled for organic compound analyses. Before the well screen and casings are placed at the bottom of the borehole, at least six inches of filter material shall be placed at the bottom to serve as a firm footing. The string of well screen and casing should then be placed into the borehole and plumbed. If centralizers are used, they shall be placed below the well screens and above the bentonite annular seals so that the placement of the filter pack, overlying bentonite seal, and annular grout will not be hindered. Centralizers placed in the wrong locations can cause bridging during material placement. If installing the well screen and casings through hollow-stem augers, the augers shall be slowly extracted as the filter pack, bentonite seal, and grout are tremied or poured into place. The gradual extraction of the augers will allow the materials being placed in the augers to flow out of the bottom of the augers into the borehole. If the augers are not gradually extracted, the materials will accumulate at the bottom of the augers causing potential bridging problems. After the string of well screen and casing is plumb, the filter material shall be placed around the well screen (preferably by the tremie pipe method) up to the designated depth. After the filter pack has been installed, the bentonite seal shall be placed directly on top of the filter pack up to the designated depth or a minimum of two ft above the filter pack, whichever is greater. After the bentonite seal has hydrated for the specified time, the annular grout shall be pumped by the tremie method into the annular space around the casings (riser assembly) up to within two ft of the ground surface or below the frost line, whichever is greater. The grout shall be allowed to cure for a minimum of 24 hours before the surface pad and protective casing are installed. After the surface pad and protective casing are installed, bumper guards (guideposts) shall be installed (if necessary).

X.C.2.b Double-Cased Wells

Double-cased wells should be constructed when there is reason to believe that interconnection of two aquifers by well construction may cause cross contamination, or when flowing sands make it impossible to install a monitoring well using conventional methods. A pilot borehole should be advanced through the overburden and the contaminated zone into a clay, confining layer, or bedrock. An outer casing (surface or pilot casing) shall be placed into the borehole and sealed with grout. The borehole and outer casing should extend into tight clay a minimum of two ft and into competent bedrock a minimum of one foot. The total depth into the clay or bedrock will vary depending upon the plasticity of the clay and the extent of weathering and fracturing of the bedrock. The size of the outer casing shall be of sufficient inside diameter to contain the inner casing and the two-inch annular space. In addition, the borehole shall be of sufficient size to contain the outer casing and the two-inch minimum outer annular space, if applicable.

The outer casing shall be grouted by the tremie method from the bottom of the borehole to within two ft of the ground surface. The grout shall be pumped into the annular space between the outer casing and the borehole wall. This can be accomplished by either placing the tremie pipe in the annular space and pumping the grout from the bottom of the borehole to the surface, or placing a grout shoe or plug inside the casing at the bottom of the borehole and pumping the grout through the bottom grout plug and up the annular space on the outside of the casing. The grout shall consist of a Type I Portland cement and bentonite to provide a rigid seal. A minimum of 24 hours shall be allowed for the grout plug (seal) to cure before attempting to drill through it. When drilling through the seal, care shall be taken to avoid cracking, shattering, and washing out of the seal. If caving conditions exist so that the outer casing cannot be sufficiently sealed by grouting, the outer casing shall be driven into place and a grout seal placed in the bottom of the casing.

X.C.2.c Bedrock Wells

The installation of monitoring wells into bedrock can be accomplished in two ways. The first method is to drill or bore a pilot borehole through the soil overburden into the bedrock. An outer casing is installed into the borehole by setting it into the bedrock, and grouting it into place. After the grout has set, the borehole can be advanced through the grout seal into the bedrock. The preferred method of advancing the borehole into the bedrock is rock coring. Rock coring makes a smooth, round hole through the seal and into the bedrock without cracking or shattering the seal. Roller cone bits are used in soft bedrock, but extreme caution should be taken when using a roller cone bit to advance through the grout seal in the bottom of the borehole because excessive water and bit pressure can cause cracking, eroding (washing), and/or shattering of the seal. Low volume air hammers may be used to advance the borehole, but they have a tendency to shatter the seal because of the hammering action. If the structural integrity of the grout seal is in question, a pressure test can be utilized to check for leaks. If the seal leaks, the seal is not acceptable. When the drilling is complete, the finished well will consist of an open borehole from the ground surface to the bottom of the well. The major limitation of open borehole bedrock wells is that the entire bedrock interval serves as the monitoring zone.

The second method is to install the outer surface casing and drill the borehole into bedrock, and then install an inner casing and well screen with the filter pack, bentonite seal, and annular grout. The well is completed with a surface protective casing and concrete pad. This well installation method gives the flexibility of isolating the monitoring zone(s) and minimizing inter-aquifer flow. In addition, it gives structural integrity to the well, especially in unstable areas (e.g., steeply dipping shales) where the bedrock has a tendency to shift or move when disturbed.

X.C.3 Well Screen and Filter Pack Design

Well screens and filter packs shall be designed to accurately sample the aquifer zone that the well is intended to sample, minimize the passage of formation materials (turbidity) into the well, and ensure sufficient structural integrity to prevent the collapse of the intake structure. The selection of the well screen length depends upon the objective of the well. Piezometers and wells where only a discrete flow path is monitored are generally completed with short screens (two ft or less). While monitoring wells are usually constructed with longer screens (usually five to ten ft), they shall be kept to the minimum length appropriate for intercepting a contaminant plume. The screen slot size shall be selected to retain from 90 to 100 percent of the filter pack material in artificially filter packed wells,

and from 50 to 100 percent of the formation material in naturally packed wells. All well screens shall be factory machine slotted.

A filter pack shall be used when: 1) the natural formation is poorly sorted; 2) a long screen interval is required or the screen spans highly stratified geologic materials of widely varying grain sizes; 3) the natural formation is uniform fine sand, silt, or clay, 4) the natural formation is thin-bedded; 5) the natural formation is poorly cemented sandstone; 6) the natural formation is highly fractured or characterized by relatively large solution channels; 7) the natural formation is shale or coal that will act as a constant source of turbidity to groundwater samples; or 8) the diameter of the borehole is significantly greater than the diameter of the screen. The use of natural formation material as a filter pack is only recommended when the natural formation materials are relatively coarse-grained, permeable, and uniform in grain size.

Filter pack materials shall consist of clean, rounded to well-rounded, hard, insoluble particles of siliceous composition (industrial grade quartz sand or glass beads). The required grain-size distribution or particle sizes of the filter pack materials shall be selected based upon a sieve analysis of the aquifer materials or the formation to be monitored. To select the appropriate filter pack particle size, the results of a sieve analysis of the formation materials are plotted on a grain-size distribution graph, and a grain-size distribution curve is generated. The 70 percent retained grain size value should be multiplied by a factor between four and six (four for fine, uniform formations and six for coarse, non-uniform formations). A second grain-size distribution curve is then drawn on the graph for this new value, ensuring that the uniformity coefficient does not exceed 2.5. The filter pack that shall be used will fall within the area defined by these two curves. Once the filter pack size is determined, the screen slot size shall be selected to retain at least 90 percent of the filter pack material.

The filter pack shall be installed in a manner that prevents bridging and particle-size segregation. Filter packs placed below the water table shall be installed by the tremie pipe method. Filter pack materials shall not be poured into the annular space unless the well is shallow (e.g., less than 30 ft deep) and the filter pack material can be poured continuously into the well without stopping. At least two inches of filter pack material shall be installed between the well screen and the borehole wall, and two ft of material shall extend above the top of the well screen. A minimum of six-inches of filter pack material shall also be placed under the bottom of the well screen to provide a firm footing and an unrestricted flow under the screened area. In deep wells (e.g., greater than 200 ft deep), the filter pack may not compress when initially installed. As a result, filter packs may need to be installed as high as five ft above the screened interval in these situations. The precise volume of filter pack material required shall be calculated and recorded before placement, and the actual volume used shall be determined and recorded during well construction. Any significant discrepancy between the calculated and actual volume shall be explained. Prior to installing the filter pack annular seal, a one to two-ft layer of chemically inert fine sand shall be placed over the filter pack to prevent the intrusion of annular sealants into the filter pack.

Several pre-fabricated groundwater sampling systems that can be installed in open boreholes are available on the market. These include multi-level borehole completion systems (e.g., Westbay MP System®) and pneumatically deployed inverting PVC membranes (e.g., SEAMIST). If these types

of borehole completions are to be used in the Facility wells, they shall be installed under the supervision of personnel from the authorized vendor.

X.C.4 Annular Sealant

The annular space between the well casing and the borehole must be properly sealed to prevent cross-contamination of samples and the groundwater. The materials used for annular sealants shall be chemically inert with respect to the highest anticipated concentration of chemical constituents expected in the groundwater at the Facility. In general, the permeability of the sealing material shall be one to two orders of magnitude lower than the least permeable parts of the formation in contact with the well. The precise volume of annular sealants required shall be calculated and recorded before placement, and the actual volume shall be determined and recorded during well construction. Any significant discrepancy between the calculated volume and the actual volume shall be explained.

During well construction, an annular seal shall be placed on top of the filter pack. This seal shall consist of a high solids (10-30 percent) bentonite material in the form of bentonite pellets, granular bentonite, or bentonite chips. The bentonite seal shall be placed in the annulus through a tremie pipe if the well is deep (greater than 30 ft), or by pouring directly down the annulus in shallow wells (less than 30 ft). If the bentonite materials are poured directly down the annulus, a tamping device shall be used to ensure that the seal is emplaced at the proper depth and the bentonite has not bridged higher in the well casing. The bentonite seal shall be placed above the filter pack a minimum of two ft vertical thickness. The bentonite seal shall be allowed to completely hydrate in conformance with the manufacturer's specifications prior to installing the overlying annular grout seal. The time required for the bentonite seal to completely hydrate will differ with the materials used and the specific conditions encountered, but is generally a minimum of four to 24 hours.

A grout seal shall be installed on top of the filter pack annular seal. The grout seal may consist of a high solids (30 percent) bentonite grout, a neat cement grout, or a cement/bentonite grout. The grout shall be pressure grouted into the annular space by the tremie pipe method, from the top of the filter pack annular seal to within a few ft of the ground surface. The tremie pipe shall be equipped with a side discharge port to minimize damage to the filter pack or filter pack annular bentonite seal during grout placement. The grout seal shall be allowed to cure for a minimum of 24 hours before the concrete surface pad is installed. All grouts shall be prepared in accordance with the manufacturer's specifications. High solids (30 percent) bentonite grouts shall have a minimum density of ten pounds per gallon (as measured by a mud balance) to ensure proper setup. Cement grouts shall be mixed using six and one-half to seven gallons of water per 94-pound bag of Type I Portand cement. Bentonite (five to ten percent) may be added to delay the setting time and reduce the shrinkage of the grout.

X.C.5 Well Development

All monitoring wells shall be developed to create an effective filter pack around the well screen, correct damage to the formation caused by drilling, remove fine particles from the formation near the borehole, and assist in restoring the natural water quality of the aquifer in the vicinity of the well. Development stresses the formation around the screen, as well as the filter pack, so that mobile fines, silts, and clays are pulled into the well and removed. Development is also used to remove any

foreign materials (e.g., water, drilling mud) that may have been introduced into the borehole during the drilling and well installation activities, and to aid in the equilibration that will occur between the filter pack, well casing, and the formation water. The development of a well is extremely important to ensuring the collection of representative groundwater samples.

Newly installed monitoring wells shall not be developed for at least 48 hours after the surface pad and outer protective casing are installed. This will allow sufficient time for the well materials to cure before the development procedures are initiated. A new monitoring well shall be developed until the column of water in the well is free of visible sediment, and the pH, temperature, turbidity, and specific conductivity have stabilized. In most cases, the above requirements can be satisfied. However, in some cases, the pH, temperature, and specific conductivity may stabilize but the water remains turbid. In this case, the well may still contain well construction materials, such as drilling mud in the form of a mud cake or formation soils that have not been washed out of the borehole. Thick drilling mud cannot be flushed out of a borehole with one or two well volumes of flushing. Instead, continuous flushing over a period of several days may be necessary to complete the well development. If the well is pumped dry, the water level shall be allowed to sufficiently recover before the next development period is initiated. The common methods used for developing wells include:

- Pumping and overpumping;
- Backwashing;
- Surging (with a surge block);
- Bailing;
- Jetting; and
- Airlift pumping.

These development procedures can be used, either individually or in combination, to achieve the most effective well development. However, the most favorable well development methods include pumping, overpumping, bailing, surging, or a combination of these methods. Well development methods and equipment that alter the chemical composition of the groundwater shall not be used. Development methods that involve adding water or other fluids to the well or borehole, or that use air to accomplish well development should be avoided, if possible. Approval shall be obtained from the Department prior to introducing air, water, or other fluids into the well for the purpose of well development. If water is introduced to a borehole during well drilling and completion, then the same or greater volume of water shall be removed from the well during development. In addition, the volume of water withdrawn from a well during development shall be recorded.

