

ATTACHMENT L

WIPP GROUNDWATER DETECTION MONITORING PROGRAM PLAN

Waste Isolation Pilot Plant
Hazardous Waste Permit
October 1, 2012

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LIST OF ABBREVIATIONS/ACRONYMS/UNITS

Bell Canyon bgs	Bell Canyon Formation below ground surface
Castile cm	Castile Formation centimeter(s)
Culebra CofC/RFA	Culebra Member of the Rustler Formation chain of custody/request for analysis
°C	degree(s) Celsius
%C	percent completeness
Dewey Lake DI	Dewey Lake Redbeds Formation deionized
DMP	Detection Monitoring Program
DMW	Detection Monitoring Well
DOE	U.S. Department of Energy
DQO	data quality objectives
EPA	U.S. Environmental Protection Agency
ft	foot (feet)
ft ²	square foot (square feet)
g/cm ³	gram(s) per cubic centimeter
HWDU	hazardous waste disposal unit(s)
km	kilometer(s)
km ²	square kilometer(s)
lb/in. ²	pound(s) per square inch
LCS	laboratory control samples
LCSD	lab control sample duplicate
Los Medaños	Los Medaños Member of the Rustler Formation
LWA	Land Withdrawal Act
m	meter(s)
M&DC	monitoring and data collection
m ²	square meter(s)
Magenta	Magenta Member of the Rustler Formation
mg/L	milligram(s) per liter
mi	mile(s)
mi ²	square mile(s)
molal	moles per kilogram
MOC	Management and Operating Contractor
MPa	megapascal(s)
mV	millivolt(s)
NIST	National Institute for Standards and Technology
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department

QA	Quality Assurance
QA/QC	quality assurance/quality control
QAO	Quality Assurance Objective
QC	quality control
PABC	Performance Assessment Baseline Calculation
RCRA	Resource Conservation and Recovery Act
RPD	relative percent difference
Rustler	Rustler Formation
%R	percent recovery
Salado	Salado Formation
SAP	Sampling and Analysis Plans
SC	specific conductance
SOP	Standard Operating Procedure
TDS	total dissolved solids
TOC	total organic carbon
TRU	transuranic
TSDF	treatment, storage, and disposal facilities
UTLV	upper tolerance limit value
VOC	volatile organic compound
WIPP	Waste Isolation Pilot Plant
WLMP	WIPP Groundwater Level Monitoring Program
µg/L	microgram(s) per liter
µm	micrometers

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ATTACHMENT L

WIPP GROUNDWATER DETECTION MONITORING PROGRAM PLAN

L-1 Introduction

The Waste Isolation Pilot Plant (**WIPP**) facility is subject to regulation under Title 20 of the New Mexico Administrative Code (**NMAC**), Chapter 4, Part 1, Subpart V (20.4.1.500 NMAC). As required by 20.4.500 NMAC (incorporating 40 CFR §264.601), the Permittees shall demonstrate that the environmental performance standards for a miscellaneous unit, which are applied to the hazardous waste disposal units (**HWDUs**) in the underground, will be met.

The WIPP facility is located in Eddy County in southeastern New Mexico (Figure L-1), within the Pecos Valley section of the southern Great Plains physiographic province. The facility is 26 miles (mi) (42 kilometers [km]) east of Carlsbad, New Mexico, in an area known as Los Medaños (the dunes). Los Medaños is a relatively flat, sparsely inhabited plateau with little water and limited land uses.

The WIPP facility (Figure L-2) consists of 16 sections of Federal land in Township 22 South, Range 31 East. The 16 sections of Federal land were withdrawn from the application of public land laws by the WIPP Land Withdrawal Act (**LWA**), Public Law 102-579. The WIPP LWA transferred the responsibility for the administration of the 16 sections from the Department of Interior, Bureau of Land Management, to the U.S. Department of Energy (**DOE**). This law specified that mining and drilling for purposes other than support of the WIPP project are prohibited within this 16 section area with the exception of Section 31. Oil and gas drilling activities are restricted in Section 31 from the surface down to 6,000 feet.

The WIPP facility includes a mined geologic repository for the disposal of transuranic (**TRU**) waste. The disposal horizon is located 2,150 feet (ft) (655 meters [m]) below the land surface in the bedded salt of the Salado Formation (**Salado**). At the WIPP facility, water-bearing units occur both above and below the disposal horizon. Groundwater monitoring of the uppermost aquifer below the facility is not required because the water-bearing unit (the Bell Canyon Formation (**Bell Canyon**)) is not considered a credible pathway for a release from the repository. This is because the repository horizon and water-bearing sandstones of the Bell Canyon are separated by over 2,000 ft (610 m) of very low-permeability evaporite sediments (Amended Renewal Application Addendum L1 (DOE, 2009)). No natural credible pathway has been established for contaminant transport to water-bearing zones below the repository horizon, as there is no hydrologic communication between the repository and underlying water-bearing zones. The U.S. Environmental Protection Agency (**EPA**) concluded in 1990 that natural vertical communication does not exist based on review of numerous studies (EPA, 1990). Furthermore, drilling boreholes for groundwater monitoring through the Salado and the Castile Formation (**Castile**) into the Bell Canyon would compromise the isolation properties of the repository medium.

Groundwater monitoring at the WIPP facility focuses on the Culebra Member (**Culebra**) of the Rustler Formation (**Rustler**) because it represents the most significant hydrologic contaminant migration pathway to the accessible environment. The Culebra is the most significant water-bearing unit lying above the repository. Groundwater movement in the Culebra, using results

1 from the basin-scale groundwater model is discussed in detail in Amended Renewal Application
2 Addendum L1, Section L1-2a, (DOE, 2009).

3 This monitoring plan addresses requirements for sample collection, Culebra groundwater
4 surface elevation monitoring, Culebra groundwater flow direction and rate determination, data
5 management, and reporting of Culebra groundwater monitoring data. It also identifies indicator
6 parameters and hazardous constituents selected to assess Culebra groundwater quality for the
7 WIPP groundwater detection monitoring program (**DMP**). Because quality assurance is an
8 integral component of the groundwater sampling, analysis, and reporting process, quality
9 assurance/quality control (**QA/QC**) elements and associated data acceptance criteria are
10 included in this plan.

11 Instructions for performing field activities that will be conducted in conjunction with this DMP are
12 provided in the WIPP Standard Operating Procedures (**SOPs**) (see Table L-3), which are
13 maintained in facility files and which comply with the applicable requirements of 20.4.1.500
14 NMAC (incorporating 40 CFR § 264.97 (d)). Procedures are required for each aspect of the
15 Culebra groundwater sampling process, including Culebra groundwater surface elevation
16 measurement, Culebra groundwater flow direction and rate determination, sampling equipment
17 installation and operation, field water-quality measurements, and sample collection. Data
18 required by this plan will be collected by qualified personnel in accordance with SOPs (Table L-
19 3).

20 L-1a Geologic and Hydrologic Characteristics

21 L-1a(1) Geology

22 The WIPP facility is situated within the Delaware Basin bounded to the north and east by the
23 Capitan Reef, which is part of the larger Permian Basin, located in the south-central region of
24 North America. Three major evaporite-bearing formations were deposited in the Delaware Basin
25 (see Figures L-3 and L-4 and Amended Renewal Application Addendum L1, Section L1-1 (DOE,
26 2009) for more detail):

- 27 • The Castile consists of interbedded anhydrites and halite. Its upper boundary is at a
28 depth of about 2,825 ft (861 m) below ground surface (**bgs**), and its thickness at the
29 WIPP facility is 1,250 ft (381 m).
- 30 • The repository is located in the Salado, which overlies the Castile and resulted from
31 prolonged desiccation that produced predominantly halite, with some carbonates,
32 anhydrites, and clay seams. Its upper boundary is at a depth of about 850 ft (259 m)
33 bgs, and it is about 2,000 ft (610 m) thick in the repository area.
- 34 • The Rustler Formation was deposited in a lagoonal environment during a major
35 freshening of the basin and consists of carbonates, anhydrites, and halites. Its beds
36 consist of clay and anhydrite and contain small amounts of brine. The Rustler's upper
37 boundary is about 500 ft (152 m) bgs, and it ranges up to 350 ft (107 m) in thickness in
38 the repository area.

39 These evaporite-bearing formations lie between two other formations significant to the geology
40 and hydrology of the WIPP facility. The Dewey Lake Redbeds Formation (**Dewey Lake**)
41 overlying the Rustler is dominated by nonmarine sediments and consists almost entirely of

1 mudstone, claystone, siltstone, and interbedded sandstone (see Amended Renewal Application
2 Addendum L1, Section L1-1c(6) (DOE, 2009)). This formation forms a 500-ft- (152-m) thick
3 barrier of fine-grained sediments that retard the downward percolation of water into the
4 evaporite units below. The Bell Canyon is the first water-bearing unit below the repository (see
5 Amended Renewal Application Addendum L1, Section L1-1c(2) (DOE, 2009)) and is confined
6 above by the thick evaporite deposits of the Castile. It consists of 1,200 ft (366 m) of
7 interbedded sandstone, shale, and siltstone.

8 The Salado was selected to host the WIPP repository for several reasons. First, it is regionally
9 extensive, underlying an area of more than 36,000 square mi (mi²) (93,240 square kilometers
10 [km²]). Second, its permeability is extremely low. Third, salt behaves mechanically in a plastic
11 manner under pressure (the lithostatic pressure at the disposal horizon is approximately 2,200
12 pounds per square inch [lb/in.²] or 14.9 megapascals [MPa]) and eventually deforms to fill any
13 opening (referred to as creep). Fourth, any fluid remaining in small fractures or openings is
14 saturated with salt, is incapable of further salt dissolution, and has probably remained in place
15 since deposition. Finally, the Salado lies between the Rustler and the Castile (Figure L-4), which
16 contain very low permeability layers that help confine and isolate waste within and keep water
17 outside of the WIPP repository (see Amended Renewal Application Addendum L1, Section L1-
18 1c(5) and L1-1c(3) (DOE, 2009)).

19 L-1a(2) Groundwater Hydrology

20 The general hydrogeology of the area surrounding the WIPP facility is described in this section
21 starting with the first geologic unit below the Salado. Addendum L1, Section L1-2a of the
22 Amended Renewal Application (DOE, 2009) provides more detailed discussions of the local and
23 regional hydrogeology. Relevant hydrological parameters for the various rock units above the
24 Salado at WIPP are summarized in Table L-1.

25 L-1a(2)(i) The Castile

26 The Castile is a basin-filling evaporite sequence of sediments surrounded by the Capitan Reef.
27 The Castile represents a major regional groundwater aquitard that effectively prevents upward
28 migration of water from the underlying Bell Canyon. Fluid present in the Castile is very restricted
29 because evaporites do not readily maintain pore space, solution channels, or open fractures at
30 depth. Drill-stem tests conducted in the Castile during construction of the WIPP facility
31 determined its permeability to be lower than detection limits; however, the hydraulic conductivity
32 has been conservatively estimated to be less than 10⁻⁸ ft (3 × 10⁻⁹ m) per day. A description of
33 the Castile brine reservoirs outside the WIPP facility area is provided in Addendum L1, Section
34 L1-2a(2)(b) of the Amended Renewal Application (DOE, 2009).

35 L-1a(2)(ii) The Salado

36 The Salado is an evaporite sequence that filled the remainder of the Delaware Basin and lapped
37 extensively over the Capitan Reef and the back-reef sediments beyond. The Salado consists of
38 approximately 2,000 ft (610 m) of bedded halite, with interbeds or seams of anhydrite, clay, and
39 polyhalite. It acts hydrologically as a regional confining bed. The porosity of the Salado is very
40 low and naturally interconnected pores are probably nonexistent in halite at the depth of the
41 disposal horizon. Fluids associated with the Salado occur mainly as very small fluid inclusions in
42 the halite crystals and also occur between crystal boundaries (interstitial fluid) of the massive
43 crystalline salt formation; fluids also occur in clay seams and anhydrite beds. Permeabilities

1 measured from the surface in the area of the WIPP facility range from 0.01 to 25 microdarcsies.
2 The most reliable value, 0.3 microdarcy, was obtained from well DOE-2. The results of
3 permeability testing at the disposal horizon are within the range of 0.001 to 0.01 microdarcy.

4 L-1a(2)(iii) The Rustler

5 The Rustler has been the subject of extensive characterization activities because it contains the
6 most transmissive hydrologic units overlying the Salado. Within the Rustler, five members have
7 been identified. Of these, the Culebra is the most transmissive and has been the focus of most
8 of the Rustler hydrologic studies.

9 The Culebra is the first continuous water-bearing zone above the Salado and is up to
10 approximately 30 ft (9 m) thick. Water in the Culebra is usually present in fractures and is
11 confined by overlying gypsum or anhydrite and underlying clay and anhydrite beds. The
12 hydraulic gradient within the Culebra in the area of the WIPP facility is approximately 20 ft per
13 mi (3.8 m per km) and becomes much flatter south and southwest of the site (Figure L-5).
14 Culebra transmissivities in the Nash Draw range up to 1,250 square ft (ft²) (116 square m [m²])
15 per day; closer to the WIPP facility, they are as low as 0.007 to 74 ft² (0.00065 to 7.0 m²) per
16 day.

17 The two primary types of field tests that are being used to characterize the flow and transport
18 characteristics of the Culebra are hydraulic tests and tracer tests.

19 The hydraulic tests consist of pump, injection, and slug testing of wells across the study area
20 (see Amended Renewal Application Addendum L1, Section L1-2a(3)(a)(ii) (DOE, 2009)). The
21 most detailed hydraulic test data exist for the WIPP hydropads (e.g., H-19). The hydropads
22 generally comprise a network of three or more wells located within a few tens of meters of each
23 other. Long-term pumping tests have been conducted at hydropads H-3, H-11, and H-19 and at
24 well WIPP-13 (see Amended Renewal Application Addendum L1, Section L1-2a(3)(a)(ii) (DOE,
25 2009)). These pumping tests provided transient pressure data both at the hydropad and over a
26 much larger area. Tests often included use of automated data-acquisition systems, providing
27 high-resolution (in both space and time) data sets. In addition to long-term pumping tests, slug
28 tests and short-term pumping tests have been conducted at individual wells to provide pressure
29 data that can be used to interpret the transmissivity at that well (see Amended Renewal
30 Application Addendum L1, Section L1-2a(3)(a)(ii) (DOE, 2009)). Detailed cross-hole hydraulic
31 testing has been conducted at the H-19 hydropad (see Amended Renewal Application
32 Addendum L1, Section L1-2a(3)(a)(ii) (DOE, 2009)).