X.C.6 Surface Completion

Monitoring wells may be completed either as flush-mounted wells, or as above-ground completions. A surface seal shall be installed over the grout seal and extended vertically up the well annulus to the land surface. The lower end of the surface seal shall extend a minimum of one ft below the frost line

to prevent damage from frost heaving. The composition of the surface seal shall be neat cement or concrete. In above-ground completions, a three-ft wide, four-inch thick concrete surface pad shall be installed around the well at the same time the protective casing is installed. The surface pad shall be sloped so that drainage will flow away from the protective casing and off the pad. In addition, a minimum of one inch of the finished pad shall be below grade or ground elevation to prevent washing and undermining by soil erosion.

- A locking protective casing shall be installed around the well casing (riser) to prevent damage or unauthorized entry. The protective casing shall be anchored in the concrete surface pad below the frost line and extend several inches above the well riser stickup. A ¼-inch weep hole shall be drilled into the protective casing just above the top of the concrete surface pad to prevent water from accumulating and freezing inside the protective casing around the well riser. A cap shall be placed on the well riser to prevent tampering or the entry of foreign materials, and a lock shall be installed on the protective casing to provide security. If the wells are located in an area that receives traffic, a minimum of three bumper guards consisting of steel pipes three to four inches in diameter and a minimum of five-ft length should be installed. The bumper guards should be installed to a minimum depth of two ft below the ground surface in a concrete footing and extend a minimum of three ft above ground surface. The pipes should be filled with concrete to provide additional strength. The pipes should be painted a bright color to reduce the possibility of vehicular damage.

- If flush-mounted completions are required (e.g., in active roadway areas), a protective structure such as a utility vault or meter box should be installed around the well casing. In addition, measures should be taken to prevent the accumulation of surface water in the protective structure and around the well intake. These measures should include outfitting the protective structure with a steel lid or manhole cover that has a rubber seal or gasket, and ensuring that the bond between the cement surface seal and the protective structure is watertight.

X.D WELL ABANDONMENT

Wells are usually abandoned when they are no longer required in the monitoring network or when they are damaged beyond repair. The goal of well abandonment is to seal the borehole in such a manner that the well cannot act as a conduit for migration of contaminants from the ground surface to the aquifer or between aquifers. To properly abandon a well, the preferred method is to completely remove the well casing and screen from the borehole, clean out the borehole, and backfill with a cement or bentonite grout, neat cement, or concrete. The well abandonment procedure must also comply with current EPA well abandonment guidance.

For wells with small diameter casing, abandonment shall be accomplished by overdrilling the well with a large diameter hollow-stem auger. After the well has been overdrilled, the well casing and grout can be lifted out of the ground with a drill rig, and the remaining filter pack can be drilled out. The open borehole can then be pressure grouted (via the tremie pipe method) from the bottom of the borehole to the ground surface. After the grout has cured, the top two ft of the borehole shall be filled with concrete to insure a secure surface seal.

Several other well abandonment procedures are available for wells with larger diameter screens and casings. One method is to force a drill stem with a tapered wedge assembly or a solid-stem auger into the well casing and pull the casing out of the ground. However, if the casing breaks or the well cannot be pulled from the ground, the well will have to be grouted in place. To abandon a well in place, a tremie pipe shall be placed at the lowest point in the well (at the bottom of the screen or in the well sump). The entire well is then pressure grouted from the bottom of the well upward. The pressurized grout will be forced out through the well screen into the filter pack and up the inside of the well casing sealing off all breaks and holes in the casing. Once the well is grouted, the casing is cut off even with the ground surface and covered with concrete.

If a PVC well cannot be abandoned due to internal casing damage (e.g., the tremie pipe cannot be extended to the bottom of the screen), it may be necessary to drill out the casing with a roller cone or drag bit using the wet rotary drilling method, or grind out the casing using a solid-stem auger equipped with a carbide tooth bit. Once the casing is removed, the open borehole can be cleaned out and pressure grouted from the bottom of the borehole upward.

X.E DOCUMENTATION

All information on the design, construction, and development of each monitoring well shall be recorded and presented on a boring log, a well construction log, and well construction diagram. The well construction log and well construction diagram shall include the following information:

- Well name/number;
- Date/time of well construction;
- Borehole diameter and well casing diameter;
- Well depth;
- Casing length;
- Casing materials;
- Casing and screen joint type;
- Screened interval(s);
- Screen materials;
- Screen slot size and design;
- Filter pack material and size;
- Filter pack volume (calculated and actual);
- Filter pack placement method;

- Filter pack interval(s);
- Annular sealant composition;
- Annular sealant placement method;
- Annular sealant volume (calculated and actual);
- Annular sealant interval(s);
- Surface sealant composition;
- Surface seal placement method;
- Surface sealant volume (calculated and actual);
- Surface sealant interval;
- Surface seal and well apron design and construction;
- Well development procedure and turbidity measurements;
- Well development purge volume(s) and stabilization parameter measurements;
- Type and design and construction of protective casing;
- Well cap and lock;
- Ground surface elevation;
- Survey reference point elevation on well casing;
- Top of monitoring well casing elevation; and
- Top of protective steel casing elevation.

XI. REPORTING REQUIREMENTS

XI.A GENERAL

The purpose of this section (XI) is to provide the reporting requirements and report formats for corrective action activities at all SWMUs, AOCs, canyons, and watershed aggregates required under this Order. This section (XI) is not intended to provide reporting requirements for every potential corrective action conducted at the Facility; therefore, the formats for all types of reports are not presented below. The described formats include the general reporting requirements and formats for site-specific investigation work plans, investigation reports, periodic monitoring reports, risk analysis reports, and corrective measures evaluations. The Respondents shall generally consider the reports to be the equivalents of RFI work plans, RFI reports, periodic monitoring reports, risk assessments, CMS plans, and CMS reports, for the purposes of RCRA compliance and the Department's fee assessments. The Respondents shall include detailed, site-specific requirements in all SWMU, AOC, canyon, and watershed aggregate investigation work plans, investigation reports, monitoring reports, and corrective measures evaluations. All plans and reports shall be prepared with technical and regulatory input from the Department. All work plans and reports shall be submitted to the Department in the form of one electronic copy and two paper copies.

The reporting requirements listed in this section (XI) do not include all sections that may be necessary to complete each type of report listed. The Respondents or the Department may determine that additional sections may be needed to address additional site-specific issues or information collected during corrective action or monitoring activities not listed below. However, the Respondents must submit variations of the general report format and the formats for reports not listed in this section (XI) in outline form to the Department for approval prior to submittal of the reports. The Department will approve or disapprove, in writing, the proposed report outline within sixty (60) days of receipt of the outline. If the Department disapproves the report outline, the Department will notify the Respondents, in writing, of the outline's deficiencies and will specify a date for submittal of a revised report outline. All reports submitted by the Respondents shall follow the general approach and limitations for data presentation described in this section (XI).

XI.B INVESTIGATION WORK PLAN

The Respondents shall fulfill the requirements acceptable to the Department for preparation of work plans for site investigations or corrective action activities at the Facility using the general outline below. The minimum requirements for describing proposed activities within each section are included. All research, locations, depths and methods of exploration, field procedures, analytical analyses, data collection methods, and schedules shall be included in each work plan. In general, interpretation of data acquired during previous investigations shall be presented only in the background sections of the work plans. The other text sections of the work plans shall be reserved for presentation of anticipated site-specific activities and procedures relevant to the project. The general work plan outline is described below.

XI.B.1 Title Page

The title page shall include the type of document; Facility name; TA designation; SWMU or AOC name, site, and any other unit name; and the submittal date. A signature block providing spaces for the name, title, and organization of the preparer and the responsible DOE and University of California representative shall be provided on the title page in accordance with 20.4.1.900 NMAC incorporating 40 C.F.R. 270.11(d)(1).

XI.B.2 Executive Summary (Abstract)

The executive summary or abstract shall provide a brief summary of the purpose and scope of the investigation to be conducted at the subject site. The Facility, SWMU or AOC name, site name, any other unit name, location, and TA designation shall be included in the executive summary.

XI.B.3 Table of Contents

The table of contents shall list all text sections, tables, figures, and appendices or attachments included in the work plan. The corresponding page numbers for the titles of each section of the work plan shall be included in the table of contents.

XI.B.4 Introduction

The introduction shall include the Facility name, TA designation, unit location, and unit status (e.g., active operations, closed, corrective action). General information on the current site usage and status shall be included in this section. A brief description of the purpose of the investigation and the type of site investigation to be conducted shall be provided in this section.

XI.B.5 Background

The background section shall describe relevant background information. This section shall briefly summarize historical site uses by the U.S. Government and any other entity since 1940, including the locations of current and former site structures and features. A labeled figure shall be included in the document showing the locations of current and former site structures and features. The locations of pertinent subsurface features such as pipelines, underground tanks, utility lines, and other subsurface structures shall be included in the background summary and labeled on the figure.

This section shall identify potential receptors, including groundwater, and include a brief summary of the type and characteristics of all waste and all contaminants, the known and possible sources of contamination, the history of releases or discharges of contamination, and the known extent of contamination. This section shall include brief summaries of results of previous investigations including references to pertinent figures, data summary tables, and text in previous reports. At a minimum, detections of contaminants encountered during previous investigations shall be presented in table format, with an accompanying figure showing sample locations. References to previous reports shall include page, table, and figure numbers for referenced information. Summary data tables and site plans showing relevant investigation locations shall be included in the tables and figures sections of the document, respectively.

XI.B.6 Site Conditions

XI.B.6.a Surface Conditions

A section on surface conditions shall provide a detailed description of current site topography, features and structures including a description of topographic drainages, man-made drainages, vegetation, erosional features, and basins. It shall also include a detailed description of current site usage and any current operations at the site. In addition, descriptions of features located in surrounding sites that may have an impact on the subject site regarding sediment transport, surface water runoff, or contaminant fate and transport shall be included in this section.

XI.B.6.b Subsurface Conditions

A section on subsurface conditions shall provide a brief, detailed description of the site conditions observed during previous subsurface investigations, including relevant soil horizons, stratigraphy, presence of groundwater, and other relevant information. A site plan showing the locations of all borings and excavations advanced during previous investigations shall be included in the figures section of the work plan. A brief description of the anticipated stratigraphic units that may be encountered during the investigation may be included in this subsection if no previous investigations have been conducted at the site.

XI.B.7 Scope of Activities

A section on the scope of activities shall briefly describe a list of all anticipated activities to be performed during the investigation including background information research, health and safety requirements that may affect or limit the completion of tasks, drilling, test pit or other excavations, well construction, field data collection, survey data collection, chemical analytical testing, aquifer testing, remediation system pilot testing, and IDW storage and disposal.

XI.B.8 Investigation Methods

A section on investigation methods shall provide a description of all anticipated locations and methods for conducting the activities to be performed during the investigation. This section shall include research methods, health and safety practices that may affect the completion of tasks, drilling methods, test pit or other excavation methods, sampling intervals and methods, well construction methods, field data collection methods, geophysical and land survey methods, field screening methods, chemical analytical testing, materials testing, aquifer testing, pilot testing, and other proposed investigation and testing methods. This information may also be summarized in table format, if appropriate.

XI.B.9 Monitoring And Sampling Program

A section on monitoring and sampling shall describe the anticipated monitoring and sampling program to be implemented after the initial investigation activities are completed. This section shall provide a description of the anticipated groundwater, ambient air, subsurface vapor, remediation system, engineering controls, and other monitoring and sampling programs to be implemented at the site.

XI.B.10 Schedule

A section shall set forth the anticipated schedule for completion of field investigation, pilot testing, and monitoring and sampling activities. In addition, this section shall set forth a schedule for submittal of reports and data to the Department including a schedule for submitting all status reports and preliminary data.

XI.B.11 Tables

The following summary tables may be included in the investigation work plans, if previous investigations have been conducted at the site. Data presented in the tables shall include information on dates of data collection, analytical methods, detection limits, and significant data quality exceptions. All data tables shall include only detected analytes and data quality exceptions that could potentially mask detections.

1. Summaries of regulatory criteria, background, and applicable cleanup levels (may be included in the analytical data tables instead of as separate tables).

2. Summaries of historical field survey location data.

3. Summaries of historical field screening and field parameter measurements of soil, rock, sediments, groundwater, surface water, and air quality data.

4. Summaries of historical soil, rock, or sediment laboratory analytical data shall include the analytical methods, detection limits, and significant data quality exceptions that could influence interpretation of the data.

5. Summaries of historical groundwater elevation and depth to groundwater data. The table shall include the monitoring well depths, the screened intervals in each well, and the dates and times measurements were taken.

6. Summaries of historical groundwater laboratory analytical data. The analytical data tables shall include the analytical methods, detection limits, and significant data quality exceptions that could influence interpretation of the data.

7. Summary of historical surface water laboratory analytical data. The analytical data tables shall include the analytical methods, detection limits, and significant data quality exceptions that could influence interpretation of the data.