33 Pressure data are collected during hydraulic tests for estimation of hydrologic characteristics
34 such as transmissivity, permeability, and storativity. The pressure data from long-term pumping
35 tests and the interpreted transmissivity values for individual wells are used in calibration of flow
36 models. Some of the hydraulic test data and interpretations are also important for the
37 interpretation of transport characteristics. For instance, the permeability values interpreted from
38 the hydraulic tests at a given hydropad are needed for interpretations of tracer test data at that
39 hydropad.

40 There is strong evidence that the permeability of the Culebra varies spatially and varies
41 sufficiently that it cannot be characterized with a uniform value or range over the region of
42 interest to WIPP. The transmissivity of the Culebra varies spatially over ten orders of magnitude
43 from east to west in the vicinity of WIPP. Transmissivities have been calculated at 1×10^{-7}

1 square feet per day (1×10^{-13} square meters per second) at well SNL-15 east of the WIPP site
2 to 1×10^3 square feet per day (1×10^{-3} square meters per second) at well H-7 in Nash Draw
3 (see Amended Renewal Application Addendum L1, Section L1-2a(3)(a)(ii) (DOE, 2009)).

4 Transmissivity variations in the Culebra are believed to be controlled by the relative abundance
5 of open fractures rather than by primary (that is, depositional) features of the unit (Roberts
6 2007). Lateral variations in depositional environments were small within the mapped region, and
7 primary features of the Culebra show little map-scale spatial variability, according to Holt and
8 Powers, 1988. Direct measurements of the density of open fractures are not available from core
9 samples because of incomplete recovery and fracturing during drilling, but observation of the
10 relatively unfractured exposures in the WIPP shafts suggests that the density of open fractures
11 in the Culebra decreases to the east.

12 Geochemical and radioisotope characteristics of the Culebra have been studied. There is
13 considerable variation in groundwater geochemistry in the Culebra. The variation has been
14 described in terms of different hydrogeochemical facies that can be mapped in the Culebra. A
15 halite-rich hydrogeochemical facies exists in the region of the WIPP site and to the east,
16 approximately corresponding to the regions in which halite exists in units above and below the
17 Culebra, and in which a large portion of the Culebra fractures are gypsum filled. An anhydrite-
18 rich hydrogeochemical facies exists west and south of the WIPP site, where there is relatively
19 less halite in adjacent strata and where there are fewer gypsum-filled fractures. Radiogenic
20 isotopic signatures suggest that the age of the groundwater in the Culebra is on the order of
21 10,000 years or more (see Amended Renewal Application Addendum L1 (DOE, 2009)).

22 The radiogenic ages of the Culebra groundwater and the geochemical differences provide
23 information potentially relevant to the groundwater flow directions and groundwater interaction
24 with other units and are important constraints on conceptual models of groundwater flow.

25 The Permittees have proposed a conceptualization of groundwater flow that explains observed
26 geochemical facies and groundwater flow patterns. The conceptualization, referred to as the
27 basin-scale groundwater model, offers a three dimensional approach to treatment of Supra-
28 Salado rock units, and assumes vertical leakage (albeit very slow) between rock units of the
29 Rustler exists (where hydraulic head is present).

30 Flow in the Culebra is considered transient. The model assumes that the groundwater system is
31 dynamic and is responding to the drying of climate that has occurred since the late Pleistocene
32 period. The Permittees assumed that recharge rates during the late Pleistocene period were
33 sufficient to maintain the water table near land surface, but has since dropped significantly.
34 Therefore, the impact of local topography on groundwater flow was greater during wetter
35 periods, with discharge from the Rustler in the vicinity of the WIPP facility to the west toward
36 Nash Draw; flow is currently dominated by more regional topographic effects during drier times,
37 with flow in the Rustler from the vicinity of the WIPP facility towards the Balmorhea-Loving
38 Trough to the south.

39 Using data from 22 wells, Siegel, Robinson, and Myers (1991) originally defined four
40 hydrochemical facies (A, B, C, and D) for Culebra groundwater based primarily on ionic strength
41 and major constituents. With the data now available from 59 wells, Domski and Beauheim
42 (2008) defined transitional A/C and B/C facies, as well as a new facies E for high-moles per
43 kilogram (molal) Na-Mg Cl brines.

- 1 • Zone B - Dilute (ionic strength ≤ 0.1 molal) CaSO_4 -rich groundwater, from southern high-
2 transmissivity area. Mg/Ca molar ratio 0.32 to 0.52.
- 3 • Zone B/C - Ionic strength 0.18 to 0.29 molal, Mg/Ca molar ratio 0.4 to 0.6.
- 4 • Zone C - Variable composition waters, ionic strength 0.3 to 1.0 molal, Mg/Ca molar ratio
5 0.4 to 1.1.
- 6 • Zone A/C - Ionic strength 1.1 to 1.6 molal, Mg/Ca molar ratio 0.5 to 1.2.
- 7 • Zone A - Ionic strength > 1.66 molal, up to 5.3 molal, Mg/Ca molar ratio 1.2 to 2.4.
- 8 • Zone D - Defined based on inferred contamination related to potash refining operations.
9 Ionic strength 3 molal, K/Na weight ratios of ~ 0.2 .
- 10 • Zone E - Wells east of the mudstone-halite margins, ionic strength 6.4 to 8.6 molal,
11 Mg/Ca molar ratio 4.1 to 6.6.

12 The low-ionic-strength (≤ 0.1 molal) facies B waters contain more sulfate than chloride, and are
13 found southwest and south of the WIPP site within and down the Culebra hydraulic gradient
14 from the southernmost closed catchment basins, mapped by Powers (2006), in the southwest
15 arm of Nash Draw. These waters reflect relatively recent recharge through gypsum karst
16 overlying the Culebra. However, with total dissolved solids (**TDS**) concentrations in excess of
17 3,000 mg/L, the facies B waters do not represent modern-day precipitation rapidly reaching the
18 Culebra. They must have residence times in the Rustler sulfate units of thousands of years
19 before reaching the Culebra.

20 The higher-ionic-strength (0.3-1 molal) facies C brines have differing compositions, representing
21 meteoric waters that have dissolved CaSO_4 , overprinted with mixing and localized processes.
22 Facies A brines (ionic strength 1.6 - 5.3 molal) are high in NaCl and are clustered along the
23 extent of halite in the middle of the Tamarisk Member of the Rustler Formation. Facies A
24 represents old waters (long flow paths) that have dissolved halite and/or connate brine, or a
25 mixture of the two from facies E. The facies D brines, as identified by Siegel, Robinson, and
26 Myers (1991), are high-ionic-strength solutions found in western Nash Draw with high K/Na
27 ratios representing waters contaminated with effluent from potash refining operations. Similar
28 water is found at shallow depth (< 36 ft (11 m)) in the upper Dewey Lake at SNL-1, just south of
29 the Intrepid East tailings pile. The newly defined facies E waters are very high ionic strength (6.4
30 - 8.6 molal) NaCl brines with high Mg/Ca ratios. The facies E brines are found east of the WIPP
31 site, where Rustler halite is present above and below the Culebra, and halite cements are
32 present in the Culebra. They represent primitive brines present since deposition of the Culebra
33 and immediately overlying strata.

34 Previously, the Permittees and others believed the geochemistry of Culebra groundwater was
35 inconsistent with flow directions. This was based on the premise that facies C water must
36 transform to facies B water (e.g. become "fresher"), which is inconsistent with the observed flow
37 direction. It is now believed that the observed geochemistry and flow directions can be
38 explained with different recharge areas and Culebra travel paths (Amended Renewal
39 Application Addendum L1 (DOE, 2009)).

1 Head distribution in the Culebra (see Amended Renewal Application Addendum L1 (DOE,
2 2009)) is consistent with basin-scale groundwater basin modeling results indicating that the
3 generalized groundwater flow direction in the Culebra is currently north to south. However, the
4 fractured nature of the Culebra, coupled with variable fluid densities, can cause localized flow
5 patterns to differ from general flow patterns.

6 Groundwater levels in the Culebra in the region around the WIPP facility have been measured
7 in numerous wells. Water-level rises have been observed and are attributed to causes
8 discussed in the Renewal Application Addendum L1, Section L1-2a(3)(a)(ii) (DOE, 2009). The
9 extent of water-level rise observed at a particular well depends on several factors, but the
10 proximity of the observation point to the cause of the water-level change appears to be a
11 primary factor.

12 Hydrological investigations conducted from 2003 through 2007 provided new information, some
13 of it confirming long-held assumptions and some offering new insight into the hydrological
14 system around the WIPP site. A Culebra monitoring network optimization study was completed
15 by McKenna (2004) and updated by Kuhlman (2010) to identify locations where new Culebra
16 monitoring wells would be of greatest value and to identify wells that could be removed from the
17 network with little loss of information.

18 As discussed in Amended Renewal Application Addendum L1, Section L1-2a(3)(a)(ii) (DOE,
19 2009), extensive hydrological testing has been performed in the new wells. This testing has
20 involved both single well tests, which provide information on local transmissivity and
21 heterogeneity, and long-term (19 to 32 days) pumping tests that have created observable
22 responses in wells up to 5.9 mi (9.5 km) away.

23 Inferences about vertical flow directions in the Culebra have been made from well data collected
24 by the Permittees. Beauheim (1987) reported flow directions towards the Culebra from both the
25 underlying Los Medaños Member (**Los Medaños**) of the Rustler and the overlying Magenta
26 Member (**Magenta**) of the Rustler across the WIPP site, indicating that the Culebra acts as a
27 drain for the units around it. This is consistent with results of basin-scale groundwater modeling.

28 Use of water from the Culebra in the WIPP facility area is quite limited because of its varying
29 yields and high salinity. The Culebra is not used for water supply in the immediate WIPP facility
30 vicinity. Its nearest use is approximately 7 mi (11 km) southwest of the WIPP facility, where
31 salinity is low enough to allow its use for livestock watering.

32 L-2 General Regulatory Requirements

33 Because geologic repositories such as the WIPP facility are defined under the Resource
34 Conservation and Recovery Act (**RCRA**) as land disposal facilities and as miscellaneous units,
35 the groundwater monitoring requirements of 20.4.1.500 NMAC (incorporating 40 CFR
36 §§264.600 through 264.603) shall be addressed. The requirements of 20.4.1.500 NMAC
37 (incorporating 40 CFR §§264.90 through 264.101) apply to miscellaneous unit treatment,
38 storage, and disposal facilities (**TSDF**) only if groundwater monitoring is needed to satisfy
39 20.4.1.500 NMAC (incorporating 40 CFR §§264.601 through 264.603) environmental
40 performance standards.

41 The New Mexico Environment Department (**NMED**) has concluded that groundwater monitoring
42 in accordance with 20.4.1.500 NMAC (incorporating 40 CFR §264 Subpart F) at the WIPP

1 facility is necessary to meet the requirements of 20.4.1.500 NMAC (incorporating 40 CFR
2 §§264.601 through 264.603).

3 L-3 WIPP Detection Monitoring Program (DMP)—Overview

4 L-3a Scope

5 This DMP plan governs groundwater sampling events conducted to meet the applicable
6 requirements of 20.4.1.500 NMAC (incorporating 40 CFR 264 Subpart F), and ensures that
7 such data are gathered in accordance with these and other applicable requirements. Analytical
8 results collected during the DMP are compared to the baseline established in this Permit to
9 determine whether or not a release has occurred.

10 There are two separate components of the Groundwater Monitoring Program, the Detection
11 Monitoring Program (DMP) and the Water Level Monitoring Program (WLMP). The first
12 component consists of a network of six Detection Monitoring Wells (DMWs). The DMWs
13 (WQSP 1-6) were constructed to be consistent with the specifications provided in the
14 Groundwater Monitoring Technical Enforcement Guidance Document and constitute the RCRA
15 groundwater monitoring network specified in the DMP. The DMWs were used to establish
16 background groundwater quality in accordance with 20.4.1.500 NMAC (incorporating 40 CFR §
17 264.97 and 264.98 (f)). The second component of the Groundwater Monitoring Program is the
18 WLMP, which is used to determine the groundwater surface elevation and flow direction. Table
19 L-4 is a list of the wells used in the WLMP as of January 1, 2011. The list of wells is subject to
20 change due to plugging and abandonment and drilling of new wells.

21 L-3b Current WIPP DMP

22 Wells WQSP-1, WQSP-2, and WQSP-3 are located directly upgradient (north) of the WIPP
23 shaft area.

24 WQSP-4, WQSP-5, and WQSP-6 are located downgradient (south) of the WIPP shaft area. All
25 three Culebra downgradient wells (WQSP-4, 5, and 6) were sited to be located generally in the
26 path of contaminants that might be released from the shaft area in the Culebra. Well WQSP-4
27 was also specifically located to monitor the zone of higher transmissivity which may represent
28 faster flow path away from the WIPP shaft area to the LWA boundary (Amended Renewal
29 Application Addendum L1, Section L1-2a(3)(a)(ii) (DOE, 2009)).

30 The compliance point is defined in 20.4.1.500 NMAC (incorporating 40 CFR §264.95) as the
31 vertical plane immediately downgradient of the hazardous waste management unit area (i.e., at
32 the downgradient footprint of the WIPP repository). Permit Part 5 specifies the point of
33 compliance as “the vertical surface located at the hydraulically downgradient limit of the
34 Underground HWDUs that extends to the Culebra Member of the Rustler Formation.” Wells
35 WQSP-4, 5, and 6 are situated to demonstrate that during the operating life of the facility
36 (including closure), release of contaminants to the general public will not occur.

37 Transport modeling suggests that travel times from the Waste Handling Shaft to the LWA
38 boundary could be on the order of thousands of years. This assumes conditions where
39 hazardous constituents migrate from the sealed repository (post closure) to the Culebra via the
40 sealed shafts.

1 Potentiometric surfaces and groundwater flow directions defined for the Culebra prior to large-
2 scale pumping in the WIPP facility area and the excavation of WIPP facility shafts suggests that
3 flow was generally to the south-southeast from the waste disposal and shaft areas (Mercer,
4 1983; Davies, 1989). Potentiometric surface maps of the Culebra adjusted for density
5 differences show very similar characteristics. The wells used for measuring the potentiometric
6 surface of the Culebra are measured monthly and listed in Table L-4.

7 L-3b(1) Detection Monitoring Well Construction Specification

8 Diagrams of the six DMP wells are shown in Figures L-7 through L-12. Detailed descriptions of
9 geology and construction methods may be found in DOE 1995.

10 The six DMP Culebra wells were drilled between September 13 and October 16, 1994. The total
11 depth of each well is shown in Table L-5. The wells were drilled through the Culebra into the
12 Los Medaños as shown in Table L-5. The wells were drilled to the top of the Culebra using
13 compressed air as the drilling fluid and a 9 $\frac{7}{8}$ -in. drill bit. The wells were then cored using a 5 $\frac{1}{4}$ -
14 in. core bit to cut 4-in. (0.1-m) diameter core to total depth. See Table L-5 for the drilling and
15 coring intervals for each well. After coring, DMP wells were reamed to 9 $\frac{7}{8}$ -in. (0.3 m) in
16 diameter to total depth. After reaming, wells were cased from the surface to total depth with 5-in.
17 (0.1-m) (0.28-in. [0.7-centimeter (cm)] wall) blank fiberglass casing with in-line 5-in.- (0.1-m)
18 diameter fiberglass 0.02-in. (0.1-cm) slotted screen across the Culebra interval as shown in
19 Table L-5 . The annulus between the borehole wall and the casing/screen is packed with sand
20 and with 8/16 Brady gravel as indicated in Table L-5.

21 L-4 Monitoring Program Description

22 The WIPP DMP has been designed to meet the groundwater monitoring requirements of
23 20.4.1.500 NMAC (incorporating 40 CFR §§264.90 through 264.101). The following sections of
24 the monitoring plan specify the components of the DMP.

25 L-4a Monitoring Frequency

26 Groundwater surface elevations will be monitored in each of the six DMWs on a monthly basis.
27 The groundwater surface elevation in each DMW will also be measured prior to each annual
28 sampling event. The groundwater surface elevation measurements in the WLMP wells will also
29 be monitored on a monthly basis when accessible. The characteristics of the DMW (sampling
30 frequency, location) will be evaluated if significant changes are observed in the groundwater
31 flow direction or gradient.

32 L-4b Analytical Parameters and Hazardous Constituents

33 The parameters listed in Part 5, Table 5.4.a and hazardous constituents listed in Part 5, Table
34 5.4.b are measured as part of the DMP.

35 Additional hazardous constituents may be identified through changes to the list of hazardous
36 waste numbers authorized for disposal at the WIPP facility. If hazardous constituents are
37 identified, these will be added to Part 5, Table 5.4.b, unless the Permittees provide justification
38 for their omission (e.g. hazardous constituent not in 40 CFR §264 Appendix IX), and this
39 omission is approved by NMED.

1 L-4c Groundwater Surface Elevation Measurement, Sample Collection and Laboratory
2 Analysis

3 Groundwater surface elevations will be measured in each DMW prior to groundwater sample
4 collection. Groundwater will be extracted using serial and final sampling methods. Serial
5 samples will be collected until groundwater field indicator parameters stabilize or three well bore
6 volumes, whichever occurs first, after which the final sample for complete analysis will be
7 collected. Final samples will then be analyzed for the parameters and constituents in Part 5,
8 Tables 5.4.a and 5.4.b.

9 L-4c(1) Groundwater Surface Elevation Monitoring Methodology

10 The WIPP groundwater level monitoring program (**WLMP**) activities are conducted in
11 accordance with the WIPP facility SOPs listed in Table L-3.

12 Groundwater surface elevation measurements will be taken monthly at each of the six DMWs
13 and prior to the annual sampling event. Additionally, groundwater surface elevation
14 measurements will be taken monthly in the other Culebra wells as listed in Table L-4, when
15 accessible. Well locations are shown in Figure L-14. If a cumulative groundwater surface
16 elevation change of more than 2 feet is detected in any DMP well over the course of one year
17 which is not attributable to site tests or natural stabilization of the site hydrologic system, the
18 Permittees will notify NMED in writing and discuss the origin of the changes in the Annual
19 Culebra Groundwater Report specified in Permit Part 5. Abnormal, unexplained changes in
20 groundwater surface elevation will be evaluated to determine if they indicate changes in site
21 recharge/discharge which could affect the assumptions regarding DMW placement and
22 constitute new information as specified in 20.4.1.900 NMAC (incorporating 40 CFR
23 §270.41(a)(2)).

24 Groundwater surface elevation monitoring will continue through the post-closure care period
25 specified in Permit Part 7. The Permittees may temporarily increase the frequency of monitoring
26 to effectively document naturally occurring or artificial perturbations that may be imposed on the
27 hydrologic systems at any point in time. This will be conducted in selected key wells by
28 increasing the frequency of the manual groundwater surface elevation measurements or by
29 monitoring water pressures with the aid of electronic pressure transducers and remote data-
30 logging systems. The Permittees will include such additional data in the reports specified in
31 Section L-5c.

32 Interpretation of groundwater surface elevation measurements and corresponding fluctuations
33 over time is complicated at the WIPP facility by spatial variation in fluid density. To monitor the
34 hydraulic gradients of the hydrologic flow systems accurately, actual groundwater surface
35 elevation measurements will be monitored at the frequencies specified in Table L-2, and the
36 Culebra groundwater densities of the fluids in the wells listed in Table L-4 will be measured
37 annually.

38 Measured Culebra water surface elevation data can be converted to equivalent freshwater head
39 from knowledge of the density of the borehole fluid, using the following formula.

1
$$p = \rho y h$$

2 where

3 p = freshwater head (length of freshwater head)

4 y = average specific gravity of the borehole fluid (unitless ratio of borehole fluid density to
5 density of fresh water)

6 ρ = freshwater density (mass/volume)

7 h = fluid column height above the datum (length)

8 If the freshwater density is assumed to be 1.000 gram per cubic centimeter (g/cm^3), then the
9 equivalent freshwater head is equal to the fluid column height times the average borehole fluid
10 specific gravity.

11 Density measurements are made annually. Density for the DMWs will be expressed as specific
12 gravity as measured in the field during sampling events using a hydrometer. Freshwater head
13 for other Culebra wells will be calculated as described above from fluid density measurements
14 obtained using pressure transducers.

15
16 L-4c(1)(i) Field Methods and Data Collection Requirements

17 To obtain an accurate groundwater surface elevation measurement, a calibrated water-level
18 measuring device will be lowered into a test well and the depth to water recorded from a known
19 reference point. An SOP will be used when making water-level measurements for this program.
20 The SOP will specify the methods to be used in obtaining groundwater-level measurements,
21 and provide general instructions including prerequisites, safety precautions, performance
22 frequency, quality assurance, data management, and records.

23 L-4c(1)(ii) Groundwater Surface Elevation Records and Document Control

24 Incoming data will be processed in a manner that ensures data integrity. The data management
25 process for groundwater surface elevation measurements will begin with completion of the field
26 data sheets. Date, time, tape measurement, equipment identification number, calibration due
27 date, initial of the field personnel, and equipment/comments will be recorded on the field data
28 sheets. If, for some unexpected reason, a measurement is not possible (e.g., a test is under
29 way that blocks entry to the well bore), then a notation as to why the measurement was not
30 taken will be recorded in the comment column. Personnel will also use the comment column to
31 report any security observations (i.e., well lock missing).

32 Data recorded on the field data sheets and submitted by field personnel will be subject to
33 applicable SOPs (see Table L-3). These procedures specify the processes for administering
34 and managing such data. The data will be entered onto a computerized work sheet. The work
35 sheet program calculates groundwater surface elevation in both feet and meters relative to the
36 top of the casing and also relative to mean sea level. The work sheet program adjusts
37 groundwater surface elevations to equivalent freshwater heads.

38 A check print will be made of the work sheet printout. The check print will be used to verify that
39 data taken in the field was properly reported on the database printout. A minimum of 10 percent

1 of the spreadsheet calculations will be randomly verified on the check print to ensure that
2 calculations are being performed correctly. If errors are found, the work sheet will be corrected.
3 Groundwater surface elevation data and equivalent freshwater heads for the Culebra wells in
4 Table L-4 will be transmitted to NMED by May 31 and November 30. Semi-annual groundwater
5 reports will also include annotated hydrographs and trend analysis.

6 L-4c(2) Groundwater Sampling

7 L-4c(2)(i) Groundwater Pumping and Sampling Systems

8 The groundwater pumping and sampling systems used to collect a groundwater sample from
9 the six DMWs will provide continuous and adequate production of water so that a representative
10 groundwater sample can be obtained.

11 The type of pumping and sampling system to be used in a well depends primarily on the aquifer
12 characteristics of the Culebra and well construction. The DMWs are individually equipped with
13 dedicated submersible pumping assemblies. Each well has a specific type of submersible
14 pump, matched to the ability of the well to yield water during pumping. The down-hole
15 submersible pumps are controlled by a variable electronic flow controller to match the
16 production capacity of the formation at each well.

17 As recommended in the "RCRA Ground-Water Monitoring Technical Enforcement Guidance
18 Document" (EPA, 1986) the wells will be purged no more than three well bore volumes or until
19 field parameters have stabilized, whichever comes first. Well purging will performed in
20 accordance with an SOP in conjunction with serial sampling to determine when the groundwater
21 chemistry stabilizes and is therefore representative of undisturbed groundwater.

22 The DMWs are cased and screened through the production interval with materials that do not
23 yield contamination to the aquifer or allow the production interval to collapse under stress (high
24 epoxy fiberglass). An electric, submersible pump installation without the use of a packer is used
25 in this instance. The largest amount of discharge from the submersible pump takes place from a
26 discharge pipe. In addition to this main discharge pipe, a dedicated sample line running parallel
27 to the discharge pipe is used. The sampling line is manufactured from a chemically inert
28 material. Cumulative flow is measured using a totalizing flow meter. Flow from the discharge
29 pipe is routed to a discharge tank for disposal.

30 The dedicated sampling line is used to collect the water sample that will undergo analysis. By
31 using a dedicated sample line, the water will not be contaminated by the metal discharge pipe.
32 The sample line will branch from the main discharge pipe a few inches above the pump. Flow
33 from the sample line will be routed into the sample collection area. Flow through the sample
34 collection line is regulated by a flow-control valve. The sample line is insulated at the surface to
35 minimize temperature fluctuations.

36 L-4c(2)(ii) Serial Samples

37 Serial sampling is the collection of sequential samples for the purpose of determining when the
38 groundwater chemistry stabilizes and is therefore representative of undisturbed groundwater.
39 The Permittees' SOP for serial sampling will provide criteria for determining when a final sample
40 should be taken. Each DMW will be purged to no than more three well bore volumes, or until
41 field parameters stabilize, whichever occurs first. Well stabilization occurs when the field-

1 analyzed parameters are within $\pm 5\%$ of three consecutive measurements. A well bore volume
2 is defined as the volume of water from static water level to the bottom of the well sump. Serial
3 samples will be analyzed in the mobile field laboratory for field indicator parameters. The
4 Permittees will provide an explanation of why the sample was collected when field indicator
5 parameters were not stabilized and place that explanation in the WIPP facility Operating
6 Record.

7 Serial samples will be collected and analyzed to detect and monitor the chemical variation of the
8 groundwater as a function of the volume of water pumped. Once serial sampling begins, the
9 frequency at which serial samples are collected and analyzed will be left to the discretion of the
10 Permittees, but will be performed a minimum of three times during a sampling round.

11 The Permittees will use appropriate field methods to identify stabilization of the following field
12 indicator parameters: pH, temperature, specific conductance, and specific gravity.

13 The three field indicator parameters of temperature, specific conductance, and pH will be
14 determined by either an "in-line" technique, using a self-contained flow cell, or an "off-line"
15 technique, in which the samples will be collected from a sample line at atmospheric pressure.
16 Specific conductance and specific gravity samples will be collected from the sample line at
17 atmospheric pressure. Because of the lack of sophisticated weights and measures equipment
18 available for field density assessments, field density evaluations will be expressed in terms of
19 specific gravity, which is a unitless measure. Density is expressed as unit weight per unit
20 volume.

21 New polyethylene containers, that are certified clean by the laboratory, will be used to collect
22 the serial samples from the sample line.

23 Serial samples collected in laboratory-certified clean containers do not require rinsing prior to
24 sample collection. Unfiltered groundwater will be used when determining temperature, pH,
25 specific conductance, and specific gravity. Sample bottles will be properly identified and labeled.

26 Samples collected will immediately be analyzed for pH and specific conductance (SC) as these
27 parameters are most sensitive to changes in ambient temperature. Temperature, pH, and
28 specific conductance, when not measured in a flow cell, will be measured at the approximate
29 time of serial sample collection. These samples will be collected from the unfiltered sample line.

30 Upon completion of the collection of the last serial sample suite, the serial sample bottles
31 accrued throughout the duration of the pumping of the well will be discarded. No serial sample
32 bottles will be reused for sampling purposes of any sort. However, serial samples may be stored
33 for a period of time depending upon the need. Standard Operating Procedures (see Table L-3)
34 defines the protocols for the collection of final and serial samples and analysis.

35 L-4c(2)(iii) Final Samples

36 The final sample will be collected once the measured field indicator parameters have stabilized
37 (refer to Section L-4(c)(2)(ii)). A serial sample will also be collected and analyzed for each day
38 of final sampling to ensure that samples collected for laboratory analysis are still representative
39 of stable conditions. Sample preservation, handling, and transportation methods will maintain
40 the integrity and representativeness of the final samples.

1 Prior to collecting the final samples, the collection team shall consider the analyses to be
2 performed so that proper shipping or storage containers can be assembled. Table L-6 presents
3 the sample containers, volumes, and holding times for laboratory samples collected as part of
4 the DMP.

5 The monitoring system will use dedicated pumping systems and sample collection lines from the
6 sampled formation to the well head.

7 Sample integrity will be ensured through appropriate decontamination procedures. Laboratory
8 glassware will be washed after each use with a solution of nonphosphorus detergent and
9 deionized (DI) water and rinsed in DI water. Sample containers will be new, certified clean
10 containers that will be discarded after one use. Groundwater surface elevation measurement
11 devices will be rinsed with fresh water after each use. Non-dedicated sample collection manifold
12 assemblies will be rinsed in accordance with SOPs after each use. The exposed ends will be
13 capped off during storage. Prior to the next use of the sampling manifold, it will be rinsed a
14 second time with DI water and a rinsate blank sample will be collected to verify cleanliness.

15 Water samples will be collected at atmospheric pressure using either the filtered or unfiltered
16 sampling lines. Detailed protocols, in the form of SOPs (see Table L-3) define how final samples
17 will be collected in a consistent and repeatable fashion for analyses.

18 Final samples will be collected in the appropriate type of container for the specific analysis to be
19 performed. The samples will be collected in new and unused glass and plastic containers (refer
20 to Table L-6). For each parameter analyzed, a sufficient volume of sample will be collected to
21 satisfy the volume requirements of the analytical laboratory (as specified by laboratory SOPs).
22 This includes an additional volume of sample water necessary for maintaining quality control
23 standards. All final samples will be treated, handled, and preserved as required for the specific
24 type of analysis to be performed. Details about sample containers, preservation, and volumes
25 required for individual types of analyses are found in the applicable SOPs generated, approved,
26 and maintained by the contract analytical laboratory.

27 Final samples will be sent to the analytical laboratories and analyzed for parameters and
28 hazardous constituents specified in Part 5, Tables 5.4a and 5.4b.