8. Summary of historical air sample screening and chemical analytical data. The data tables shall include the screening instruments used, laboratory analytical methods, detection limits, and significant data quality exceptions that could influence interpretation of the data.

9. Summary of historical pilot testing data, if applicable, including units of measurement and types of instruments used to obtain measurements.

XI.B.12 Figures

The following figures shall be included with each investigation work plan for each site, including presentation of data where previous investigations have been conducted. All figures must include an accurate bar scale and a north arrow. An explanation shall be included on each figure for all abbreviations, symbols, acronyms, and qualifiers. All maps shall contain a date of preparation.

1. A vicinity map showing topography and the general location of the site relative to surrounding features and properties.

2. A site plan that presents pertinent site features and structures, underground utilities, well locations, and remediation system locations and details. Off-site well locations and other relevant features shall be included on the site plan, if appropriate. Additional site plans may be required to present the locations of relevant off-site well locations, structures, and features.

3. Figures showing historical and proposed soil boring or excavation locations and sampling locations.

4. Figures presenting historical soil sample field screening and laboratory analytical data.

5. Figures presenting the locations of all existing and proposed borings and vapor monitoring well locations.

6. Figures showing all existing and proposed wells and piezometers, presenting historical groundwater elevation data, and indicating groundwater flow directions.

7. Figures presenting historical groundwater laboratory analytical data, if applicable. The chemical analytical data corresponding to each sampling location can be presented in tabular form on the figure or as an isoconcentration map.

8. Figures presenting historical and proposed surface water sample locations and field measurement data, if applicable.

9. Figures presenting historical surface water laboratory analytical data, if applicable.

10. Figures showing historical and proposed air sampling locations and presenting historical air quality data.

11. Figures presenting historical pilot testing locations and data, where applicable, including site plans and graphic data presentation.

12. Figures presenting geologic cross-sections, based on outcrop and borehole data acquired during previous investigations.

XI.B.13 Appendices

An IDW management plan shall be included as an appendix to the investigation work plan. The results of historical investigations required in this Order shall be included as an appendix to the investigation work plan. Additional appendices may be necessary to present additional data or documentation not listed above.

XI.C INVESTIGATION REPORT

The Respondents shall fulfill the requirements acceptable to the Department for preparation of investigation reports at the Facility using the general outline below. This section (XI.C) describes the minimum requirements for reporting within each site. All data collected during each site investigation event in the reporting period shall be included in the reports. In general, interpretation of data shall be presented only in the background, conclusions and recommendations sections of the reports. The other text sections of the reports shall be reserved for presentation of facts and data without interpretation or qualifications. The general report outline is provided below.

XI.C.1 Title Page

The title page shall include the type of document; Facility name; TA designation; SWMU or AOC name, site, and any other unit name; and the submittal date. A signature block providing spaces for the name, title, and organization of the preparer and the responsible DOE and University of California representative shall be provided on the title page in accordance with 20.4.1.900 NMAC incorporating 40 C.F.R. 270.11(d)(1).

XI.C.2 Executive Summary (Abstract)

The executive summary or abstract shall provide a brief summary of the purpose, scope, and results of the investigation; site names; location; and TA designation. In addition, this section shall include a brief summary of conclusions based on the investigation data collected and recommendations for future investigation, monitoring, remedial action or site closure.

XI.C.3 Table of Contents

The table of contents shall list all text sections, subsections, tables, figures, and appendices or attachments included in the report. The corresponding page numbers for the titles of each section of the report shall be included in the table of contents.

XI.C.4 Introduction

The introduction section shall include the Facility name, TA designation, unit location, and unit status (e.g., active operations, closed, corrective action). General information on the site usage and status shall be included in this section. A brief description of the purpose of the investigation, the type of site investigation conducted, and the type of results presented in the report also shall be provided in this section.

XI.C.5 Background

The background section shall describe relevant background information. This section shall briefly summarize historical site uses by the U.S. Government since the 1940s, including the locations of current and former site structures and features. A labeled figure shall be included in the document showing the locations of current and former site structures and features. The locations of subsurface features such as pipelines, underground tanks, utility lines, and other subsurface structures shall be included in the background summary and labeled on the figure. In addition, this section shall include a brief summary of the possible sources of contamination, the history of releases or discharges of contamination, the known extent of contamination, and the results of previous investigations including references to previous reports. The references to previous reports shall include page, table, and figure numbers for referenced information. A site plan, showing relevant investigation locations, and summary data tables shall be included in the figures and tables sections of the document, respectively.

XI.C.6 Scope of Activities

A section on the scope of activities shall briefly describe all activities performed during the investigation event including background information research, implemented health and safety measures that affected or limited the completion of tasks, drilling, test pit or other excavation methods, well construction methods, field data collection, survey data collection, chemical analytical testing, aquifer testing, remediation system pilot testing, and IDW storage or disposal.

XI.C.7 Field Investigation Results

A section shall provide a summary of the procedures used and the results of all field investigation activities conducted at the site including the dates that investigation activities were conducted, the type and purpose of field investigation activities performed, field screening measurements, logging and sampling results, pilot test results, construction details, and conditions observed. Field observations or conditions that altered the planned work or may have influenced the results of sampling, testing, and logging shall be reported in this section. Tables summarizing all pertinent sampling, testing, and screening results shall be prepared in a format approved by the Department. The tables shall be presented in the tables section of the report. At a minimum, the following sections shall be included.

XI.C.7.a Surface Conditions

A section on surface conditions shall describe current site topography, features, and structures including topographic drainages, man-made drainages, vegetation, and erosional features. It shall also include a description of current site uses and any operations at the site. In addition, descriptions of features located in surrounding sites that may have an impact on the subject site regarding sediment transport, surface water runoff, or contaminant transport shall be included in this subsection.

XI.C.7.b Exploratory Drilling or Excavation Investigations

A section shall describe the locations, methods, and depths of subsurface explorations. The description shall include the types of equipment used, the logging procedures, the soil or rock classification system used to describe the observed materials, exploration equipment decontamination procedures, and conditions encountered that may have affected or limited the investigation.

A description of the site conditions observed during subsurface investigation activities shall be included in this section, including soil horizon and stratigraphic information. Site plans showing the locations of all borings and excavations shall be included in the figures section of the report. Boring and test pit logs for all exploratory borings and test pits shall be presented in an appendix or attachment to the report.

XI.C.7.c Exploratory and Monitoring Well Boring Geophysical Logging

A section shall describe the methods, dates of measurement, depth intervals measured, and the results of geophysical logging. The relative merits and limitations of each geophysical logging method employed shall be discussed, along with any field conditions or instrument malfunctions that occurred that may have affected the results of the geophysical logging.

XI.C.7.d Subsurface Conditions

A section on subsurface conditions shall describe known subsurface lithology and structures, based on observations made during the current and previous subsurface investigations, including interpretation of geophysical logs and as-built drawings of man-made structures. A description of the known locations of pipelines and utility lines and observed geologic structures shall also be included in this section. A site plan showing boring and excavation locations and the locations of the site's above- and below-ground structures shall be included in the figures section of the report. In addition, cross-sections shall be constructed, if appropriate, to provide additional visual presentation of site or regional subsurface conditions.

XI.C.7.e Monitoring Well Construction, Boring, or Excavation Abandonment

A section shall describe the methods and details of monitoring well construction and the methods used to abandon or backfill exploratory borings and excavations. The description shall include the dates of well construction, boring abandonment, or excavation backfilling. In addition, well construction diagrams shall be included in an appendix or attachment with the associated boring logs for monitoring well borings.

XI.C.7.f Groundwater Conditions

A section shall describe groundwater conditions observed beneath the subject site and relate local groundwater conditions to regional groundwater conditions. A description of the depths to water, aquifer thickness, and groundwater flow directions shall be included in this section for alluvial groundwater, shallow perched groundwater, intermediate perched groundwater, and regional groundwater, as appropriate to the investigation. Figures showing well locations, surrounding area,

and groundwater elevations and flow directions for each hydrologic zone shall be included in the figures section of the report.

XI.C.7.g Surface Water Conditions

A section shall describe surface water conditions and include a description of surface water runoff, drainage, surface water sediment transport, and contaminant transport in surface water as suspended load and as a dissolved phase in surface water via natural and man-made drainages, if applicable. A description of contaminant fate and transport shall be included, if appropriate.

XI.C.7.h Surface Air and Subsurface Vapor Conditions

A section shall describe surface air and subsurface vapor monitoring and sampling methods used during the site investigation. It shall also describe observations made during the site investigation regarding subsurface flow pathways and the subsurface air-flow regime.

XI.C.7.i Materials Testing Results

A section shall discuss the materials testing results, such as core permeability testing, grain size analysis, or other materials testing results. Sample collection methods, locations, and depths shall also be included. Corresponding summary tables shall be included in the tables section of the report.

XI.C.7.j Pilot Testing Results

A section shall discuss the results of any pilot testing. Pilot testing is typically conducted after initial subsurface investigations are completed and the need for additional investigation or remediation has been evaluated. Pilot testing, including aquifer testing and remediation system pilot testing, shall be addressed through separate work plans and pilot test reports. The format for pilot test work plans and reports shall be approved by the Department prior to submittal.

XI.C.8 Regulatory Criteria

A section shall set forth the applicable cleanup standards, risk-based screening levels, and risk-based cleanup goals for each pertinent medium at the subject site. The appropriate cleanup levels for each site shall be included if site-specific levels have been established at separate Facility sites or units. A table summarizing the applicable cleanup standards or inclusion of applicable cleanup standards in the data tables shall be included as part of the document. Risk-based evaluation procedures, if used to calculate cleanup levels, shall be presented in a separate document or in an appendix to this report. If cleanup levels calculated in a risk evaluation are employed, the risk evaluation document shall be referenced and shall include pertinent page numbers for referenced information.

XI.C.9 Site Contamination

A section shall provide a description of sampling intervals and methods for detection of surface and subsurface contamination in soils, rock, sediments, groundwater, and surface water, and as vapor-phase contamination. Only factual information shall be included in this section. Interpretation of the data shall be reserved for the summary and conclusions sections of the report.

XI.C.9.a Soil, Rock, and Sediment Sampling

A section shall describe the sampling of soil, rock, and sediment. It shall include the dates, locations and methods of sample collection; sampling intervals; sample logging methods; screening sample selection methods; and laboratory sample selection methods including the collection depths for samples submitted for laboratory analyses. A site plan showing the sample locations shall be included in the figures section of the report.

XI.C.9.b Soil, Rock, and Sediment Sample Field Screening Results

A section shall describe the field screening methods used during the investigation and the field screening results. Field screening results also shall be presented in summary tables in the tables section of the document. The limitations of field screening instrumentation and any conditions that influenced the results of field screening shall be discussed in this subsection.

XI.C.9.c Soil, Rock, and Sediment Sampling Analytical Results

A section shall summarize the results of laboratory analysis for soil, rock, and sediment samples. It shall also describe the analytical methods used and provide a comparison of the analytical results to background levels, cleanup standards, or established cleanup levels for the site. The laboratory results also shall be presented in summary tables in the tables section of the document. Field conditions and sample collection methods that could potentially affect the analytical results shall be described in this section. If appropriate, soil analytical data shall be presented with sample locations on a site plan and included in the figures section of the report.

XI.C.9.d Groundwater Sampling

A section on groundwater sampling shall describe the dates, locations, depths, and methods of sample collection; methods for sample logging; and methods for screening and laboratory sample selection. A map showing all site and surrounding area well locations shall be included in the figures section of the report.

XI.C.9.e Groundwater General Chemistry

A section on the general groundwater chemistry shall describe the results of measurement of field purging parameters and field analytical measurements. Field parameter measurements and field analytical results also shall be presented in summary tables in the tables section of the document. The limitations of field measurement instrumentation and any conditions that may have influenced the results of field screening shall be discussed in this section. As determined by the Respondents and the Department, relevant water chemistry concentrations shall be presented as data tables or as isoconcentration contours on a map included in the figures section of the report.

XI.C.9.f Groundwater Chemical Analytical Results

A section shall summarize the results of groundwater chemical analyses. It shall describe the groundwater chemical analytical methods and analytical results. It shall also provide a comparison of the data to cleanup standards or established cleanup levels for the site. The rationale or purpose

for altering or modifying the groundwater sampling program outlined in the site investigation work plan shall also be provided in this section. Field conditions shall be described in this section that may have affected the analytical results during sample collection. Tables summarizing the groundwater laboratory, field, and QA/QC chemical analytical data; applicable cleanup levels; and modifications to the groundwater sampling program shall be provided in the tables section of the report. Relevant contaminant concentrations shall be presented as data tables or as isoconcentration contours on a map included in the figures section of the report.

XI.C.9.g Surface Water Sampling

A section shall describe the surface water sampling and shall include the dates, times, locations, depths, and methods of sample collection. It shall also describe methods for sample logging, sample-screening methods, and laboratory sample selection methods. A map showing all surface-water sampling locations shall be included in the figures section of the report.

XI.C.9.h Surface Water General Chemistry

A section on the surface water general chemistry shall describe the results of measurement of field parameters and field analytical measurements. Field parameter measurements and field analytical results also shall be presented in summary tables in the tables section of the document. The limitations of field measurement instrumentation and any conditions that influenced the results of field screening shall be discussed in this section. Relevant water chemistry concentrations shall be presented as data tables on a map included in the figures section of the report.

XI.C.9.i Surface Water Chemical Analytical Results

A section shall summarize the results of surface water chemical analyses. It shall describe the analytical methods and analytical results, and provide a comparison of the data to the cleanup standards or established background or cleanup levels for the site. The rationale or purpose for altering or modifying the surface-water sampling program outlined in the site investigation work plan also shall be provided in this section. Field conditions that may have affected the analytical results during sample collection shall be described in this section. Tables summarizing the surface water laboratory, field, and analytical QA/QC data; applicable cleanup levels; and modifications to the surface-water sampling program shall be provided in the tables section of the report. Contaminant concentrations shall be presented as data tables on a map included in the figures section of the report.

XI.C.9.j Air and Subsurface Vapor Sampling

A section shall describe the air and subsurface vapor sampling. It shall describe the dates, locations, depths or elevations above ground surface, methods of sample collection, methods for sample logging, and methods for laboratory sample selection. A map showing all air sampling locations shall be provided in the figures section of the report.

XI.C.9.k Air and Subsurface Vapor Field Screening Results

A section shall describe the air and subsurface vapor field screening results. It shall describe the field screening methods used for ambient air and subsurface vapors during the investigation and the field screening results. Field screening results shall also be presented in summary tables in the tables section of the report. The locations of ambient air and subsurface vapor screening sample collection shall be presented on a site plan included in the figures section of the report. The limitations of field screening instrumentation and any conditions that influenced the results of field screening shall be discussed in this section.

XI.C.9.l Air and Subsurface Vapor Laboratory Analytical Results

A section shall describe the results of air and subsurface vapor laboratory analyses. It shall describe the air sampling laboratory analytical methods and analytical results, and provide a comparison of the data to emissions standards or established cleanup or emissions levels for the site. The rationale or purpose for altering or modifying the air monitoring or sampling program outlined in the site investigation work plan also shall be provided in this section. Field conditions that may have affected the analytical results during sample collection shall be described in this section. Tables summarizing the air sample laboratory, field, and analytical QA/QC data; applicable cleanup levels or emissions standards; and modifications to the air-sampling program shall be provided in the tables section of the report. Contaminant concentrations shall be presented as data tables or as isoconcentration contours on a map included in the figures section of the report.

XI.C.10 Conclusions

A conclusions section shall provide a brief summary of the investigation activities and a discussion of the conclusions of the investigation conducted at the site. In addition, this section shall provide a comparison of the results to applicable cleanup levels, and to relevant historical investigation results and analytical data. Potential receptors, including groundwater, shall be identified and discussed. An explanation shall be provided with regard to data gaps. A risk assessment may be included as an appendix to the investigation report; however, the risk analysis shall be presented in the Risk Assessment format described in Section XI.E of this document. References to the risk analysis shall be presented only in the summary and conclusions sections of the Investigation Report.

XI.C.11 Recommendations

A recommendations section shall discuss the need for further investigation, corrective measures, and risk analyses, based on the conclusions provided in the conclusions section. It shall include explanations regarding additional sampling, monitoring, and site closure. A corresponding schedule for further action regarding the site shall also be provided.

XI.C.12 Tables

A section shall provide the following summary tables. With prior approval from the Department, the Respondents may combine one or more of the tables. Data presented in the tables shall include the current data, dates of data collection, analytical methods, detection limits, and significant data

quality exceptions. All summary data tables shall include only detected analytes and data quality exceptions that could potentially mask detections.

1. Tables summarizing regulatory criteria, background levels, and applicable cleanup levels (this information may be included in the analytical data tables instead of as separate tables).

2. Tables summarizing field survey location data. Separate tables shall be prepared for well locations and individual medium sampling locations except where the locations are the same for more than one medium.

3. Tables summarizing field screening and field parameter measurements of soil, rock, sediments, groundwater, surface water, and air quality data.

4. A table summarizing soil, rock, and/or sediment laboratory analytical data. It shall include the analytical methods, detection limits, and significant data quality exceptions that would influence interpretation of the data.

5. A table summarizing the groundwater elevations and depths to groundwater. The table shall include the monitoring well depths and the screened intervals in each well.

6. A table summarizing the groundwater laboratory analytical data. The analytical data tables shall include the analytical methods, detection limits, and significant data quality exceptions that would influence interpretation of the data.

7. A table summarizing the surface water laboratory analytical data. The analytical data tables shall include the analytical methods, detection limits, and significant data quality exceptions that would influence interpretation of the data.

8. A table summarizing the air sample screening and chemical analytical data. The data tables shall include the screening instruments used, laboratory analytical methods, detection limits, and significant data quality exceptions that would influence interpretation of the data.

9. Tables summarizing the pilot testing data, if applicable, including units of measurement and types of instruments used to obtain measurements.

10. A table summarizing the materials testing data.

XI.C.13 Figures

A section shall provide the following figures. All figures shall include an accurate bar scale and a north arrow. An explanation shall be provided on each figure for all abbreviations, symbols, acronyms, and qualifiers. All maps shall have a date.

1. A vicinity map showing topography and the general location of the subject site relative to surrounding features and properties.

2. A site plan that presents pertinent site features and structures, underground utilities, well locations, and remediation system location(s) and details. Off-site well locations and other

relevant features shall be included on the site plan. Additional site plans may be required to present the locations of relevant off-site well locations, structures and features.

3. Figures showing boring or excavation locations and sampling locations.

4. Figures presenting soil sample field screening and laboratory analytical data.

5. Figures displaying the locations of all newly installed and existing wells and borings.

6. Figures presenting monitoring well and piezometer locations, groundwater elevation data, and groundwater flow directions.

7. Figures presenting groundwater laboratory analytical data, including any past data requested by the Department. The chemical analytical data corresponding to each sampling location may be presented in table form on the figure or as an isoconcentration map.

8. Figures presenting surface water sample locations and field measurement data including any past data requested by the Department.

9. Figures presenting surface water laboratory analytical data including any past data requested by the Department. The laboratory analytical data corresponding to each sampling location may be presented in table form on the figure.

10. Figures showing air sampling locations and presenting air quality data. The field screening or laboratory analytical data corresponding to each sampling location may be presented in table form on the figure or as an isoconcentration map.

11. Figures presenting geologic cross-sections based on outcrop and borehole data.

12. Figures presenting pilot testing locations and data, where applicable, including site plans or graphic data presentation.

XI.C.14 Appendices

Each investigation report shall include the following appendices. Additional appendices may be necessary to present data or documentation not listed below.

XI.C.14.a Field Methods

An appendix shall provide detailed descriptions of the methods used to acquire field measurements of each medium that was surveyed or tested during the investigation. This appendix shall include exploratory drilling or excavation methods, the methods and types of instruments used to obtain field screening, field analytical or field parameter measurements, instrument calibration procedures, sampling methods for each medium investigated, decontamination procedures, sample handling procedures, documentation procedures, and a description of field conditions that affected procedural or sample testing results. Methods of measuring and sampling during pilot testing shall be reported in this appendix, if applicable. Geophysical logging methods shall be discussed in a separate section

of this appendix. IDW storage and disposal methods shall also be discussed in this appendix. Copies of IDW disposal documentation shall be provided in a separate appendix.

XI.C.14.b Boring/Test Pit Logs and Well Construction Diagrams

An appendix shall provide boring logs, test pit logs, or other excavation logs, and well construction details. In addition, a key to symbols and a soil or rock classification system shall be included in this appendix. Geophysical logs shall be provided in a separate section of this appendix.

XI.C.14.c Anaytical Program

An appendix shall discuss the analytical methods, a summary of data quality objectives, and the data quality review procedures. A summary of data quality exceptions and their effect on the acceptability of the field and laboratory analytical data with regard to the investigation and the site status shall be included in this appendix along with references to the case narratives provided in the laboratory reports.

XI.C.14.d Anaytical Reports

An appendix shall provide the contract laboratory final analytical data reports generated for the investigation. The reports shall include all chain-of-custody records and QA/QC results provided by the laboratory. The laboratory reports shall be provided electronically in a format approved by the Department and shall be in the form of a final laboratory report. Paper copies of all chain-of-custody records shall be provided with the reports. Laboratory report data tables may be submitted in Microsoft™ Excel format.

XI.C.14.e Other Appendices

Other appendices containing additional information shall be included as required by the Department or as otherwise appropriate.

XI.D PERIODIC MONITORING REPORT

The Respondents shall use the following guidance for preparing periodic monitoring reports. The reports shall present the reporting of periodic groundwater, surface water, vapor, and remediation system monitoring at the Facility. The following sections provide a general outline for monitoring reports, and also provide the minimum requirements for reporting for specific Facility sites, watersheds, and regional monitoring. All data collected during each monitoring and sampling event in the reporting period shall be included in the reports. In general, interpretation of data shall be presented only in the background, conclusions, and recommendations sections of the reports. The other text sections of the reports shall be reserved for presentation of facts and data without interpretation or qualifications.

XI.D.1 Title Page

The title page shall include the type of document; Facility name; TA designation; SWMU or AOC name, site, watershed, and any other unit name; and the submittal date. A signature block providing spaces for the name, title, and organization of the preparer and the responsible DOE and University

of California representative shall be provided on the title page in accordance with 20.4.1.900 NMAC incorporating 40 C.F.R. 270.11(d)(1).

XI.D.2 Executive Summary (Abstract)

The executive summary or abstract shall provide a brief summary of the purpose, scope, and results of the monitoring conducted at the subject site during the reporting period. The watershed, SWMU, AOC and site name; location; and TA designation shall be included in the executive summary. In addition, this section shall include a brief summary of conclusions based on the monitoring data collected.

XI.D.3 Table of Contents

The table of contents shall list all text sections, subsections, tables, figures, and appendices or attachments included in the report. The corresponding page numbers for the titles of each section of the report shall be included in the table of contents.

XI.D.4 Introduction

The introduction section shall include the Facility name, TA designation, unit location, and unit status (active operations, closed, corrective action, etc.). General information on the site usage and status shall be included in this section. A brief description of the purpose of the monitoring, type of monitoring conducted, and the type of results presented in the report also shall be provided in this section.

XI.D.5 Scope of Activities

A section on the scope of activities shall briefly describe all activities performed during the monitoring event or reporting period including field data collection, analytical testing, remediation system monitoring, if applicable, and purge/decontamination water storage and disposal.

XI.D.6 Regulatory Criteria

A section on regulatory criteria shall provide information regarding applicable cleanup standards, risk-based screening levels, and risk-based cleanup goals for the subject site. A table summarizing the applicable cleanup standards or inclusion of applicable cleanup standards in the data tables can be substituted for this section. The appropriate cleanup levels for each site shall be included, if site-specific levels have been established at separate sites. Risk-based evaluation procedures, if used to calculate cleanup levels, must either be included as an attachment or referenced. The specific document and page numbers must be included for all referenced materials.

XI.D.7 Monitoring Results

A section shall provide a summary of the results of monitoring conducted at the site. This section shall include the dates and times that monitoring was conducted, the measured depths to groundwater, directions of groundwater flow, field air and water quality measurements, radionuclide surveys, static pressures, field measurements, and a comparison to previous monitoring results. Field observations or conditions that may influence the results of monitoring shall be reported in this

section. Tables summarizing vapor-monitoring parameters, groundwater elevations, depths to groundwater measurements, and other field measurements can be substituted for this section. The tables shall include all information required in Section XI.D.11 below.

XI.D.8 Analytical Data Results

A section shall discuss the results of the chemical analyses. It shall provide the dates of vapor or groundwater sampling, the vapor or groundwater analytical methods, and the analytical results. It shall also provide a comparison of the data to previous results and to cleanup standards or established cleanup levels for the site. The rationale or purpose for altering or modifying the sampling program shall be provided in this section. A table summarizing the laboratory analytical data, QA/QC data, applicable cleanup levels, and modifications to the vapor and groundwater sampling program can be substituted for this section. The tables shall include all information required in Section XI.D.11 below.

XI.D.9 Remediation System Monitoring

A section shall discuss the remediation system monitoring. It shall summarize the remediation system's capabilities and performance. It shall also provide monitoring data, treatment system discharge sampling requirements, and system influent and effluent sample analytical results. The dates of operation, system failures, and modifications made to the remediation system during the reporting period shall also be included in this section. A summary table may be substituted for this section. The tables shall include all information required in Section XI.D.11 below.