29 Duplicates of the final sample will be provided to WIPP Project oversight agencies when
30 requested.

31 Wastes resulting from the sampling and field analysis of groundwater are disposed of in
32 accordance with the WIPP SOPs (see Table L-3).

33 L-4c(2)(iv) Sample Preservation, Tracking, Packaging, and Transportation

34 Many of the chemical constituents measured by the DMP are not chemically stable and require
35 preservation and special handling techniques. Samples requiring acidification will be treated as
36 requested by the analytical laboratory.

37 The analytical laboratory receiving the samples will prescribe the type and amount of
38 preservative, the container material type, the required sample volumes that shall be collected,
39 and the shipping requirements. This information will be recorded on the Final Sample Checklist
40 for use by field personnel when final samples are being collected. The Permittees will follow the

1 EPA "RCRA Ground-Water Monitoring Technical Enforcement Guidance Document," Table 4-1
2 (EPA, 1986), when laboratory SOPs do not specify sample container, volume, or preservation
3 requirements. WIPP SOPs (see Table L-3) provide instructions to ensure proper sample
4 preservation and shipping.

5 The sample tracking system at the WIPP facility uses uniquely numbered chain of custody/
6 request for analysis (CofC/RFA) forms. The primary consideration for storage or transportation
7 is that samples shall be analyzed within the prescribed holding times for the analytes of interest.
8 WIPP SOPs (see Table L-3) provide instructions to ensure proper sample tracking protocol.

9 L-4c(2)(v) Sample Documentation and Custody

10 To ensure the integrity of samples from the time of collection through reporting date, sample
11 collection, handling, and custody shall be documented. Sample custody and documentation
12 procedures for sampling and analysis activities are detailed in WIPP facility SOPs (see Table L-
13 3).

14 Standardized forms used to document samples will include sample identification numbers,
15 sample labels, custody tape, the sample tracking data, and CofC/RFA form. An example form is
16 shown in Figure L-13.

17 Sample Numbers and Labels

18 A unique sample identification number will be assigned to each sample sent to the laboratory for
19 analysis. The sample identification numbers will be used to track the sample from the time of
20 collection through data reporting. Every sample container sent to the laboratory for analysis will
21 be identified with a label affixed to it. Sample label information will be completed in indelible ink
22 and will contain the following information: sample identification number with sample matrix type;
23 sample location; analysis requested; time and date of collection; preservative(s), if any; and the
24 sampler's name or initials.

25 Custody Seals

26 Custody seals will be used to detect unauthorized sample tampering from collection through
27 analysis. For example, custody seals that are adhesive-backed strips are destroyed when
28 removed or when the container is opened. The seal will be dated, initialed, and affixed to the
29 sample container in such a manner that it is necessary to break the seal to open the container.
30 Seals will be affixed to sample containers in the field immediately after collection. Upon receipt
31 at the laboratory, the laboratory custodian will inspect the seal for integrity; a broken seal will
32 invalidate the sample.

33 Sample Identification and Tracking

34 Sample tracking information will be completed for each sample collected. The sample tracking
35 information includes the following information: CofC/RFA form number; date sample(s) were
36 sent to the lab; laboratory name; acknowledgment of receipt or comments; well name and round
37 number. Sample codes will indicate the well location; the geologic formation where the water
38 was collected from, the sampling round number; and the sample number. The code is broken
39 down as follows:

1 WQ6¹C²R2³N1⁴

- 2 ¹ Well identification (e.g., WQSP-6 in this case)
3 ² Geologic formation (e.g., the Culebra in this case)
4 ³ Sample round no. (Round 2)
5 ⁴ Sample no. (N1)

6 To distinguish duplicate samples from other samples, a "D" is added as the last digit to signify a
7 duplicate. Sample tracking information will be completed in the field by the sampling team.

8 Sample tracking is monitored and documented with the CofC/RFA form and the shipping airbill.
9 Both of these documents are included in the data packets. Receipt at the analytical laboratory
10 may be monitored, if necessary, via the shipper's website tracking application. Samples are
11 considered complete when a copy of the original CofC/RFA form is merged with the Field Lab
12 copy of the same document.

13 Chain of Custody and Request for Analysis

14 A CofC/RFA form will be completed during or immediately following sample collection and will
15 accompany the sample through analysis and disposal. The CofC/RFA form will be signed and
16 dated each time the sample custody is transferred. A sample will be considered to be in a
17 person's custody if: the sample is in his/her physical possession; the sample is in his/her
18 unobstructed view; and/or the sample is placed, by the last person in possession of it, in a
19 secured area with restricted access. During shipment, the carrier's air bill number serves as
20 custody verification. Upon receipt of the samples at the analytical laboratory, the laboratory
21 sample custodian acknowledges possession of the samples by signing and dating the
22 CofC/RFA form. The completed original (top page) of the CofC/RFA will be returned to the
23 Permittees with the laboratory analytical report and becomes part of the permanent record of
24 the sampling event. The CofC/RFA form also contains specific instructions to the analytical
25 laboratory for sample analysis, potential hazards, and disposal instructions.

26 L-4c(3) Laboratory Analysis

27 Analysis of samples will be performed using methods selected to be consistent with EPA
28 recommended procedures in SW 846 (EPA, 1996). Additional detail on analytical techniques
29 and methods will be given in laboratory SOPs. In Part 5, Tables 5.4.a and 5.4.b presents the
30 analytical parameters and hazardous constituents for the WIPP DMP.

31 The Permittees will establish the criteria for laboratory selection, including the stipulation that
32 the laboratory follow the procedures specified in SW 846 and that the laboratory follow EPA
33 protocols unless alternate methods or protocols are approved by the NMED. The analytical
34 laboratory shall demonstrate, through laboratory SOPs that it will follow appropriate EPA SW
35 846 requirements and the requirements specified by the EPA protocols unless alternate
36 methods or protocols are approved by the NMED. The analytical laboratory shall also provide
37 documentation to the Permittees describing the sensitivity of laboratory instrumentation. This
38 documentation will be retained in the WIPP facility Operating Record. Instrumentation sensitivity
39 needs to be considered because of regulatory requirements governing constituent
40 concentrations in groundwater and the complexity of brines associated with the Culebra
41 groundwater.

1 The laboratory will maintain documentation of sample handling and custody, analytical results,
2 and internal quality control (QC) data. Additionally, the laboratory will analyze QC samples in
3 accordance with this plan and its own internal QC program for indicators of analytical accuracy
4 and precision. Data generated outside of laboratory acceptance limits will trigger an evaluation
5 and, if appropriate, corrective action as directed by the Permittees. The laboratory will report the
6 results of the environmental sample and QC sample analyses and any necessary corrective
7 actions that were performed. In the event that more than one analytical laboratory is used (e.g.,
8 for different analyses), each one will have the responsibilities specified above. A copy of the
9 laboratory SOPs will be maintained in WIPP facility files. The Permittees will provide NMED with
10 an initial set of applicable laboratory SOPs for information purposes, and provide NMED with
11 any updated SOPs on an annual basis by January 31.

12 Data validation will be performed and reported in the Annual Culebra Groundwater Report and
13 will be maintained in the WIPP facility Operating Record.

14 L-4d Calibration

15 L-4d(1) Sampling and Groundwater Elevation Monitoring Equipment Calibration

16 The equipment used to collect data for this DMP will be calibrated in accordance with SOPs.
17 The Permittees will be responsible for calibrating needed equipment on schedule and for
18 maintaining current calibration records for each piece of equipment.

19 L-4d(2) Groundwater Surface Elevation Monitoring Equipment Calibration Requirements

20 The equipment used in taking groundwater surface elevation measurements will be maintained
21 in accordance with WIPP facility SOPs (see Table L-3). The Permittees will be responsible for
22 ensuring equipment is calibrated on schedule in accordance with SOPs. The Permittees will
23 also be responsible for maintaining copies of records of the most recent calibration for each
24 piece of equipment.

25 L-4e Statistical Analysis of Laboratory Analytical Data

26 Analytical data collected as part of the DMP will be evaluated using appropriate statistical
27 techniques. The following specifies the statistical analysis to be performed by the Permittees.

28 L-4e(1) Temporal and Spatial Analysis

29 Temporal and spatial analyses of the data were completed as part of establishing the water
30 quality baseline (Crawley and Nagy, 1998; IT, 2000). As a result, the Permittees determined to
31 evaluate changes relative to baseline on an individual location basis and to report the
32 concentrations of constituents as a time series, either in tabular form or as time plots. No
33 particular seasonal variations have been noted in the concentrations of groundwater samples
34 collected during the spring and autumn; therefore, continuing temporal analysis is not required.

35 The analytical results for constituents will be reported as time series, either in tabular form or as
36 time plots or both, and compared to the 95th percentile values or reporting limits identified in
37 Part 5, Table 5.6.

1 L-4e(2) Distributions and Descriptive Statistics

2 Techniques were established to compare detection monitoring data generated during the
3 baseline studies. A 95th upper tolerance limit value (**UTLV**) or 95th percentile was determined
4 from those data sets where target analytes were measured at concentrations above the method
5 detection limits. The UTLV is provided for normal or lognormal distributions and a 95th
6 percentile confidence interval is provided for data sets that are nonparametric or have greater
7 than 15 percent non-detects. For analytes with only a few detects (greater than 95 percent non-
8 detects), an accurate 95th percentile cannot be calculated. For these analytes, the maximum
9 detected concentration is used as the baseline value. For the analytes that are non-detect in all
10 the samples, the method reporting limit was used as the baseline value.

11 L-4e(3) Action Levels

12 Using baseline distributions, actions levels were identified in accordance with methodologies
13 described in the baseline documents. Action levels are based on the 95th percentile or reporting
14 limits identified in the baseline. If the groundwater concentration of a constituent identified in
15 Part 5, Table 5.6 is found to exceed an action level, a test for outliers is performed in
16 accordance with the methodologies specified in "Statistical Analysis of Groundwater Monitoring
17 Data at RCRA Facilities" (EPA, 2009).

18 L-4e(4) Comparisons and Reporting

19 Prior to TRU mixed waste receipt, measurements were made of each background groundwater
20 quality hazardous constituent specified in Part 5, Table L-5.4b at every detection monitoring well
21 during each of the ten background sampling events (with the exception of trans-1,2-
22 dichloroethylene and vanadium that were added after TRU mixed disposal began). These
23 measurements serve as a statistical baseline (Part 5, Table 5.6) that is used for evaluating the
24 significance of the results of subsequent sampling events during detection monitoring. Time-
25 trend control charts with associated screening values for each hazardous constituent are used
26 for this evaluation. The Permittees will compare the results from groundwater hazardous
27 constituents of ongoing annual groundwater sample analysis to these baseline values in
28 accordance with 20.4.1.500 NMAC (incorporating 40 CFR §264.97(h)(4)). If the comparisons
29 show that a constituent statistically exceeds the baseline of the DMWs (as defined in 20.4.1.500
30 NMAC (incorporating 40 CFR §264.98(f)), the well shall be resampled and an analysis
31 performed as soon as possible, in accordance with 20.4.1.500 NMAC (incorporating 40 CFR
32 §264.98(g)(3)). The results of the statistical comparison will be reported annually to the NMED
33 in the Annual Culebra Groundwater Report by November 30, as required under 20.4.1.500
34 NMAC (incorporating 40 CFR §264.98(g)).

35 L-5 Reporting

36 L-5a Laboratory Data Reports

37 Laboratory data will be provided in electronic and hard copy reports to the Permittees and will
38 contain the following information for each analytical report:

- 39 • A brief narrative summarizing laboratory analyses performed, date of issue, deviations
40 from the analytical method, technical problems affecting data quality, laboratory quality

1 checks, corrective actions (if any), and the project manager's signature approving
2 issuance of the data report.

- 3 • Header information for each analytical data summary sheet including: sample number
4 and corresponding laboratory identification number; sample matrix; date of collection,
5 receipt, preparation and analysis; and analyst's name.
- 6 • Parameter and hazardous constituents, analytical results, reporting units, reporting limit,
7 analytical method used.
- 8 • Results of QC sample analyses for all concurrently analyzed QC samples.

9 All analytical results will be provided to NMED as specified in the Permit Part 5.

10 L-5b Statistical Analysis and Reporting of Results

11 Analytical results for hazardous constituents from annual groundwater sampling activities will be
12 compared and interpreted by the Permittees through generation of statistical analyses as
13 specified in Section L-4e. The Permittees will perform statistical analyses; the results will be
14 included in the Annual Culebra Groundwater Report in summary form, and will also be provided
15 to NMED as specified in Permit Part 5.

16 L-5c Semi-Annual Groundwater Surface Elevation Report and Annual Culebra Groundwater 17 Report

18 Data collected from this DMP will be reported to NMED as specified in Permit Part 5 in the
19 Annual Culebra Groundwater Report. The report will include all applicable information that may
20 affect the comparison of background groundwater quality and groundwater surface elevation
21 data through time. This information will include but is not limited to:

- 22 • DMW and WLMP well configuration changes that may have occurred from the time of
23 the last measurement (i.e., plug installation and removal, packer removal and
24 reinstallation, or both; and the type and quantity of fluids that may have been introduced
25 into the test wells).
- 26 • Pumping activities that may have taken place since publication of the last annual report
27 (i.e., related to groundwater quality sampling, hydraulic testing, and shaft installation or
28 grouting) that may have taken place since the last annual groundwater report.
- 29 • A discussion of the origins of abnormal unexpected changes in the groundwater surface
30 elevation, which is not attributable to site tests or natural stabilization of the site
31 hydrologic system that exceeds 2 ft in a DMP well over the course of the period covered
32 by the Annual Culebra Groundwater Report (this may indicate changes in
33 recharge/discharge which would affect the assumptions regarding DMP well placement
34 and constitute new information as specified in 20.4.1.900 NMAC (incorporating 40 CFR
35 §270.41(a)(2)).
- 36 • The results of the annual measurements of densities.