XI.D.10 Summary

A summary section shall provide a discussion and conclusions of the monitoring conducted at the site. In addition, this section shall provide a comparison of the results to applicable cleanup levels, and to relevant historical monitoring and chemical analytical data. An explanation shall be provided with regard to data gaps. A discussion of remediation system performance, monitoring results, modifications, if applicable, and compliance with discharge requirements shall be provided in this section. Recommendations and explanations regarding future monitoring, remedial actions, or site closure shall also be included in this section.

XI.D.11 Tables

A section shall provide the following summary tables. With prior approval from the Department, the Respondents may combine one or more of the tables. Data presented in the tables shall include the current data plus data from the three previous monitoring events or, if data from less than three monitoring events is available, data acquired during previous investigations and vapor, groundwater, and remediation system monitoring. The dates of data collection shall be included in the tables. Summary tables may be substituted for portions of the text. All data tables shall include only detected analytes and data quality exceptions that could potentially mask detections.

1. A table summarizing the regulatory criteria (a Regulatory Criteria text section may be substituted for this table or the applicable cleanup levels may be included in the analytical data tables).

2. A table summarizing groundwater elevations and depths to groundwater data. The table shall include the monitoring well depths, the screened intervals in each well, and the dates and times of measurements.

3. A table summarizing field measurements of surface water quality data.

4. A table summarizing radionuclide survey data (must include historical radionuclide survey data as described above).

5. A table summarizing field measurements of vapor monitoring data (must include historical vapor monitoring data as described above).

6. A table summarizing field measurements of groundwater quality data (must include historical water quality data as described above).

7. A table summarizing vapor sample analytical data (must include historical vapor sample analytical data as described above).

8. A table summarizing surface water analytical data (must include historical surface water analytical data as described above).

9. A table summarizing groundwater analytical data (must include historical groundwater analytical data as described above).

10. A table summarizing remediation system monitoring data, if applicable (must include historical remediation system monitoring data as described above).

XI.D.12 Figures

The section shall include the following figures. All figures shall include an accurate bar scale and a north arrow. An explanation shall be provided on each figure for all abbreviations, symbols, acronyms, and qualifiers. All figures shall have a date.

1. A vicinity map showing topography and the general location of the subject site relative to surrounding features or properties.

2. A Facility site plan that presents pertinent site features and structures, well and piezometer locations, and remediation system location(s) and features. Off-site well locations and pertinent features shall be included on the site plan, if practical. Additional site plans may be required to present the locations of relevant off-site well locations, structures, and features.

3. Figures presenting the locations of piezometer, monitoring and other well locations, groundwater elevation data, and groundwater flow directions.

4. Figures presenting groundwater analytical data for the current monitoring event. The analytical data corresponding to each sampling location may be presented in table form on the figure or as an isoconcentration map.

5. Figures presenting surface water sampling locations and analytical data for the current monitoring period.

6. Figures presenting vapor sampling locations and analytical data for the current monitoring event. The analytical data corresponding to each sampling location may be presented in table form on the figure or as an isoconcentration map.

7. Figures presenting geologic cross-sections based on outcrop and borehole data, if applicable.

XI.D.13 Appendices

Each monitoring report shall include the following appendices. Additional appendices may be necessary to present data or documentation not listed below.

XI.D.13.a Field Methods

An appendix shall include the methods used to acquire field measurements of groundwater elevations, vapor and water quality data, and vapor and groundwater samples. It shall include the methods and types of instruments used to measure depths to water, air or headspace parameters, and water quality parameters. In addition, decontamination, well purging techniques, well sampling techniques, and sample handling procedures shall be provided in this appendix. Methods of measuring and sampling remediation systems shall be reported in this section, if applicable. Purge and decontamination water storage and disposal methods shall also be presented in this appendix. Copies of purge and decontamination water disposal documentation shall be provided in a separate appendix.

XI.D.13.b Analytical Program

An appendix shall discuss the analytical program. It shall include the analytical methods, a summary of data quality objectives, and data quality review procedures. A summary of data quality exceptions and their effect on the acceptability of the analytical data with regard to the monitoring event and the site status shall be included in this appendix along with references to case narratives provided in the laboratory reports.

XI.D.13.c Analytical Reports

An appendix shall provide the analytical reports and shall include the contract laboratory final chemical analytical data reports generated for the investigation during this reporting period. The reports must include all chain-of-custody records and QA/QC results provided by the laboratory. The laboratory reports shall be provided electronically in a format approved by the Department and shall be in the form of a final laboratory report. Paper copies of all chain-of-custody records shall be provided with the reports. Laboratory report data tables may be submitted in Microsoft™ Excel format.

XI.E RISK ASSESSMENT REPORT

The Respondents shall prepare risk assessment reports for sites requiring corrective action at the Facility using the format listed below. This section (XI.E) provides a general outline for risk

assessments and also lists the minimum requirements for describing risk assessment elements. In general, interpretation of data shall be presented only in the background, conceptual site model, and conclusions and recommendations sections of the reports. The other text sections of the Risk Assessment report shall be reserved for presentation of sampling results from all investigations, conceptual and mathematical elements of the risk assessment, and presentations of toxicity information and screening values used in the risk assessment. Section XI.E.8 and subsequent sections should be presented in separate sections for the human health and ecological risk assessments, but the general risk assessment outline applicable to both sections is provided below.

XI.E.1 Title Page

The title page shall include the type of document; Facility name; TA designation; SWMU or AOC name, site, and any other unit name; and the submittal date. A signature block providing spaces for the name, title, and organization of the preparer and the responsible DOE and University of California representative shall be provided on the title page in accordance with 20.4.1.900 NMAC incorporating 40 C.F.R. 270.11(d)(1).

XI.E.2 Executive Summary (Abstract)

The executive summary or abstract section shall provide a brief summary of the purpose and scope of the risk assessment of the subject site. The Executive Summary shall also briefly summarize the conclusions of the risk assessment. The Facility, SWMU, AOC, and site names; location; and TA designation shall be included in the executive summary.

XI.E.3 Table of Contents

The table of contents shall list all text sections, subsections, tables, figures, and appendices or attachments included in the risk assessment. The corresponding page numbers for the titles of each unit of the report shall be included in the table of contents.

XI.E.4 Introduction

The introduction section shall include the Facility name, TA designation, unit location, and unit status (e.g., active operations, closed, corrective action). General information on the current site usage and status shall be included in this section.

XI.E.5 Background

The background section shall describe relevant background information. This section shall briefly summarize historical site uses by the U.S. Government and any other entity since 1940, including the locations of current and former site structures and features. A labeled figure shall be included in the document showing the locations of current and former site structures and features.

XI.E.5.a Site Description

A section shall describe current site topography, features and structures including topographic drainages, man-made drainages, erosional features, current site uses, and other data relevant to assessing risk at the site. Depth to groundwater and direction of groundwater flow shall be included

in this section. The presence and location of surface water bodies such as springs or wetlands shall be noted in this section. Photographs of the site may be incorporated into this section. Ecological features of the site shall be described here, including type and amount of vegetative cover, observed and expected wildlife receptors, and level of disturbance of the site. The LANL ecological checklist for the site may be included as an appendix or attachment to the document. A topographical map of the site and vicinity of the site showing habitat types, boundaries of each habitat, and any surface water features shall be included in the figures section of the document.

XI.E.5.b Sampling Results

A section shall discuss the results of the sampling at the site. It shall include a description of the history of releases of contaminants, the known and possible sources of contamination, and the vertical and lateral extent of contamination present in each medium. This section shall include summaries of sampling results of all investigations including site plans (included in the figures section of the report) showing locations of detected contaminants. This section shall reference pertinent figures, data summary tables, and references in previous reports. References to previous reports shall include page, table, and figure numbers for referenced information. Summaries of sampling data shall include for each constituent: the maximum value detected, the detection limit, the 95 percent upper confidence level (UCL) of the mean value detected (if applicable to the data set), and whether the 95 percent UCL of the mean was calculated based on a normal or lognormal distribution. Background values used for comparison to inorganic constituents at the site shall be presented here. The table of background values should appear in the tables section of the document and include actual values used as well as the origin of the values (e.g. Facility-wide, site-specific, UCL, upper tolerance level (UTL)). This section shall also include a discussion of how "non-detect" sample results were handled in the averaging of data.

XI.E.6 Conceptual Site Model

A section shall present the conceptual site model. It shall include information on the expected fate and transport of contaminants detected at the site. This section shall provide a list of all sources of contamination at the site. Sources that are no longer considered to be ongoing but represent the point of origination for contaminants transported to other locations shall be included. The discussion of fate and transport shall address potential migration of each contaminant in each medium, potential breakdown products and their migration, and anticipated pathways of exposure for human or ecological receptors. Diagrammatic representations of the conceptual site model shall appear in the figures section of the document.

For human health risk assessments, the conceptual site model shall include residential land use as the future land use for all risk assessments. In addition, site-specific future land use may be included, provided that written approval to consider a site-specific future land use has been obtained from the Department prior to inclusion in the risk assessment. If a site-specific future land use scenario appears in the risk assessment, all values for exposure parameters and the source of those values shall be included in table format and presented in the tables section of the document.

Conceptual site models presented for ecological risk assessments shall identify assessment endpoints and measurement receptors for the site. The discussion of the model shall explain how the

measurement receptors for the site are protective of the wildlife receptors identified by the Respondents in the site description section (see Section XI.E.5.a).

XI.E.7 Risk Screening Levels

A section shall present the actual screening values used for each contaminant for comparison to all human health and ecological risk screening levels. The Department's SSLs for residential soil shall be used to screen soil for human health using EPA's *Risk Assessment Guidance for Superfund (RAGS), Volume I, Part A, 1989*. For those contaminants not appearing on the Department's SSL table, the EPA Region 6 soil screening value adjusted to meet the Department's risk goal of 10^{-5} for total risk for carcinogens shall be used to screen the site for human health risks. Screening for ecological risk shall be conducted using the LANL ESLs if the LANL ESLs have received written approval from the Department. If the LANL ESLs have not been approved by the Department or the LANL ESLs database does not contain a screening value for the receptor or contaminant of concern, the Respondents shall use U.S. EPA's ECO-SSLs, or derive a screening level using the methodology in the Department's "*Guidance for Assessing Ecological Risks Posed by Chemicals: Screening – Level Ecological Risk Assessment"*. If no valid toxicological studies exist for a particular receptor or contaminant, the contaminant/receptor combination shall be addressed using qualitative methods. If an approved site-specific risk scenario is used for the human health risk assessment, this section shall include all toxicity information and exposure assessment equations used for the site-specific scenario as well as the sources for that information. Other regulatory levels applicable to screening the site, such as drinking water MCLs, shall also be included in this section.

XI.E.8 Risk Assessment Results

A section shall present all risk values, hazard quotients (HQ), and HIs for human health under projected future residential scenario and any site-specific scenarios. This section shall also present the HQ and HI for each contaminant for each ecological receptor.

XI.E.8.a Uncertainty Analysis

A section shall include discussion of qualitative, semi-quantitative, and quantitative uncertainty in the risk assessment and estimate the potential impact of the various uncertainties.

XI.E.9 Conclusions and Recommendations

A section shall include the interpretation of the results of the risk assessment and any recommendations for future disposition of the site. This section may include additional information and considerations that the Respondents believe are relevant to the analysis of the site.

XI.E.10 Tables

A section shall provide the following summary tables, as appropriate. With prior approval from the Department, the Respondents may combine one or more of the tables. Data presented in the summary tables shall include information on detection limits and significant data quality exceptions. All data tables shall include only detected analytes and data quality exceptions that could potentially mask detections.

1. A table presenting background values used for comparison to inorganic constituents at the site. Table shall include actual values used as well as the origin of the values (Facility-wide, site-specific, UCL, UTL, or maximum).

2. A table summarizing sampling data shall include, for each constituent, all detected values above background, the maximum value detected, the 95 percent UCL of the mean value detected (if applicable to the data set), and whether that 95 percent UCL of the mean was calculated based on a normal or lognormal distribution.

3. A table of all screening values used and the sources of those values.

4. A table presenting all risk values, HQs, and HIs under projected future residential scenario for human health.

5. A table presenting all risk values, HQs, and HIs under approved additional site-specific future land use scenario for human health.

6. A table presenting the HQ and HI for each contaminant for each ecological receptor.

XI.E.11 Figures

A section shall present the following figures for each site, as appropriate. With prior approval from the Department, the Respondents may combine one or more of the figures. All figures shall include an accurate bar scale and a north arrow. An explanation shall be provided on each figure for all abbreviations, symbols, acronyms, and qualifiers.

1. A vicinity map showing topography and the general location of the subject site relative to surrounding features or properties.

2. For human health risk assessments, a site plan that presents pertinent site features and structures, underground utilities, well locations, and remediation system location(s) and its details. Off-site well locations and other relevant features shall be included on the site plan if practical. Additional site plans may be required to present the locations of relevant off-site well locations, structures, and features.

3. For ecological risk assessments, a topographical map of the site and vicinity of the site showing habitat types, boundaries of each habitat, and any surface water features.

4. Conceptual site model diagrams for both human health and ecological risk assessments.

XI.E.12 Appendices

Each risk assessment report shall include appendices containing supporting data. Appendices may include the results of statistical analyses of data sets and comparisons of data, LANL ecological checklists for the site, full sets of results of all sampling investigations at the site, or other data as appropriate.

XI.F CORRECTIVE MEASURES EVALUATION

The Respondents shall prepare corrective measures evaluations for sites requiring corrective measures using the format listed below. This section (XI.F) provides a general outline for corrective measures evaluations and also lists the minimum requirements for describing corrective measures when preparing these documents. All investigation summaries, site condition descriptions, corrective action goals, corrective action options, remedial options selection criteria, and schedules shall be included in the corrective measures evaluations. In general, interpretation of historical investigation data shall be presented only in the background sections of the corrective measures evaluations. At a minimum, detections of contaminants encountered during previous site investigations shall be presented in the corrective measures evaluations in table format with an accompanying site plan showing sample locations. The other text sections of the corrective measures evaluations shall be reserved for presentation of corrective action-related information regarding anticipated or potential site-specific corrective action options and methods relevant to the project. The general corrective measures evaluation outline is provided below.

XI.F.1 Title Page

The title page shall include the type of document; Facility name; TA designation; SWMU or AOC name, site, and any other unit name; and the submittal date. A signature block providing spaces for the name, title, and organization of the preparer and the responsible DOE and University of California representative shall be provided on the title page in accordance with 20.4.1.900 NMAC incorporating 40 C.F.R. 270.11(d)(1).

XI.F.2 Executive Summary (Abstract)

This executive summary or abstract shall provide a brief summary of the purpose and scope of the corrective measures evaluation to be conducted at the subject site. The executive summary or abstract shall also briefly summarize the conclusions of the evaluation. The SWMU, AOC, and site names; location; and TA designation shall be included in the executive summary.

XI.F.3 Table of Contents

The table of contents shall list all text sections, subsections, tables, figures, and appendices or attachments included in the corrective measures evaluation. The corresponding page numbers for the titles of each section of the report shall be included in the table of contents.

XI.F.4 Introduction

The introduction section shall include the Facility name, TA designation, site location, and site status (active operations, closed, corrective action, etc.). General information on the current site usage and status shall be included in this section. A brief description of the purpose of the corrective measures evaluation and the corrective action objectives for the project also shall be provided in this section.

XI.F.5 Background

The background section shall describe the relevant background information. This section shall briefly summarize historical site uses by the U.S. Government and any other entity since 1940, including the locations of current and former site structures and features. A labeled figure shall be included in the document showing the locations of current and former site structures and features. The locations of subsurface features such as pipelines, underground tanks, utility lines, and other subsurface structures shall be included in the background section and labeled on the site plan.

This section shall include contaminant and waste characteristics, a brief summary of the history of contaminant releases, known and possible sources of contamination, and the vertical and lateral extent of contamination present in each medium. This section shall include brief summaries of results of previous investigations, including references to pertinent figures, data summary tables, and text in previous reports. References to previous reports shall include page, table, and figure numbers for referenced information. Summary tables and site plans showing relevant investigation locations shall be referenced and included in the tables and figures sections of the document, respectively.

XI.F.6 Site Conditions

XI.F.6.a Surface Conditions

A section on surface conditions shall describe current and historic site topography, features, and structures, including a description of topographic drainages, man-made drainages, vegetation, and erosional features. It shall also include a description of current uses of the site and any current operations at the site. This section shall also include a description of those features that could potentially influence corrective action option selection or implementation such as archeological sites, wetlands, or other features that may affect remedial activities. In addition, descriptions of features located in surrounding sites that may have an effect on the subject site regarding sediment transport, surface water runoff or contaminant transport shall be included in this section. A site plan displaying the locations of all pertinent surface features and structures shall be included in the figures section of the corrective measures evaluation.

XI.F.6.b Subsurface Conditions

A section on subsurface conditions shall describe the site conditions observed during previous subsurface investigations. It shall include relevant soil horizon and stratigraphic information, groundwater conditions, fracture data, and subsurface vapor information. A site plan displaying the locations of all borings and excavations advanced during previous investigations shall be included in the figures section of the corrective measures evaluation. A brief description of the stratigraphic units anticipated to be present beneath the site may be included in this section if stratigraphic information is not available from previous investigations conducted at the site.

XI.F.7 Potential Receptors

XI.F.7.a Sources

A section shall provide a list of all sources of contamination at the subject site where corrective measures are to be considered or required. Sources that are no longer considered to be releasing contaminants at the site, but may be the point of origination for contaminants transported to other locations, shall be included in this section.

XI.F.7.b Pathways

A section shall describe potential migration pathways that could result in either acute or chronic exposures to contaminants. It shall include such pathways as utility trenches, paleochannels, surface exposures, surface drainages, stratigraphic units, fractures, structures, and other features. The migration pathways for each contaminant and each medium should be tied to the potential receptors for each pathway. A discussion of contaminant characteristics relating to fate and transport of contaminants through each pathway shall also be included in this section.

XI.F.7.c Receptors

A section shall provide a listing and description of all anticipated potential receptors that could possibly be affected by the contamination present at the site. Potential receptors shall include human and ecological receptors, groundwater, and other features such as pathways that could divert or accelerate the transport of contamination to human receptors, ecological receptors, and groundwater.

XI.F.8 Regulatory Criteria

A section shall set forth the applicable cleanup standards, risk-based screening levels, and risk-based cleanup goals for each medium at the site. The appropriate cleanup levels for each site shall be included, if site-specific levels have been established. A table summarizing the applicable cleanup standards, or inclusion of applicable cleanup standards in the summary data tables providing the results of previous investigations, shall be included in the tables section of the document. If cleanup levels calculated in a risk evaluation are employed, the risk evaluation document shall be referenced including pertinent page numbers for referenced information.

XI.F.9 Identification of Corrective Measures Options

A section shall identify and describe potential corrective measures for source, pathway, and receptor controls. Corrective measures options shall include the range of available options including, but not limited to, a no action alternative, institutional controls, engineering controls, in-situ and on-site remediation alternatives, complete removal, and any combination of alternatives that would potentially achieve cleanup goals.

XI.F.10 Evaluation of Corrective Measures Options

A section shall provide an evaluation of the corrective measures options identified in Section XI.F.9 above. The evaluation shall be based on the applicability, technical feasibility, effectiveness, implementability, impacts to human health and the environment, and cost of each option. A table

summarizing the corrective measures alternatives and the criteria listed below shall be included in the tables section of this document. The general basis for evaluation of corrective measures options is defined below.

XI.F.10.a Applicability

Applicability addresses the overall suitability for the corrective action option for containment or remediation of the contaminants in the subject medium for protection of human health and the environment.

XI.F.10.b Technical Feasibility

Technical feasibility describes the uncertainty in designing, constructing, and operating a specific remedial alternative. The description shall include an evaluation of historical applications of the remedial alternative including performance, reliability, and minimization of hazards.

XI.F.10.c Effectiveness

Effectiveness assesses the ability of the corrective measure to mitigate the measured or potential impact of contamination in a medium under the current and projected site conditions. The assessment also shall include the anticipated duration for the technology to attain regulatory compliance. In general, all corrective measures described above will have the ability to mitigate the impacts of contamination at the site, but not all remedial options will be equally effective at achieving the desired cleanup goals to the degree and within the same time frame as other options.

XI.F.10.d Implementability

Implementability characterizes the degree of difficulty involved during the installation, construction, and operation of the corrective measure. Operation and maintenance of the alternative shall be addressed in this section.

XI.F.10.e Human Health and Ecological Protectiveness

This category evaluates the short-term (remedy installation-related) and long-term (remedy operation-related) hazards to human health and the environment of implementing the corrective measure. The assessment shall include whether the technology will create a hazard or increase existing hazards and the possible methods of hazard reduction.

XI.F.10.f Cost

This section shall discuss the anticipated cost of implementing the corrective measure. The costs shall be divided into: 1) capital costs associated with construction, installation, pilot testing, evaluation, permitting, and reporting of the effectiveness of the alternative; and 2) continuing costs associated with operating, maintaining, monitoring, testing, and reporting on the use and effectiveness of the technology.

XI.F.11 Selection of Preferred Corrective Measure

The Respondents shall propose the preferred corrective measure(s) at the site and provide a justification for the selection in this section. The proposal shall be based upon the ability of the remedial alternative to: 1) achieve cleanup objectives in a timely manner; 2) protect human and ecological receptors; 3) control or eliminate the sources of contamination; 4) control migration of released contaminants; and 5) manage remediation waste in accordance with State and Federal regulations. The justification shall include the supporting rationale for the remedy selection, based on the factors listed in Section XI.F.10 and a discussion of short- and long-term objectives for the site. The benefits and possible hazards of each potential corrective measure alternative shall be included in this section.

XI.F.12 Design Criteria To Meet Cleanup Objectives

The Respondents shall present descriptions of the preliminary design for the selected corrective measures in this section. The description shall include appropriate preliminary plans and specifications to effectively illustrate the technology and the anticipated implementation of the remedial option at the subject area. The preliminary design shall discuss the design life of the alternative and provide engineering calculations for proposed remediation systems.

XI.F.13 Schedule

A section shall set forth a proposed schedule for completion of remedy-related activities such as bench tests, pilot testing, construction, installation, remedial excavation, cap construction, installation of monitoring points, and other remedial actions. The anticipated duration of corrective action operations and the schedule for conducting monitoring and sampling activities shall also be presented. In addition, this section shall provide a schedule for submittal of reports and data to the Department, including a schedule for submitting all status reports and preliminary data.

XI.F.14 Tables

A section shall present the following summary tables, as appropriate. With prior approval from the Department, the Respondents may combine one or more of the tables. Data presented in the summary tables shall include information on dates of sample collection, analytical methods, detection limits, and significant data quality exceptions. All data tables shall include only detected analytes and data quality exceptions that could potentially mask detections.

1. A table summarizing regulatory criteria, background, and/or the applicable cleanup standards.

2. A table summarizing historical field survey location data.

3. Tables summarizing historical field screening and field parameter measurements of soil, rock, sediments, groundwater, surface water, and air quality data.

4. Tables summarizing historical soil, rock, or sediment laboratory analytical data. The summary tables shall include the analytical methods, detection limits, and significant data quality exceptions that would influence interpretation of the data.

5. A table summarizing historical groundwater elevation and depth to groundwater data. The table shall include the monitoring well depths and the screened intervals in each well.

6. Tables summarizing historical groundwater laboratory analytical data. The analytical data tables shall include the analytical methods, detection limits, and significant data quality exceptions that would influence interpretation of the data.

7. Tables summarizing historical surface water laboratory analytical data. The analytical data tables shall include the analytical methods, detection limits, and significant data quality exceptions that would influence interpretation of the data.

8. Tables summarizing historical air sample screening and analytical data. The data tables shall include the screening instruments used, laboratory analytical methods, detection limits, and significant data quality exceptions that would influence interpretation of the data.

9. Tables summarizing historical pilot testing data, if applicable, including units of measurement and types of instruments used to obtain measurements.

10. A table summarizing the corrective measures alternatives and evaluation criteria.

11. A table presenting the schedule for installation, construction, implementation, and reporting of selected corrective measures.

XI.F.15 Figures

A section shall present the following figures for each site, as appropriate. All figures must include an accurate bar scale and a north arrow. An explanation shall be provided on each figure for all abbreviations, symbols, acronyms, and qualifiers. All figures shall have a date.

1. A vicinity map showing topography and the general location of the subject site relative to surrounding features or properties.

2. A unit site plan that presents pertinent site features and structures, underground utilities, well locations, and remediation system locations and details. Off-site well locations and other relevant features shall be included on the site plan if practical. Additional site plans may be required to present the locations of relevant off-site well locations, structures, and features.

3. Figures showing historical soil boring or excavation locations and sampling locations.

4. Figures presenting historical soil sample field screening and laboratory analytical data, if appropriate.

5. Figures showing all existing wells including vapor monitoring wells and piezometers. The figures shall present historical groundwater elevation data and indicate groundwater flow directions.

6. Figures presenting historical groundwater laboratory analytical data including past data, if applicable. The analytical data corresponding to each sampling location may be presented in table form on the figure or as an isoconcentration map.

7. Figures presenting historical surface water sample locations and analytical data including past data, if applicable. The laboratory analytical data corresponding to each sampling location may be presented in table form on the figure.

8. Figures presenting historical air sampling locations and presenting air quality data. The field screening or laboratory analytical data corresponding to each sampling location may be presented in table form on the figure or as an isoconcentration map.

9. Figures presenting historical pilot testing locations and data, where applicable, including site plans or graphic data presentation.