- 1 • Annotated hydrographs.
- 2 • Groundwater flow rate and direction.
- 3 • Potentiometric surface map generated using the following steps:
 - 4 – Examine hydrographs to identify month having the largest number of Culebra water
 - 5 levels available with the fewest wells affected by pumping or other anthropogenic
 - 6 events.
 - 7 – Convert water levels from subject month to equivalent freshwater heads using fluid
 - 8 densities appropriate to the date.
 - 9 – Fit trend surface through freshwater heads.
 - 10 – Extrapolate the trend surface to the boundaries of the model domain used for the
 - 11 current Performance Assessment Baseline Calculations (**PABCs**) and define initial
 - 12 fixed-head boundary conditions based on the trend surface.
 - 13 – Using the ensemble-average Culebra transmissivity field used for the current PABC,
 - 14 optimize the model boundary heads to improve the fit of the model to the freshwater
 - 15 heads at the wells using optimization software interactively with MODFLOW.
 - 16 – Run MODFLOW with optimal boundary conditions fit.
 - 17 – Contour MODFLOW head results on WIPP site.
 - 18 – Compute particle path and travel time from the Waste Handling Shaft to the LWA
 - 19 Boundary.
 - 20 – Data analysis that will accompany the potentiometric surface map will include:
 - 21 • Measured versus modeled scatter plot diagram
 - 22 • Frequency of modeled head residuals
 - 23 • Modeled residual freshwater head at each well
 - 24 • Explanations for modeled misfit residuals greater than 16.4 feet (5 meters).
 - 25 • Semi-annual groundwater surface elevation results will be reported as specified in
 - 26 Permit Part 5, Condition 5.10.2.2.

27 The DMP data used in generating the Annual Culebra Groundwater Report will be maintained
28 as part of the WIPP facility Operating Record and will be provided to NMED for review as
29 specified in the permit.

1 L-6 Records Management

2 Records generated during groundwater sampling and water level monitoring will be maintained
3 in either project files at the Permittees facility or the Operating Record. Project files will include,
4 but are not limited to:

- 5 • Sampling and Analysis Plans (**SAPs**)
- 6 • SOPs
- 7 • Field Data Entry Sheets
- 8 • CofC/RFA forms
- 9 • Analytical Laboratory Data Reports
- 10 • Variance Logs and Nonconformance Reports
- 11 • Corrective Action Reports.

12 Detection Monitoring Program monitoring, testing, and analytical data and WLMP data will be
13 maintained in the WIPP facility Operating Record.

14 L-7 Quality Assurance Requirements

15 Quality Assurance (**QA**) requirements specific to the DMP are presented in this section.

16 L-7a Data Quality Objectives and Quality Assurance Objectives

17 L-7a(1) Data Quality Objectives

18 Data Quality Objectives (DQOs) are qualitative and quantitative statements that specify the
19 quality of data required to support project decisions. DQOs have been established to ensure
20 that the data collected will be of a sufficient and known quality for their intended uses. The
21 overall DQOs for this DMP are shown in the following sections.

22 L-7a(1)(i) Detection Monitoring Program

23 Collect accurate and defensible data of known quality that will be sufficient to assess the
24 concentrations of constituents in the groundwater underlying the WIPP facility.

25 L-7a(1)(ii) Water Level Monitoring Program

26 Collect accurate and defensible data of known quality that will be sufficient to assess the
27 groundwater flow direction and rate at the WIPP facility.

28 L-7a(2) Quality Assurance Objectives

29 Quality Assurance Objectives (**QAOs**) for measurement data have been specified in terms of
30 accuracy, precision, completeness, representativeness, and comparability.

31

1 L-7a(2)(i) Accuracy

2 Accuracy is the closeness of agreement between a measurement and an accepted reference
3 value. When applied to a set of observed values, accuracy is a combination of a random
4 component and a common systematic error (bias) component. Measurements for accuracy will
5 include analysis of calibration standards, laboratory control samples, matrix spike samples, and
6 surrogate spike recoveries. The bias component of accuracy is expressed as percent recovery
7 (%R). Percent recovery is expressed as follows:

8
$$\%R = \frac{(\text{measured sample concentration})}{\text{true concentration}} \times 100$$

9 L-7a(2)(i)(A) Accuracy Objectives for Field Measurements

10 Field measurements will include pH, Specific Conductance (SC), temperature, specific gravity
11 and static groundwater surface elevation. Field measurement accuracy will be determined using
12 calibration standards. Thermometers used for field measurements will be calibrated to the
13 National Institute for Standards and Technology (**NIST**) traceable standard on an annual basis
14 to ensure accuracy. Accuracy of groundwater surface elevation measurements will be checked
15 before each measurement period by verifying calibration of the device within the specified
16 schedule. WIPP document WP 13-1 outlines the basic requirements for field equipment use and
17 calibration. WIPP facility SOPs contains instructions that outline protocols for maintaining
18 current calibration of groundwater surface elevation measurement instrumentation.

19 L-7a(2)(i)(B) Accuracy Objectives for Laboratory Measurements

20 Analytical system accuracy will be quantified using the following laboratory accuracy QC
21 checks: calibration standards, laboratory control samples (**LCS**), laboratory blanks, matrix and
22 surrogate spike recoveries. Single LCSs and matrix spike and surrogate spike sample analyses
23 will be expressed as %R. Laboratory analytical accuracy is parameter dependent and will be
24 prescribed in the laboratory SOP.

25 L-7a(2)(ii) Precision

26 Precision is the agreement among a set of replicate measurements without assumption or
27 knowledge of the true value. Precision data will be derived from duplicate field and laboratory
28 measurements. Precision will be expressed as relative percent difference (**RPD**), which is
29 calculated as follows:

30
$$RPD = \frac{(|\text{measured value sample 1} - \text{measured value sample 2}|)}{\text{average of measured samples 1 + 2}} \times 100$$

31 L-7a(2)(ii)(A) Precision Objectives for Field Measurements

32 Specific conductance, pH, and temperature will be measured during well purging and after
33 sampling. SC measurements will be precise to $\pm 10\%$ pH to 0.10 standard unit, specific gravity to
34 0.01 by hydrometer and temperature to 0.10 degrees Celsius ($^{\circ}\text{C}$). Water-level measurements
35 will be precise to ± 0.01 ft. The precision of water density measurements, when measured in the

1 field using down hole instrumentation, will be determined on a well-by-well basis and will result
2 in no more than a ± 2 ft of error in the derived fresh-water head.

3 L-7a(2)(ii)(B) Precision Objectives for Laboratory Measurements

4 Precision of laboratory analyses will be determined by analyzing a LCS and a lab control
5 sample duplicate (**LCSD**) or by analyzing one of the field samples in duplicate depending on the
6 requirements of the particular standard method. The precision is measured as the RPD of the
7 recoveries for the spiked LCS/LCSD pair or the RPD of the duplicate sample analysis results.
8 Laboratory analytical precision is also parameter dependent and will be prescribed in laboratory
9 SOPs.

10 L-7a(2)(iii) Contamination

11 In addition to measurements of precision and bias, QC checks for contamination will be
12 performed. QC samples including trip blanks, field blanks, and method blanks will be analyzed
13 to assess and document contamination attributable to sample collection equipment, sample
14 handling and shipping, and laboratory reagents and glassware. Trip blanks will be used to
15 assess volatile organic compound (**VOC**) sample contamination during shipment and handling
16 and will be collected and analyzed at a frequency of 1 sample per sample shipment. Field
17 blanks will be used to assess field sample collection methods and will be collected and analyzed
18 at a minimum frequency of one sample per 20 samples (five percent of the samples collected).
19 Method blanks will be used to assess contamination resulting from the analytical process and
20 will be analyzed at a minimum frequency of one sample per 20 samples, or five percent of the
21 samples collected. Evaluation of sample blanks will be performed following U.S. EPA "National
22 Functional Guidelines for Organic Data Review" (EPA, 1999) and "National Functional
23 Guidelines for Evaluating Inorganics Analyses" (EPA, 2004). Only method blanks will be
24 analyzed via wet chemistry methods. The criteria for evaluating method blanks will be
25 established as follows: If method blank results exceed method reporting limits, then that value
26 will become the detection limit for the sample batch. Detection of analytes of interest in method
27 blank samples may be used to disqualify some samples, requiring resampling and additional
28 analyses on a case-by-case basis.

29 L-7a(2)(iv) Completeness

30 Completeness is a measure of the amount of usable valid data resulting from a data collection
31 activity, given the sample design and analysis. Completeness may be affected by unexpected
32 conditions that may occur during the data collection process.

33 Occurrences that reduce the amount of data collected include sample container breakage
34 during sample shipment or in the laboratory and data generated while the laboratory was
35 operating outside prescribed QC limits. All attempts will be made to minimize data loss and to
36 recover lost data whenever possible. The completeness objective for analysis of Part 5, Table
37 5.4a parameters will be 90 percent and 100 percent analysis of Part 5, Table 5.4.b hazardous
38 constituents. If the completeness objective for Part 5 Table 5.4.b hazardous constituents is not
39 met, the Permittees will determine the need for resampling on a case-by-case basis. Numerical
40 expression of the completeness (**%C**) of data is as follows:

$$\%C = \frac{\text{number of accepted samples}}{\text{total number of samples collected}} \times 100$$

L-7a(2)(v) Representativeness

Representativeness is the degree to which sample analyses accurately and precisely represent the media they are intended to represent. Data representativeness for this DMP will be accomplished through implementing approved sampling procedures and the use of validated analytical methods. Sampling procedures will be designed to minimize factors affecting the integrity of the samples. Groundwater samples will only be collected after well purging criteria have been met. The analytical methods selected will be those that will most accurately and precisely represent the true concentration of analytes of interest.

For water levels and density, representativeness is a qualitative term that describes the extent to which a sampling design adequately reflects the environmental conditions of a site. The SOPs for measurement ensure that samples are representative of site conditions.

L-7a(2)(vi) Comparability

Comparability is the extent to which one data set can be compared to another. Comparability will be achieved through reporting data in consistent units and collection and analysis of samples using consistent methodology. Aqueous samples will consistently be reported in units of measures dictated by the analytical method. Units of measure include:

- Milligrams per liter (mg/L) for alkalinity, inorganic compounds and metals
- Micrograms per liter (µg/L) for VOCs and semivolatile organic compounds (**SVOCs**).

Culebra groundwater surface elevation measurements will be expressed as equivalent freshwater elevation in feet above mean sea level.

L-7b Design Control

The approved design for the DMP is specified in this Permit. Modifications to the DMP will be processed in accordance with 20.4.1.900 NMAC (incorporating 40 CFR §§ 270.42).

L-7c Instructions, Procedures, and Drawings

The preparation and use of instructions and procedures at the WIPP facility are outlined in the WIPP facility document WP 13-1(see Table L-3). Activities performed for the DMP that may affect groundwater data quality will be performed in accordance with approved procedures which comply with the Permit.

L-7d Document Control

Permittees will ensure that the latest approved versions of WIPP facility SOPs will be used in performing groundwater monitoring functions and that obsolete materials will be adequately identified or removed from work areas.

1 L-7e Inspection and Surveillance

2 Inspection and surveillance activities will be conducted as outlined in WIPP document WP 13-1
3 (see Table L-3). The Permittees will be responsible for performing the applicable WIPP facility
4 SOPs.

5 L-7f Control of Monitoring and Data Collection Equipment

6 WIPP document WP 13-1 (see Table L-3) outlines the basic requirements for control and
7 calibrating monitoring and data collection (**M&DC**) equipment. M&DC equipment shall be
8 properly controlled, calibrated, and maintained according to WIPP facility SOPs (see Table L-3)
9 to ensure continued accuracy of groundwater monitoring data. Results of calibrations,
10 maintenance, and repair will be documented. Calibration records will identify the reference
11 standard and the relationship to national standards or nationally accepted measurement
12 systems. Records will be maintained to track uses of M&DC equipment. If M&DC equipment is
13 found to be out of tolerance, the equipment will be tagged and it will not be used until
14 corrections are made.

15 L-7g Control of Nonconforming Conditions

16 In accordance with WP 13-1 (see Table L-3), equipment that does not conform to specified
17 requirements will be controlled to prevent use. The disposition of defective items will be
18 documented on records traceable to the affected items. Prior to final disposition, faulty items will
19 be tagged and segregated. Repaired equipment will be subject to the original acceptance
20 inspections and tests prior to use.

21 L-7h Corrective Action

22 Requirements for the development and implementation of a system to determine, document,
23 and initiate appropriate corrective actions after encountering conditions adverse to quality at the
24 WIPP facility are outlined in WIPP document WP 13-1 (see Table L-3). Conditions adverse to
25 acceptable quality will be documented and reported in accordance with corrective action
26 procedures and corrected as soon as practical. Immediate action will be taken to control work
27 performed under conditions adverse to acceptable quality and its results to prevent quality
28 degradation.

29 L-7i Quality Assurance Records

30 WIPP document WP 13-1(see Table L-3) outlines the policy that will be used at the WIPP facility
31 regarding identification, preparation, collection, storage, maintenance, disposition, and
32 permanent storage of QA records.

33 Records to be generated in the DMP will be specified by procedure. QA and RCRA operating
34 records will be identified. This will be the basis for the labeling of records as "QA" or "RCRA
35 operating record" on the Environmental Monitoring Records Inventory and Disposition Schedule.

36

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1 L-8 References

- 2 Beauheim, R.L., 1986. "Hydraulic-Test Interpretations for Well DOE-2 at the Waste Isolation
3 Pilot Plant (WIPP) Site," *SAND86-1364*, Sandia National Laboratories/New Mexico,
4 Albuquerque, New Mexico.
- 5 Beauheim, R.L., 1987. "Analysis of Pumping Tests at the Culebra Dolomite Conducted at the H-
6 3 Hydropad at the Waste Isolation Pilot Plant (WIPP) Site," *SAND86-2311*, Sandia National
7 Laboratories/New Mexico, Albuquerque, New Mexico.
- 8 Corbet, T.F., and P.M. Knupp, 1996. "The Role of Regional Groundwater Flow in the
9 Hydrogeology of the Culebra Member of the Rustler Formation at the Waste Isolation Pilot Plant
10 (WIPP), Southeastern New Mexico," *SAND96-2133*, Sandia National Laboratories/New Mexico,
11 Albuquerque, New Mexico.
- 12 Crawley, M. and M. Nagy, 1998. "WIPP RCRA Background Groundwater Quality Baseline
13 Report," DOE/WIPP-98-2285.
- 14 Davies, P.B., 1989. "Variable-Density Ground-Water Flow and Paleohydrology in the Waste
15 Isolation Pilot Plant (WIPP) Region, Southeastern New Mexico," U.S. Geological Survey Open-
16 File Report 88-490, Albuquerque, New Mexico.
- 17 DOE, see U.S. Department of Energy.
- 18 Domenico, P.A., and F.W. Schwartz, 1990. "Physical and Chemical Hydrogeology," New York:
19 John Wiley & Sons, Textbook.
- 20 Domski, P.S., and R.L. Beauheim. 2008. Evaluation of Culebra Brine Chemistry. AP-125. ERMS
21 549336. Carlsbad, NM: Sandia National Laboratories. (In development)
- 22 Domski, P.S., D.T. Upton, and R.L. Beauheim, 1996. "Hydraulic Testing Around Room Q:
23 Evaluation of the Effects of Mining on the Hydraulic Properties of Salado Evaporites," *SAND96-
24 0435*, Sandia National Laboratories/New Mexico, Albuquerque, New Mexico.
- 25 Earlough, E.C., Jr., 1977. "Advances in Well Test Analysis," Society of Petroleum Engineers of
26 AIME, Textbook, Dallas, Texas.
- 27 EPA, see U.S. Environmental Protection Agency.
- 28 Holt, R.M., and D.W. Powers, 1988. "Facies Variability and Post-Deposition Alteration Within the
29 Rustler Formation in the Vicinity of the Waste Isolation Pilot Plant, Southeastern New Mexico,"
30 *DOE-WIPP-88-04*, U.S. Department of Energy, Carlsbad, New Mexico.
- 31 IT Corporation, "2000 Addendum 1 Waste Isolation Pilot Plant RCRA Background Groundwater
32 Quality Baseline Update Report." Albuquerque, New Mexico.
- 33 Kuhlman, K.L. 2010. Analysis Report, AP-111 Revision 1, Culebra Water Level Monitoring
34 Network Design. ERMS 554054. Carlsbad, NM: Sandia National Laboratories.