10. Figures presenting geologic cross-sections based on outcrop and borehole data, if applicable.

11. Figures presenting the locations of existing and proposed remediation systems.

12. Figures presenting existing remedial system design and construction details.

13. Figures presenting preliminary design and construction details for preferred corrective measures.

XI.F.16 Appendices

Each corrective measures evaluation shall include, as an appendix, the management plan for waste generated as a result of construction, installation, or operation of remedial systems or activities conducted. Each corrective measures evaluation shall include additional appendices presenting relevant additional data, such as pilot testing or investigation data, remediation system design specifications, system performance data, or cost analyses as necessary.

XII. COMPLIANCE SCHEDULE TABLES

The Respondents shall follow the specified compliance schedules for all of the SWMUs, AOCs, canyons, and watershed aggregates included in this Order. Table XII-1 presents the sampling and monitoring schedule for alluvial, intermediate, and regional groundwater monitoring wells and springs. Tables XII-2 and XII-3 present the compliance schedules of deliverables. The details of the compliance activities and deliverables can be found in Sections IV, V, and VI.

TABLE XII-1

Groundwater Monitoring and Sampling Schedule

Canyon Watershed	Sampling Frequency	Alluvial Wells	Intermediate Wells	Regional Wells	Springs
Los Alamos/ Pueblo	Quarterly	Los Alamos: LAO-B LAO-0.3 LAO-0.6 LAO-0.91 LAO-1.6(g) LAO-1.8 LLAO-1b LLAO-3 LLAO-4 LLAO-5 LAO-1.2 LAO-2 LAO-3A LAO-4.5C LAO-5 LAO-6 LAO-6A LAUZ-1 LAUZ-2 Highway Department wells near Totavi: MW-3 MW-5 MW-6 MW-9 Pueblo: All ER wells (including POI-4) ES wells: APCO-1	Los Alamos: LADP-3 R-9i LAOI(a)-1.1 Pueblo: TW-1a[1] TW-2a[1] POI-4	Los Alamos: R-5 R-7 R-9 TW-3[1] Pueblo: TW-1[1] TW-2[1] TW-4	Skate Rink LA 5.19 DP Basalt Los Alamos Otowi Sacred Springs
Mortandad	Quarterly	MCO-2[1] MCO-3[1] MCO-4B MCO-5 MCO-6 or 6B	MCOBT-4.4 MCOBT-8.5	R-15 R-22 TW-8[1]	

Canyon Watershed	Sampling Frequency	Alluvial Wells	Intermediate Wells	Regional Wells	Springs
		MCO-7 MCO-7.5 MT-4 TSWB-6 CDBO-1 through 9			
Water Canyon/ Cañon de Valle	Quarterly	16-2655 16-2656 16-2657 16-2658 16-2659 WCO-1 WCO-2 WCO-3 Beta Hole	CdV-15-3 CdV-37-2	CdV-37-2 CdV-15-3	Water Canyon Gallery Peter Seep SWSC Line Burning Ground Fish Ladder Hollow Martin Springs
Pajarito	Quarterly	BG-1 BG-4 18-MW-5 18-MW-7 18-MW-8 18-MW-9 18-MW-10 18-MW-11 18-MW-12 18-MW-16 18-MW-17 18-MW-18 PCO-1 PCO-2 PCO-3	R-19	R-19 R-22 (top 2 zones quarterly; others limited suite annually)	PC Spring Homestead Starmers Charlie Kieling Bulldog Threemile A & B TA-18
Sandia	Quarterly	SCO-1 SCO-2	R-12	R-12	
Ancho	Quarterly		R-31	DT-5a DT-9 DT-10 R-31	Ancho Spring (monitored annually)
Chaquehui	Annually				DOE
Frijoles	Annually				10

Canyon Watershed	Sampling Frequency	Alluvial Wells	Intermediate Wells	Regional Wells	Springs
White Rock-Rio Grande Springs	Annually				La Mesita 1 2 Sandia 3 3a 5 5a 6 6a 7 8 9 9a 9b
White Rock-Rio Grande Springs	Quarterly				4 4a 4aa 4b[2] 4c
Surface Water	See Sections IV, VI, IX				

[1] Groundwater shall be monitored until the well is properly plugged and abandoned. TW-8, MCO-2, and MCO-3 replacement wells will be monitored once installed in accordance with the above schedule.

[2] Spring samples shall also be analyzed for stable isotopes and nitrogen isotopes.

TABLE XII-2

Schedule of Deliverables by Technical Area, Watershed Aggregate Area, or Canyon

DATE	DELIVERABLE
Technical Area	
SWMU 3-010(a)	
31-December-02	Geophysical Investigation Report
30-April-03	Groundwater Investigation Work Plan
31-May-04	Investigation Report
SWMUs 10-003(a-o), 10-007 (Bayo Canyon Site)	
30-June-04	Investigation Work Plan
30-September-05	Investigation Report
SWMU 16-003(o)	
31-March -04	Investigation Work Plan
31-August -05	Investigation Report
SWMU 16-008(a)	
31-March-04	Investigation Work Plan
31-November-04	Investigation Report
SWMU 16-018 (MDA P), TA-16-387	
31-January-03	Closure Report
30-November-04	Groundwater and Storm Water Monitoring Plan
SWMUs 16-021(c), 16-003(k)	
31-July-02	Interim Measures Report
31-December-02	Investigation Work Plan for Additional Wells
31-July-03	CMS Report for Surface System/Alluvial Groundwater
31-July-03	Phase III RFI Report
31-October-04	CMI Plan for Surface System/Alluvial Groundwater
30-April-05	Investigation Report for Groundwater
31-March-06	CMS Report for Intermediate and Regional Groundwater
31-March-07	CMI Plan for Intermediate and Regional Groundwater
SWMU 21-011(k)	
30-April-02	Voluntary Corrective Measures Plan
30-June-04	Voluntary Corrective Measures Report
SWMU 21-014 (MDA A)	
31-May-06	Investigation Work Plan
30-August-07	Investigation Report
SWMU 21-015 (MDA B)	
31-December-04	Investigation Work Plan

DATE	DELIVERABLE
31-December-05	Investigation Report
SWMUs 21-001, 21-010(a-h), 21-011(a, c-j), 21-016(a-c), 21-028(a), C-21-009, C-21-012 (MDA T)	
31-May-03	Investigation Work Plan
31-August-04	Investigation Report
SWMUs 21-017(a-c), 21-022(f) (MDA U)	
30-November-04	Investigation Work Plan
28-February-06	Investigation Report
SWMUs 21-013(b, g), 21-018(a, b) (MDA V)	
31-March-06	Investigation Work Plan
31-March-07	Investigation Report
SWMU 21-024(i)	
31-August-02	Voluntary Corrective Measures Plan
31-March-03	Voluntary Corrective Measures Report
TA-35 (Middle Mortandad/Ten Site Aggregate Area)	
31-March-02	SAP
30-September-03	SAP Addendum
28-February-05	Investigation Report
SWMUs 49-001(a-g), 49-003, AOC C-49-008(d) (MDA AB, Areas 1, 3, 4, 11, and 12)	
31-July-06	Investigation Work Plan
30-November-07	Investigation Report
SWMUs 49-005(a), 49-006, AOCs C-49-002, C-49-005(b), C-49-008(a, b) (Areas 5, 6, and 10)	
30-June-08	Investigation Work Plan
31-July-09	Investigation Report
SWMU 50-009 (MDA C)	
31-January-03	Investigation Work Plan
31-May-04	Investigation Report
SWMUs 53-002(a, b)	
31-July-03	Investigation Report
SWMU 54-004 (MDA H)	
30-September-02	Investigation Report Addendum
31-March-03	CMS Report
31-March-04	CMI Plan
SWMU 54-006 (MDA L)	
31-May-03	Investigation Work Plan
31-December-03	Investigation Report

DATE	DELIVERABLE
31-October-04	CMS Work Plan
31-October-05	CMS Report
SWMUs 54-013(b), 54-014(b-d), 54-015(k), 54-017, 54-018, 54-019, 54-020 (MDA G)	
30-April-03	Investigation Work Plan
31-October-03	Investigation Report
30-April-04	CMS Work Plan
31-December-04	CMS Report
TA-57 Aggregate Area (Fenton Hill)	
31-December-10	Investigation Work Plan
SWMUs 73-001(a-d), 73-004(d) (Airport Landfill)	
Drainages:	
31-July-02	Interim Measures Plan
30-June-03	Interim Measures Report
Mesa Top:	
30-September-02	Phase I Investigation Work Plan
30-April-04	Phase II Investigation Work Plan
31-December-06	Investigation Report
SWMU 73-002	
31-August-05	Investigation Work Plan
31-May-06	Investigation Report
Watershed Aggregate Areas	
Los Alamos/Pueblo Watershed	
6 Regional Wells	
Within four months after well construction is completed.	Well Completion Report
DP Site Aggregate Area[1]	
30-April-05	Investigation Work Plan
Pueblo Canyon Aggregate Area[1]	
31-August-04	Investigation Work Plan
Bayo Canyon Aggregate Area[1]	
30-April-06	Investigation Work Plan
Upper Los Alamos Canyon Aggregate Area[1]	
31-October-06	Investigation Work Plan
Lower Los Alamos Canyon Aggregate Area[1]	
31-October-08	Investigation Work Plan
Guaje/Barrancas/Rendija Canyons Aggregate Area[1]	

DATE	DELIVERABLE
31-October-09	Investigation Work Plan
Mortandad Watershed	
3 Regional Wells	
Within four months after well construction is completed.	Well Completion Report
Upper Mortandad Canyon Aggregate Area[1]	
30-November-07	Investigation Work Plan
Upper Cañada del Buey Aggregate Area[1]	
30-June-07	Investigation Work Plan
Middle Cañada del Buey Aggregate Area[1]	
31-October-07	Investigation Work Plan
Lower Mortandad/Cedro Aggregate Area[1]	
31-October-09	Investigation Work Plan
Lower Mortandad/Cañada del Buey Aggregate Area[1]	
30-April-09	Investigation Work Plan
Water Canyon/Cañon de Valle Watershed	
6 Regional Wells	
Within four months after well construction is completed.	Well Completion Report
Cañon de Valle Aggregate Area[1]	
31-January-05	Investigation Work Plan
S-Site Aggregate Area[1]	
30-April-07	Investigation Work Plan
Upper Water Canyon Aggregate Area[1]	
31-August-10	Investigation Work Plan
Lower Water/Indio Canyon Aggregate Area[1]	
30-April-10	Investigation Work Plan
Potrillo/Fence Aggregate Area[1]	
30-April-08	Investigation Work Plan
Sandia Watershed	
2 Regional Wells	
Four months after well construction is completed.	Well Completion Report
Upper Sandia Canyon Aggregate Area[1]	
30-June-07	Investigation Work Plan
Lower Sandia Aggregate Area[1]	
30-April-09	Investigation Work Plan
Pajarito Watershed	
4 Regional Wells	

DATE	DELIVERABLE
Within four months after well construction is completed.	Well Completion Report
Threemile Canyon Aggregate Area[1]	
31-October-07	Investigation Work Plan
Lower Pajarito Canyon Aggregate Area[1]	
31-October-07	Investigation Work Plan
Starmer/Upper Pajarito Canyon Aggregate Area[1]	
31-January-08	Investigation Work Plan
Twomile Canyon Aggregate Area[1]	
31-January-10	Investigation Work Plan
Ancho Watershed	
2 Regional Wells	
Within four months after well construction is completed.	Well Completion Report
North Ancho Canyon Aggregate Area[1]	
31-August-08	Investigation Work Plan
South Ancho Canyon Aggregate Area[1]	
31-January-11	Investigation Work Plan
Chaquehui Watershed	
Chaquehui Canyon Aggregate Area[1]	
30-November-09	Investigation Work Plan
Frijoles Watershed	
Frijoles Canyon Aggregate Area[1]	
31-October-11	Investigation Work Plan
Technical Area 57	
TA-57 Aggregate Area (Fenton Hill)[1]	
31-March-11	Investigation Work Plan
Canyons	
Ancho/Chaquehui/Indio Canyons	
30-September-05	Investigation Work Plan
31-March-07	Investigation Report
Los Alamos/Pueblo Canyons	
31-August-03	Investigation Work Plan Addendum
31-October-04	Investigation Report
Mortandad Canyon	
30-June-03	Groundwater Investigation Work Plan
31-January-05	Investigation Report
North Canyons (Guaje/Barrancas/Rendija)	
31-August-07	Investigation Report
Pajarito Canyon	

DATE	DELIVERABLE
30-June-05	Investigation Report
Potrillo/Fence Canyons	
31-October-05	Investigation Work Plan
31-January-07	Investigation Report
Sandia Canyon/Cañada del Buey	
31-August-05	Investigation Report
Water Canyon/Cañon de Valle	
30-June-03	Investigation Work Plan
28-February-05	Investigation Report
Site-Wide	
31-May-03	Stabilization Plan
31-January-04	Stabilization Report
31-July-04	Stabilization Report
31-January-05	Stabilization Report
31-July-05	Stabilization Report
31-January-06	Stabilization Report
31-July-06	Stabilization Report
31-January-07	Stabilization Report
31-July-07	Stabilization Report
31-January-08	Stabilization Report
31-July-08	Stabilization Report
31-January-09	Stabilization Report
31-July-09	Stabilization Report
31-January-10	Stabilization Report
31-July-10	Stabilization Report
31-January-11	Stabilization Report
31-July-11	Stabilization Report

[1]Investigation Work Plans for the Aggregate Areas shall include a schedule for submitting the Investigation Reports.