- 1 McKenna, S. A. 2004. Analysis Report: Culebra Water Level Monitoring Network Design. AP-
2 111. ERMS 540477. Carlsbad, NM: Sandia National Laboratories.
- 3 Mercer, J.W., 1983. "Geohydrology of the Proposed Waste Isolation Pilot Plant Site, Los
4 Medaños Area, Southeastern New Mexico," U.S. Geological Survey, Water Resources
5 Investigations 83-4016, 113 pp.
- 6 Powers, D. W. 2006. Analysis Report: Task 1B of AP-114; Identify Possible Area of Recharge to
7 the Culebra West and South of WIPP (April 1). ERMS 543094. Carlsbad, NM: Sandia National
8 Laboratories.
- 9 Roberts, R. M. 2007. Analysis of Culebra Hydraulic Tests Performed Between June 2006 and
10 September 2007. ERMS 547418. Carlsbad, NM: Sandia National Laboratories.
- 11 Siegel, M.D., K. L. Robinson, and J. Myers. 1991. "Solute Relationships in Groundwaters from
12 the Culebra Dolomite and Related Rocks in the Waste Isolation Pilot Plant Area, Southeastern
13 New Mexico," SAND88-0196.
- 14 U.S. Department of Energy (DOE), 1995. "Basic Data Report for WQSP-1 through WQSP-6A,"
15 DOE/WIPP-95-2154.
- 16 U.S. Department of Energy (DOE), 2009, WIPP Hazardous Waste Facility Permit Amended
17 Renewal Application, Carlsbad, New Mexico.
- 18 U.S. Environmental Protection Agency (EPA), 2009. "Statistical Analysis of Ground-Water
19 Monitoring Data at RCRA Facilities, Unified Guidance," U.S. Environmental Protection Agency,
20 Washington, D.C.
- 21 U.S. Environmental Protection Agency (EPA), 1999. "National Functional Guidelines for Organic
22 Data Review," U.S. Environmental Protection Agency, Washington, D.C.
- 23 U.S. Environmental Protection Agency (EPA), 1990. "Background Documentation for the U.S.
24 Environmental Protection Agency's Proposed Decision on the No-Migration Variance for U.S.
25 Department of Energy's Waste Isolation Pilot Plant," U.S. Environmental Protection Agency,
26 Washington, D.C.
- 27 U.S. Environmental Protection Agency (EPA), 2004. "Functional Guidelines for Evaluating
28 Inorganics Analyses," U.S. Environmental Protection Agency, Washington, D.C.
- 29 U.S. Environmental Protection Agency (EPA), 1986. "RCRA Ground-Water Monitoring
30 Technical Enforcement Guidance Document," U.S. Environmental Protection Agency,
31 Washington, D.C.
- 32 U.S. Environmental Protection Agency (EPA), 1996. "Test Methods for Evaluating Solid Waste,"
33 SW-846, third ed., Office of Solid Waste and Emergency Response, Washington, D.C.

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TABLES

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**Table L-1
Hydrological Parameters for Rock Units above the Salado at WIPP**

Unit	Hydraulic Conductivity	Storage	Thickness	Hydraulic Gradient	
Santa Rosa	2×10^{-8} to 2×10^{-6} m/s (1) (2)		0 to 91 m	0.001 (5)	
Dewey Lake	10^{-8} m/s	Specific storage 1×10^{-5} (1/m) (2)	152 m	0.001 (5)	
Rustler	Forty-niner	1×10^{-13} to 1×10^{-11} m/s (anhydrite) 1×10^{-9} m/s (mudstone) (2)	Specific storage 1×10^{-5} (1/m) (2)	13 to 23 m	NA (6)
	Magenta	$1 \times 10^{-8.5}$ to $1 \times 10^{-6.5}$ m/s (2)	Specific storage 1×10^{-5} (1/m) (2)	7 to 8.5 m	3 to 6
	Tamarisk	1×10^{-13} to 1×10^{-11} m/s (anhydrite) 1×10^{-9} m/s (mudstone) (2)	Specific storage 1×10^{-5} (1/m) (2)	26 to 56 m	NA (6)
	Culebra	$1 \times 10^{-7.5}$ to $1 \times 10^{-5.5}$ m/s (2)	Specific storage 1×10^{-5} (1/m) (2)	4 to 11.6 m	0.003 to 0.007 (5)
	Los Medaños	6×10^{-15} to 1×10^{-13} m/s 1.5×10^{-11} to 1.2×10^{-11} m/s (basal interval)	Specific storage 1×10^{-5} (1/m) (2)	29 to 38 m	NA (6)

Matrix characteristics relevant to fluid flow include values used in this table such as permeability, hydraulic conductivity, gradient, etc.)

Table Notes:

- (1) The Santa Rosa Formation is not present in the western portion of the WIPP site. It was combined with the Dewey Lake Red Beds in three-dimensional regional groundwater flow modeling (Corbet and Knupp, 1996), and the range of values entered here are those used in that study for the Dewey Lake/Triassic hydrostratigraphic unit.
- (2) Values or ranges of values given for these entries are the values used in three-dimensional regional groundwater flow modeling (Corbet and Knupp, 1996). Values are estimated based on literature values for similar rock types, adjusted to be consistent with site-specific data where available. Ranges of values include spatial variation over the WIPP site and differences in values used in different simulations to test model sensitivity to the parameter.

- (3) Hydraulic gradient is a dimensionless term describing change in the elevation of hydraulic head divided by change in horizontal distance. Values given in these entries are determined from potentiometric surfaces. The range of values given for the Culebra reflects the highest and lowest gradients observed within the WIPP site boundary. Values for the Dewey Lake and Santa Rosa are assumed to be the same as the gradient determined from the water table. Note that the Santa Rosa Formation is absent or above the water table in most of the controlled area, and that the concept of a horizontal hydraulic gradient is not meaningful for these regions.
- (4) Flow in units of very low hydraulic conductivity is slow, and primarily vertical. The concept of a horizontal hydraulic gradient is not applicable.

Sources: Beauheim, 1986; Domenico and Schwartz, 1990; Domski, Upton, and Beauheim, 1996; Earlough, 1977.

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Table L-2
WIPP Groundwater Detection Monitoring Program Sample Collection and Groundwater Surface Elevation Measurement Frequency

Installation	Frequency
Groundwater Quality Sampling	
DMWs	Annually
Groundwater Surface Elevation Monitoring	
DMWs	Monthly and prior to sampling events
WLMP Wells (see Table L-4)	Monthly

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**Table L-3
 Standard Operating Procedures Applicable to the DMP**

Number	Title/Description
WP 02-EM1010	Field Parameter Measurements and Final Sample Collection: This procedure provides general instructions necessary to perform field analyses of serial samples in support of the DMP. Serial samples are collected and analyzed at the field laboratory for field indicators. Serial sample results help determine if pumped groundwater is representative of undisturbed groundwater within the formation. This procedure also describes the steps for collecting groundwater samples from the DMWs near the WIPP facility. Samples are collected and analyzed at the Field Laboratory until stabilization of the field parameters occurs. Final samples for Resource Conservation and Recovery Act (RCRA) analyses are collected and analyzed by a contract laboratory.
WP 02-EM1014	Groundwater Level Measurement: This document describes the method used for groundwater level measurements in support of groundwater monitoring at the WIPP facility using a portable electronic water-level probe.
WP 02-EM1021	Pressure Density Survey: This procedure defines the field methodology used to determine the average density of fluid standing in the well bores of groundwater-level monitoring wells. The data derived from the survey are used to calculate equivalent freshwater heads at non-detection monitoring wells. Because most pressure densities are obtained by Sandia National Laboratories via pressure transducers installed in wells, this procedure is used to obtain pressure densities at wells not equipped with fixed transducers.
WP 02-EM1026	Water Level Data Handling and Reporting: This procedure provides instructions on handling water level data. Data are collected and recorded on field forms in accordance with WP 02-EM1014. This procedure is initiated when wells in the water surveillance program have been measured for a given month.
WP 02-EM3001	Administrative Processes for Environmental Monitoring and Hydrology Programs: This procedure provides the administrative guidance environmental monitoring personnel use to maintain quality control associated with environmental monitoring sampling and reporting activities. This administrative procedure does not pertain to volatile organic compound (VOC) monitoring, with the exception of Section 5.0 which pertains to the regulatory reporting review process.
WP 02-EM3003	Data Validation and Verification of RCRA Constituents: This procedure provides instructions on performing verification and validation of laboratory data containing the analytical results of groundwater monitoring samples. This procedure is applied only to the non-radiological analyses results for compliance data associated with the detection monitoring samples. The data reviewed for this procedure includes general chemistry parameters and RCRA constituents.
WP-02-RC.01	Hazardous and Universal Waste Management Plan: This plan describes the responsibilities and handling requirements for hazardous and universal wastes generated at the WIPP facility. It is meant to ensure that these wastes are properly handled, accumulated, and transported to an approved Treatment, Storage, Disposal Facility (TSDF) in accordance with applicable state and federal regulations, U.S. Department of Energy (DOE) Orders, and Management and Operating Contractor (MOC) policies and procedures. This plan implements applicable sections of 20.4.1.100-1102 New Mexico Administrative Code (NMAC), <i>Hazardous Waste Management</i> (incorporating 40 <i>Code of Federal Regulations</i> [CFR] Parts 260-268 and 273).
WP 10-AD3029	Calibration and Control of Monitoring and Data Collection Equipment: This procedure provides direction for the control and calibration of Monitoring and Data Collection (M&DC) equipment at the WIPP facility, and ensures traceability to NIST (National Institute of Standards and Technology) standards, international standards, or intrinsic standards. This procedure also establishes requirements and responsibilities for identifying recall equipment, and for obtaining calibration services for WIPP facility M&DC equipment.
WP 13-1	Management and Operating Contractor Quality Assurance Program Description: This document establishes the minimum quality requirements for MOC personnel and guidance for the development and implementation of QA programs by MOC organizations.

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**Table L-4
January 2011 Culebra WLMP**

WELL ID	WELL ID	WELL ID
AEC-7	H-17	SNL-15
C-2737	H-19 pad*	SNL-16
ERDA-9	I-461	SNL-17
H-02b2	SNL-01	SNL-18
H-03b2	SNL-02	SNL-19
H-04bR	SNL-03	WQSP-1
H-05b	SNL-05	WQSP-2
H-06bR	SNL-06	WQSP-3
H-07b1	SNL-08	WQSP-4
H-9bR	SNL-09	WQSP-5
H-10c	SNL-10	WQSP-6
H-11b4	SNL-12	WIPP-11
H-12	SNL-13	WIPP-13
H-15R	SNL-14	WIPP-19
H-16		

*H-19b0 monthly

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Table L-5
Details of Construction for the Six Culebra Detection Monitoring Wells

NAME (Figure)	DATE DRILLED	TOTAL DEPTH feet (meters) bgs	DEPTH INTO LOS MEDAÑOS feet (meters)	DRILLING DEPTHS feet (meters) bgs		CASING feet (meters) bgs		PACKING feet (meters) bgs		CULEBRA INTERVAL feet (meters) bgs
				WITH AIR	CORING	DEPTH FOR 5 in. CASING	INTERVAL FOR SLOTTED SCREEN	SAND PACK INTERVAL	BRADY GRAVEL PACK INTERVAL	
WQSP-1 Figure L-7	September 13 through 16, 1994	737 (225)	15 (5)	696 (212)	696 to 737 (212 to 225)	737 (225)	702 to 727 (214 to 222)	640 to 651 (195 to 198)	651 to 737 (198 to 225)	699 to 722 (213 to 220)
WQSP-2 Figure L-8	September 6 through 12, 1994	846 (258)	12 (4)	800 (244)	800 to 846 (244 to 258)	846 (258)	811 to 836 (247 to 255)	790 to 793 (241 to 242)	793 to 846 (242 to 258)	810.1 to 833.7 (247 to 254)
WQSP-3 Figure L-9	October 20 through 26, 1994	880 (268)	10 (3)	833 (254)	833 to 880 (254 to 268)	880 (268)	844 to 869 (257 to 265)	827 to 830 (252 to 253)	830 to 880 (253 to 268)	844 to 870 (257 to 265)
WQSP-4 Figure L-10	October 5 through 10, 1994,	800 (244)	9 (3)	740 (226)	740 to 798 (226 to 243)	800 (244)	764 to 789 (233 to 240)	752 to 755 (229 to 230)	755 to 800 (230 to 244)	766 to 790.8 (233 to 241)
WQSP-5 Figure L-11	October 12 through 18, 1994,	681 (208)	7 (2)	648 (198)	648 to 676 (198 to 206)	681 (208)	646 to 671 (197 to 205)	623 to 626 (190 to 191)	626 to 681 (191 to 208)	648 to 674.4 (198 to 205)
WQSP-6 Figure L-12	September 26 through October 3, 1994	616.6 (188)	10 (3)	568 (173)	568 to 617 (173 to 188)	617 (188)	581 to 606 (177 to 185)	567 to 570 (173 to 174)	570 to 616.6 (174 to 188)	582 to 606.9 (177 to 185)

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4
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6

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**Table L-6
Analytical Parameter and Sample Requirements**

(10) PARAMETERS	(12) NO. OF BOTTLES	(13) VOLUME	(14) TYPE	(15) ACID WASH	(16) SAMPLE FILTER	(17) PRESERVATIVE	(18) HOLDING TIME
Indicator ¹ Parameters: <ul style="list-style-type: none"> • pH • SC • TOC 	- - 4	25 ml ² 100 ml ² 15 ml ²	Glass Glass Glass	Field determined Field determined yes	No? No No	Field determined Field determined HCl	None None 28 days ²
General Chemistry	1	1 Liter	Plastic	Yes	No	HNO ₃ , pH<2	not specified in DMP
Phenolics	1	1 Liter	Amber Glass	Yes	No	H ₂ SO ₄ , pH<2	not specified in DMP
Metals/Cations	2	1 Liter	Plastic	Yes	No	HNO ₃ , pH<2	6 months ^{2,3}
VOC	4	40 ml	Glass	No	No	HCL, ph<2	14 days ²
VOC (Purgable)	2	40 ml	Glass	No	No	HCL, ph<2	14 days ²
VOC (Non-Purgable)	2	40 ml	Glass	No	No	HCL, ph<2	14 days ²
BN/As	1	½ Gallon	Amber Glass	Yes	No	None	
TCLP	1	1 Liter	Plastic	Yes	No	HNO ₃ , pH<2	7 days ²
Cyanide (Total)	1	1 Liter	Plastic	Yes	No	NaOH, pH>12	14 days ²
Sulfide	1	250 ml	Amber Glass	Yes	No	NaOH + Zn Acetate	28 days ²
Radionuclides	1	1 Gallon	Plastic Cube	Yes	Yes	HNO ₃ , pH<2	6 months ²

1 = RCRA Detection Monitoring Analytes

2 = As specified in Table 4-1 of the RCRA TEGD

3 = Reduced holding time of 1 week for WIPP-specific Divalent cation 2 samples noted in the GMD

Note: Unless otherwise indicated, data are from DOE Procedure WP 02-EM1006 methods and are provided as information only.