TABLE XII-3

Schedule of Deliverables by Calendar Year

SITE	DELIVERABLE	DUE DATE
		CY02
TA-35 (Middle Mortandad/Ten Site Aggregate Area)	SAP	3/31/02
SWMU 21-011(k)	Voluntary Corrective Measures Plan	4/30/02
SWMUs 16-021(c), 16-003(k)	Interim Measures Report	7/31/02
SWMUs 73-001(a-d), 73-004(d) (Airport Landfill – Drainages)	Interim Measures Plan	7/31/02
SWMU 21-024(i)	Voluntary Corrective Measures Plan	8/31/02
SWMU 54-004 (MDA H)	Investigation Report Addendum	9/30/02
SWMUs 73-001(a-d), 73-004(d) (Airport Landfill - Mesa Top)	Phase I Investigation Work Plan	9/30/02
SWMU 3-010(a)	Geophysical Investigation Report	12/31/02
SWMUs 16-021(c), 16-003(k)	Investigation Work Plan for Additional Wells	12/31/02
8 Regional Wells	Well Completion Report	Within 4 months after well construction is completed.
		CY03
SWMU 50-009 (MDA C)	Investigation Work Plan	1/31/03
SWMU 16-018 (MDA P)	Closure Report	1/31/03
SWMU 54-004 (MDA H)	Corrective Measures Study Report	3/31/03
SWMU 21-024(i)	Voluntary Corrective Measures Report	3/31/03
SWMU 3-010(a)	Groundwater Investigation Work Plan	4/30/03
SWMUs 54-013(b), 54-014(b-d), 54-015(k), 54-017, 54-018, 54-019, 54-020 (MDA G)	Investigation Work Plan	4/30/03
SWMU 54-006 (MDA L)	Investigation Work Plan	5/31/03
SWMUs 21-001, 21-010(a-h), 21-011(a, c-j), 21-016(a-c), and 21-028(a), and AOCs C-21-009 and C-21-012 (MDA T)	Investigation Work Plan	5/31/03
Site-Wide	Stabilization Plan	5/31/03
Mortandad Canyon	Groundwater Investigation Work Plan	6/30/03

SITE	DELIVERABLE	DUE DATE
Water Canyon/Cañon de Valle	Investigation Work Plan	6/30/03
SWMUs 73-001(a-d), 73-004(d) (Airport Landfill - Drainage Tract)	Interim Measures Report	6/30/03
SWMUs 53-002(a, b)	Investigation Report	7/31/03
SWMUs 16-021(c), 16-003(k)	Corrective Measures Study Report for Surface Water/Alluvial Groundwater	7/31/03
SWMUs 16-021(c), 16-003(k)	Phase III RCRA Facility Investigation Report	7/31/03
Los Alamos /Pueblo Canyon	Investigation Work Plan Addendum	8/31/03
TA-35 (Middle Mortandad/Ten Site Aggregate Area)	SAP Addendum	9/30/03
SWMUs 54-013(b), 54-014(b-d), 54-015(k), 54-017, 54-018, 54-019, 54-020 (MDA G)	Investigation Report	10/31/03
SWMU 54-006 (MDA L)	Investigation Report	12/31/03
6 Regional Wells	Well Completion Report	Within 4 months after well construction is completed.
		CY04
Site-Wide	Stabilization Report	1/31/04
SWMU 16-008(a)	Investigation Work Plan	3/31/04
SWMU 16-003(o)	Investigation Work Plan	3/31/04
SWMU 54-004 (MDA H)	Corrective Measures Implementation Plan	3/31/04
SWMUs 73-001(a-d), 73-004(d) (Airport Landfill – Mesa Top)	Phase II Investigation Work Plan	4/30/04
SWMUs 54-013(b), 54-014(b-d), 54-015(k), 54-017, 54-018, 54-019, 54-020 (MDA G)	Corrective Measures Study Work Plan	4/30/04
SWMU 3-010(a)	Investigation Report	5/31/04
SWMU 50-009 (MDA C)	Investigation Report	5/31/04
SWMUs 10-002(a, b), 10-003(a-o), 10-004(b), 10-007	Investigation Work Plan	6/30/04
SWMU 21-011(k)	Voluntary Corrective Measures Report	6/30/04
Site-Wide	Stabilization Report	7/31/04
SWMUs 21-001, 21-010(a-h), 21-011(a, c-j), 21-016(a-c), and 21-028(a),	Investigation Report	8/31/04

SITE	DELIVERABLE	DUE DATE
and AOCs C-21-009 and C-21-012 (MDA T)		
Pueblo Canyon Aggregate Area[1]	Investigation Work Plan	8/31/04
Los Alamos/Pueblo Canyon	Investigation Report	10/31/04
SWMUs 16-021(c), 16-003(k)	Corrective Measures Implementation Plan for Surface Water/Alluvial Groundwater	10/31/04
SWMU 54-006 (MDA L)	Corrective Measures Study Work Plan	10/31/04
SWMU 16-018 (MDA P)	Groundwater and Storm Water Monitoring Plan	11/30/04
SWMU 16-008(a)	Investigation Report	11/30/04
SWMUs 21-017(a-c), 21-022(f) (MDA U)	Investigation Work Plan	11/30/04
SWMUs 54-013(b), 54-014(b-d), 54-015(k), 54-017, 54-018, 54-019, 54-020 (MDA G)	Corrective Measures Report	12/31/04
SWMU 21-015(MDA B)	Investigation Work Plan	12/31/04
5 Regional Wells	Well Completion Report	Within 4 months after well construction is completed.
		CY05
Mortandad Canyon	Investigation Report	1/31/05
Cañon de Valle Aggregate Area[1]	Investigation Work Plan	1/31/05
Site-Wide	Stabilization Report	1/31/05
TA-35 (Middle Mortandad/Ten Site Aggregate Area)	Investigation Report	2/28/05
Water Canyon/Cañon de Valle	Investigation Report	2/28/05
DP Site Aggregate Area[1]	Investigation Work Plan	4/30/05
SWMUs 16-021(c), 16-003(k)	Investigation Report for Groundwater	4/30/05
Pajarito Canyon	Investigation Report	6/30/05
Site-Wide	Stabilization Report	7/31/05
SWMU 73-002	Investigation Work Plan	8/31/05
SWMU 16-003(o)	Investigation Report	8/31/05
Sandia Canyon /Cañada del Buey	Investigation Report	8/31/05
SWMUs 10-002(a, b), 10-003(a-o), 10-004(b), 10-007	Investigation Report	9/30/05
Ancho/Chaquehui/Indio Canyons	Investigation Work Plan	9/30/05
SWMU 54-006 (MDA L)	Corrective Measures Report	10/31/05
Potrillo/Fence Canyons	Investigation Work Plan	10/31/05
SWMU 21-015 (MDA B)	Investigation Report	12/31/05

SITE	DELIVERABLE	DUE DATE
4 Regional Wells	Well Completion Report	Within 4 months after well construction is completed.
		CY06
Site-Wide	Stabilization Report	1/31/06
SWMUs 21-017(a-c), 21-022(f) (MDA U)	Investigation Report	2/28/06
SWMUs 21-013(b, g), 21-018(a, b) (MDA V)	Investigation Work Plan	3/31/06
SWMUs 16-021(c), 16-003(k)	Corrective Measures Study Report for Intermediate and Regional Groundwater	3/31/06
Bayo Canyon Aggregate Area[1]	Investigation Work Plan	4/30/06
SWMU 21-014 (MDA A)	Investigation Work Plan	5/31/06
SWMU 73-002	Investigation Report	5/31/06
SWMUs 49-001(a-g), 49-003, C-49-008(d) (MDA AB)	Investigation Work Plan	7/31/06
Site-Wide	Stabilization Report	7/31/06
Upper Los Alamos Canyon Aggregate Area[1]	Investigation Work Plan	10/31/06
SWMUs 73-001(a-d), 73-004(d) (Airport Landfill - Mesa Top)	Investigation Report	12/31/06
		CY07
Potrillo/Fence Canyons	Investigation Report	1/31/07
Site-Wide	Stabilization Report	1/31/07
SWMUs 21-013(b, g), 21-018(a, b) (MDA V)	Investigation Report	3/31/07
SWMUs 16-021(c), 16-003(k)	Corrective Measures Implementation Plan for Intermediate and Regional Groundwater	3/31/07
S-Site Aggregate Area[1]	Investigation Work Plan	4/30/07
Ancho/Chaquehui/Indio Canyons	Investigation Report	5/31/07
Upper Cañada del Buey Aggregate Area[1]	Investigation Work Plan	6/30/07
Upper Sandia Canyon Aggregate Area[1]	Investigation Work Plan	6/30/07
Site-Wide	Stabilization Report	7/31/07
SWMU 21-014 (MDA A)	Investigation Report	8/31/07
North Canyons (Guaje/Bayo/ Barrancas/Rendija)	Investigation Report	8/31/07
Middle Cañada del Buey Aggregate Area[1]	Investigation Work Plan	10/31/07
Lower Pajarito Canyon Aggregate Area[1]	Investigation Work Plan	10/31/07

SITE	DELIVERABLE	DUE DATE
Threemile Canyon Aggregate Area[1]	Investigation Work Plan	10/31/07
Upper Mortandad Canyon Aggregate Area[1]	Investigation Work Plan	11/30/07
SWMUs 49-001(a-g), 49-003, C-49-008(d) (MDA AB)	Investigation Report	11/30/07
		CY08
Starmer/Upper Pajarito Canyon Aggregate Area[1]	Investigation Work Plan	1/31/08
Site-Wide	Stabilization Report	1/31/08
Potrillo/Fence Aggregate Area[1]	Investigation Work Plan	4/30/08
SWMUs 49-005(a), 49-006, C-49-002, C-49-005(b), C-49-008(a, b) (Areas 5, 6, and 10)	Investigation Work Plan	6/30/08
Site-Wide	Stabilization Report	7/31/08
North Ancho Canyon Aggregate Area[1]	Investigation Work Plan	8/31/08
Lower Los Alamos Canyon Aggregate Area[1]	Investigation Work Plan	10/31/08
		CY09
Site-Wide	Stabilization Report	1/31/09
Lower Sandia Canyon Aggregate Area[1]	Investigation Work Plan	4/30/09
Lower Mortandad/Cañada del Buey Aggregate Area[1]	Investigation Work Plan	4/30/09
SWMUs 49-005(a), 49-006, C-49-002, C-49-005(b), C-49-008(a, b)	Investigation Report	7/31/09
Site-Wide	Stabilization Report	7/31/09
Lower Mortandad/Cedro Canyons Aggregate Area[1]	Investigation Work Plan	10/31/09
Guaje/Barrancas/ Rendija Aggregate Area[1]	Investigation Work Plan	10/31/09
Chaquehui Canyon Aggregate Area[1]	Investigation Work Plan	11/30/09
		CY10
Twomile Canyon Aggregate Area[1]	Investigation Work Plan	1/31/10
Site-Wide	Stabilization Report	1/31/10
Lower Water/Indio Canyons Aggregate Area[1]	Investigation Work Plan	4/30/10
Site-Wide	Stabilization Report	7/31/10
Upper Water Canyon Aggregate Area[1]	Investigation Work Plan	8/31/10
		CY11
South Ancho Canyon Aggregate Area[1]	Investigation Work Plan	1/31/11
Site-Wide	Stabilization Report	1/31/11
TA-57 Aggregate Area (Fenton Hill)[1]	Investigation Work Plan	3/31/11
Site-Wide	Stabilization Report	7/31/11

SITE	DELIVERABLE	DUE DATE
Frijoles Canyon Aggregate Area[1]	Investigation Work Plan	10/31/11

[1]Investigation Work Plans for the Aggregate Areas shall include a schedule for submitting the Investigation Reports.

XIII. EFFECTIVE DATE

The effective date of this Order is the date the Order is signed by the Secretary of the Department. The Order shall remain in effect until the Department determines in writing that all the requirements of the Order have been met.

IT IS SO ORDERED.

DATE: 26 November 2002

BY: John R. D'Antonio

JOHN R. D'ANTONIO, JR.

Cabinet Secretary

New Mexico Environment Department