Note: Deviations from this table are allowed with prior approval by the NMED.

1
2

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1

FIGURES

2

1

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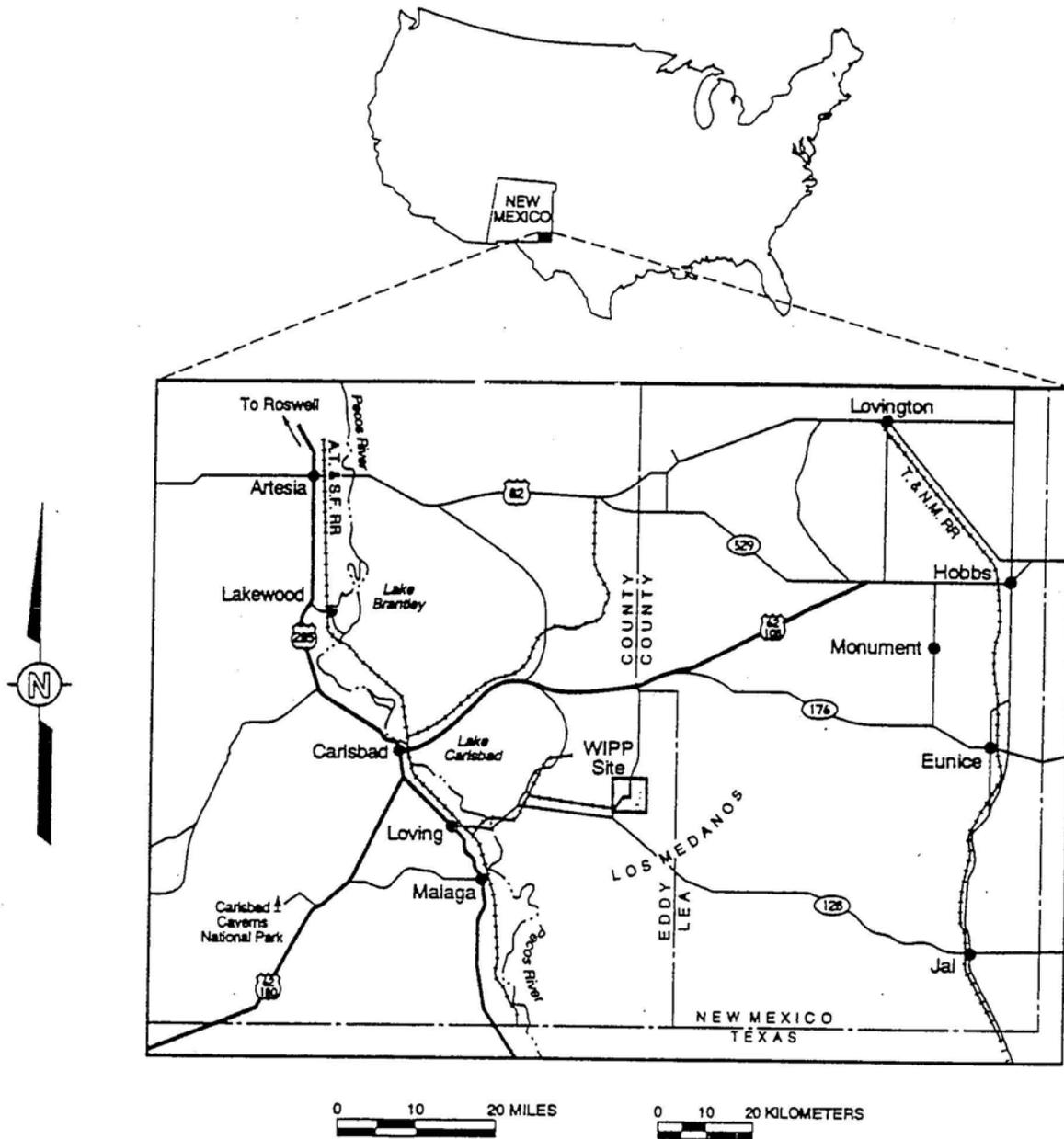


Figure L-1
General Location of the WIPP Facility

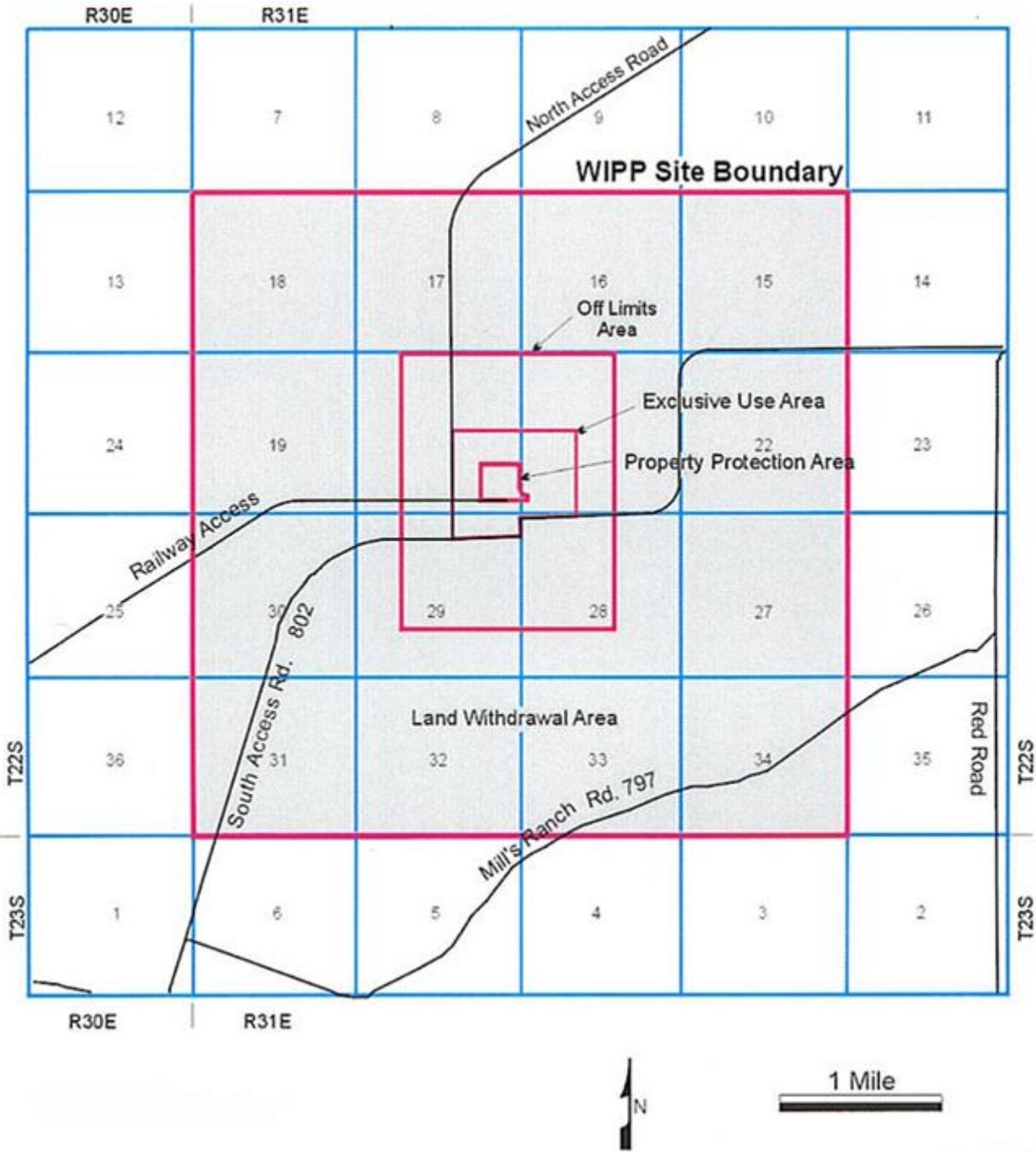


Figure L-2
WIPP Facility Boundaries Showing 16-square-Mile Land Withdrawal Boundary

SYSTEM	SERIES	GROUP	FORMATION	MEMBER
RECENT	RECENT		SURFICIAL DEPOSITS	
QUATERNARY	PLEISTOCENE		MESCALERO CALICHE	
			GATUÑA	
TERTIARY	MID-PLIOCENE		OGALLALA	
TRIASSIC		DOCKUM	SANTA ROSA	
PERMIAN	OCHOAN		DEWEY LAKE	
			RUSTLER	Forty-niner
				Magenta
				Tamarisk
				Culebra
				Los Medaños
	SALADO	Upper		
		McNutt Potash		
		Lower		
	CASTILE			
	GUADALUPIAN	DELAWARE MOUNTAIN	BELL CANYON	
			CHERRY CANYON	
			BRUSHY CANYON	

Figure L-3
 Site Geologic Column

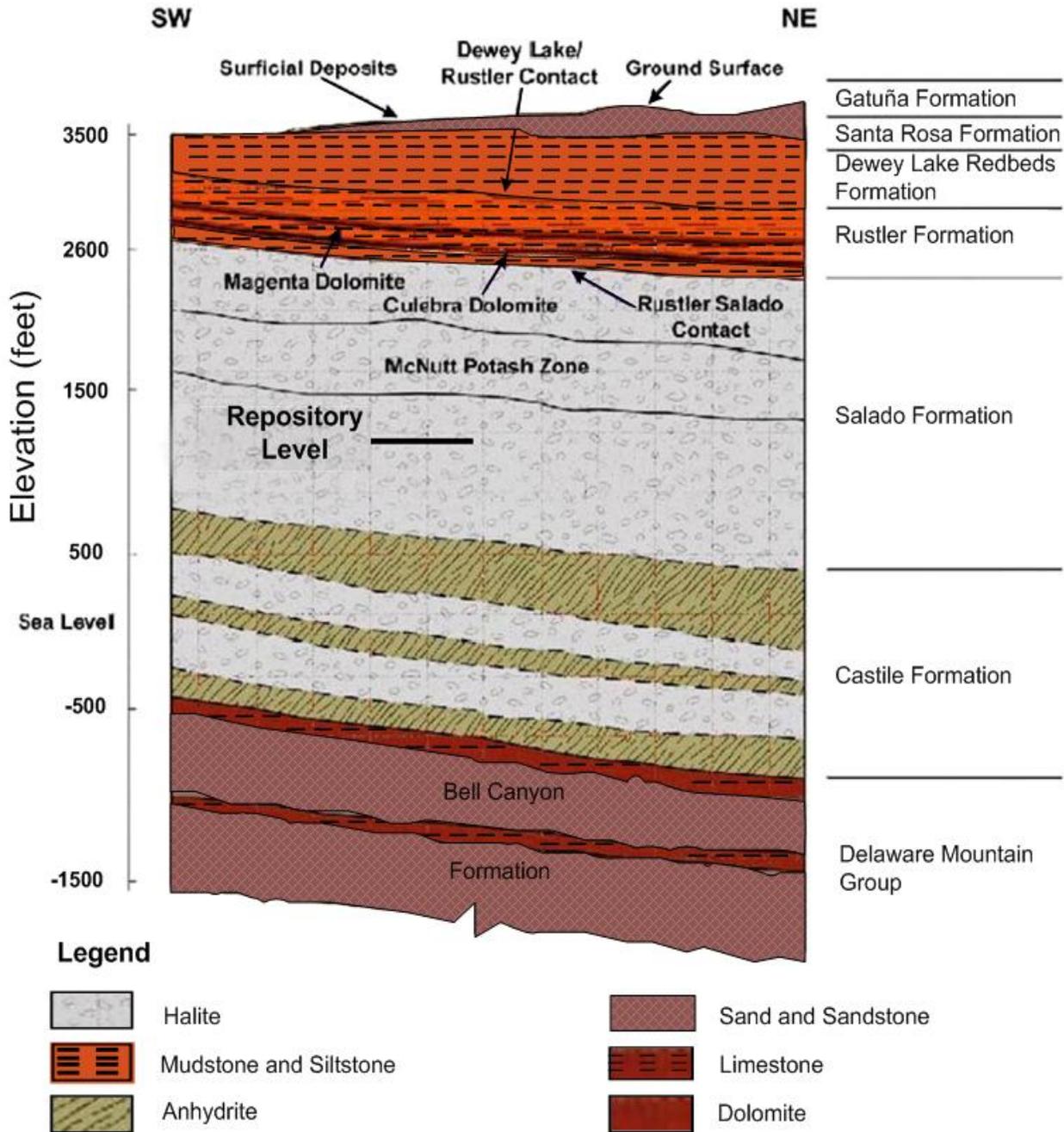


Figure L-4
Generalized Stratigraphic Cross Section above Bell Canyon Formation at WIPP Site

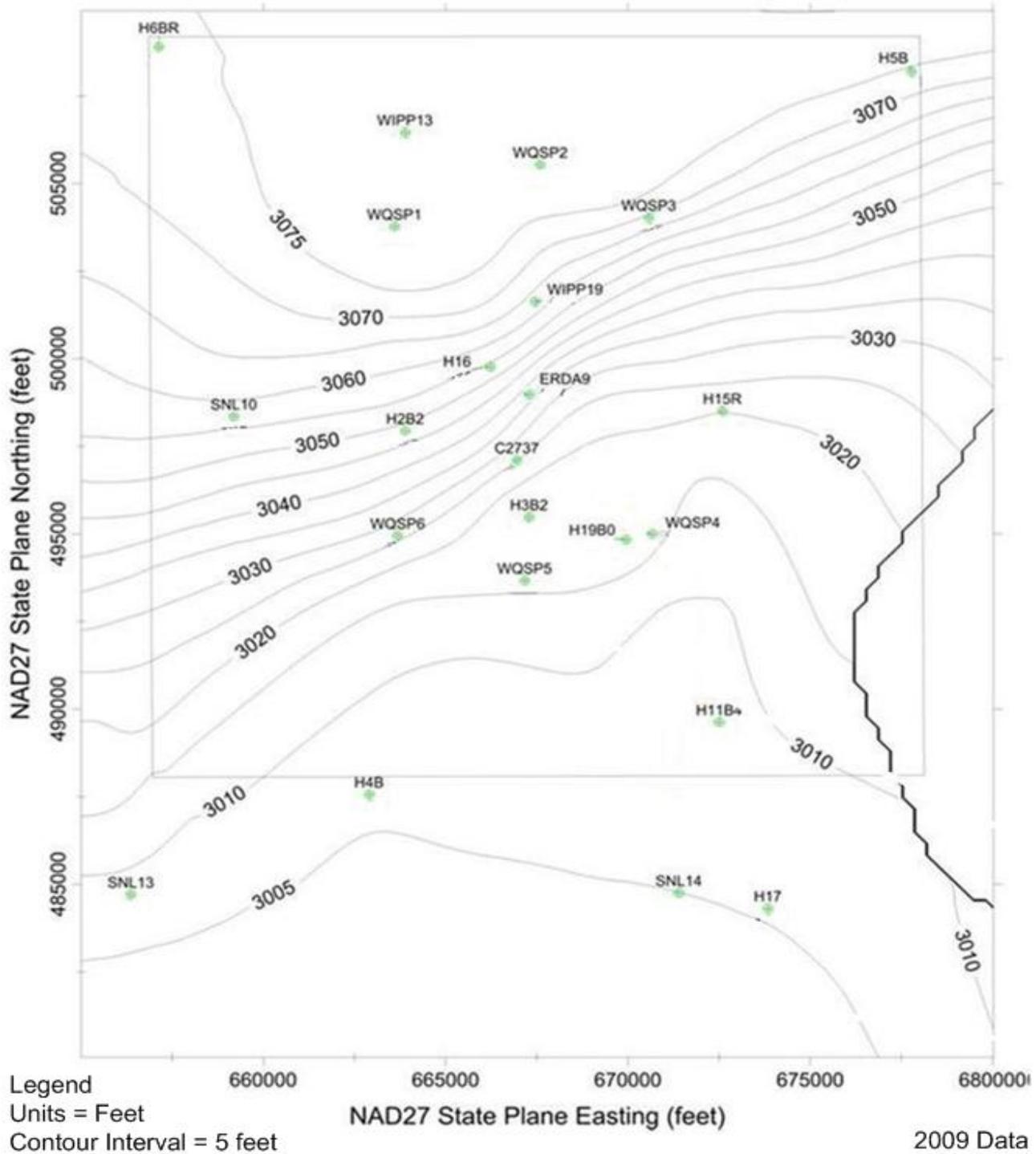
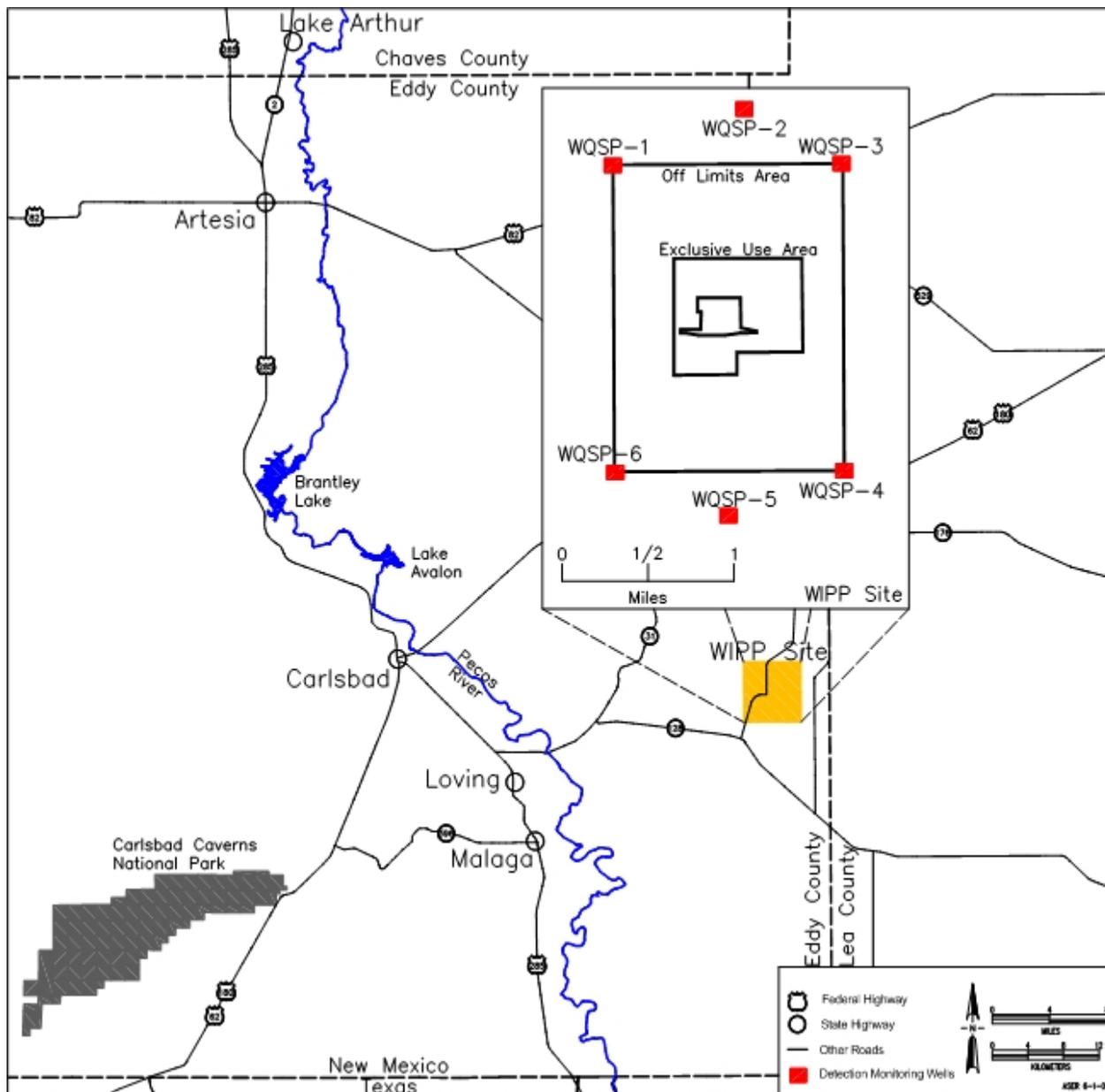


Figure L-5
Culebra Freshwater-Head Potentiometric Surface



NOTE: Point of compliance is defined in Part 5.3.1.

Figure L-6
Detection Monitoring Well Locations

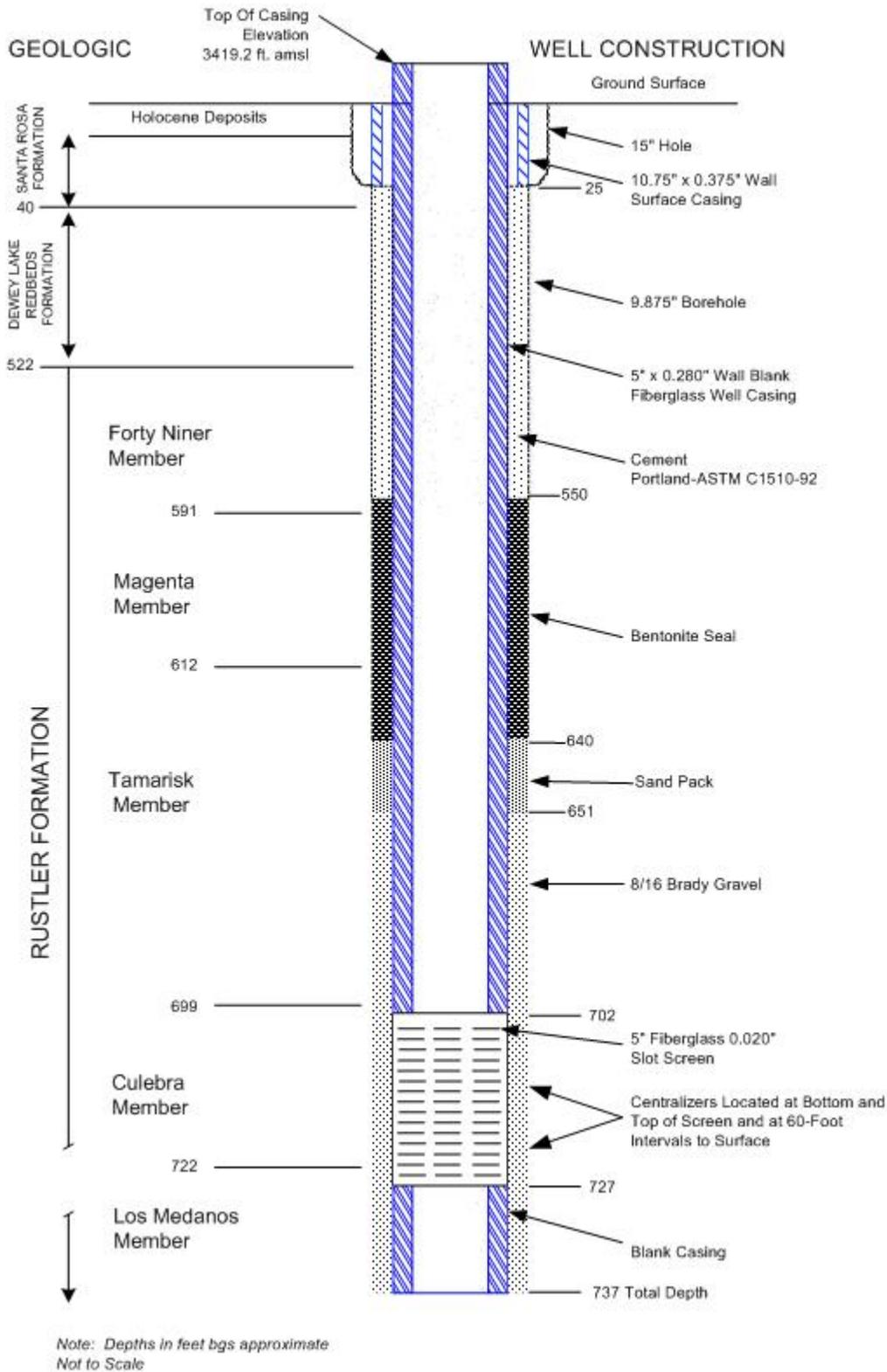


Figure L-7
As-Built Configuration of Well WQSP-1

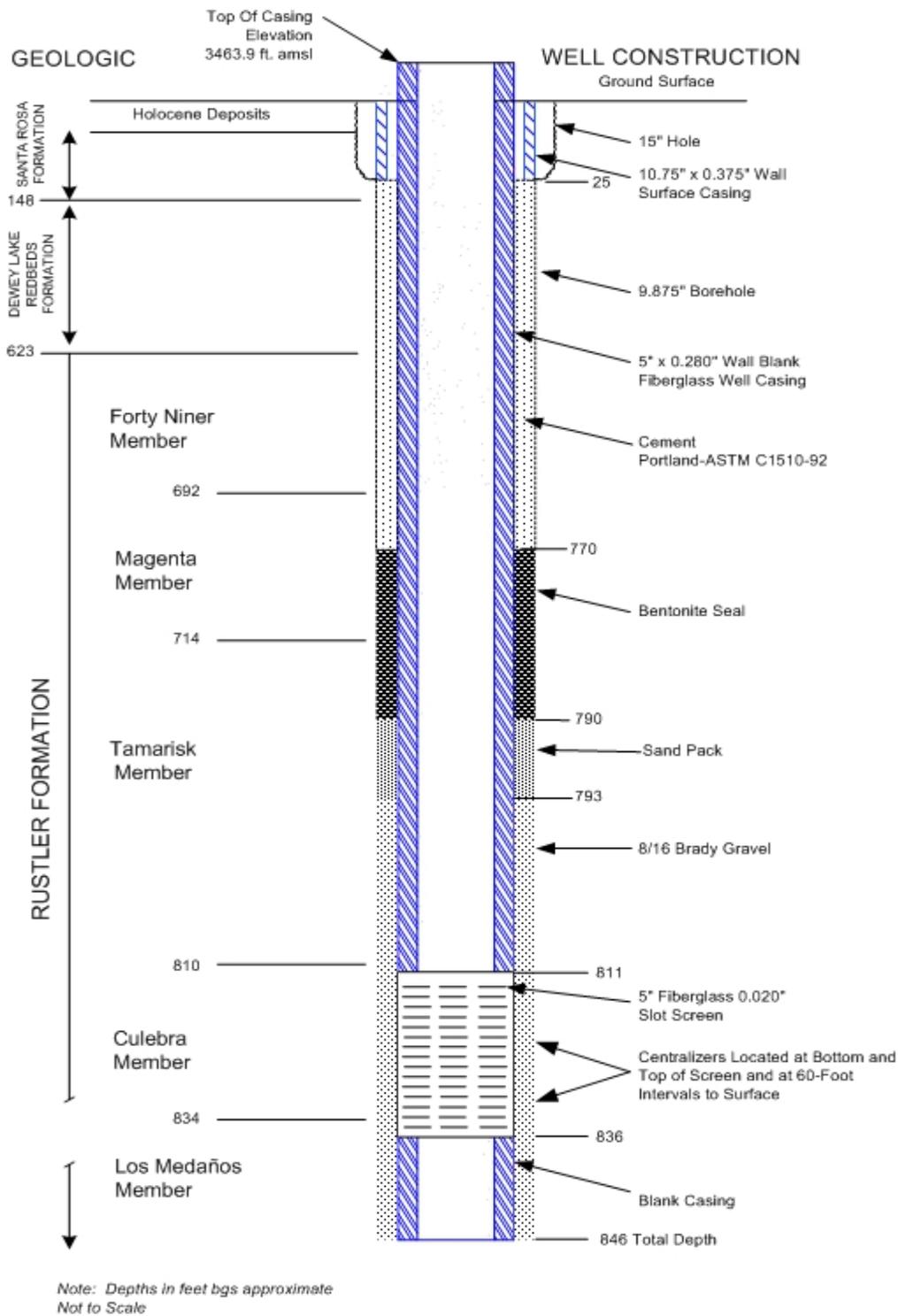
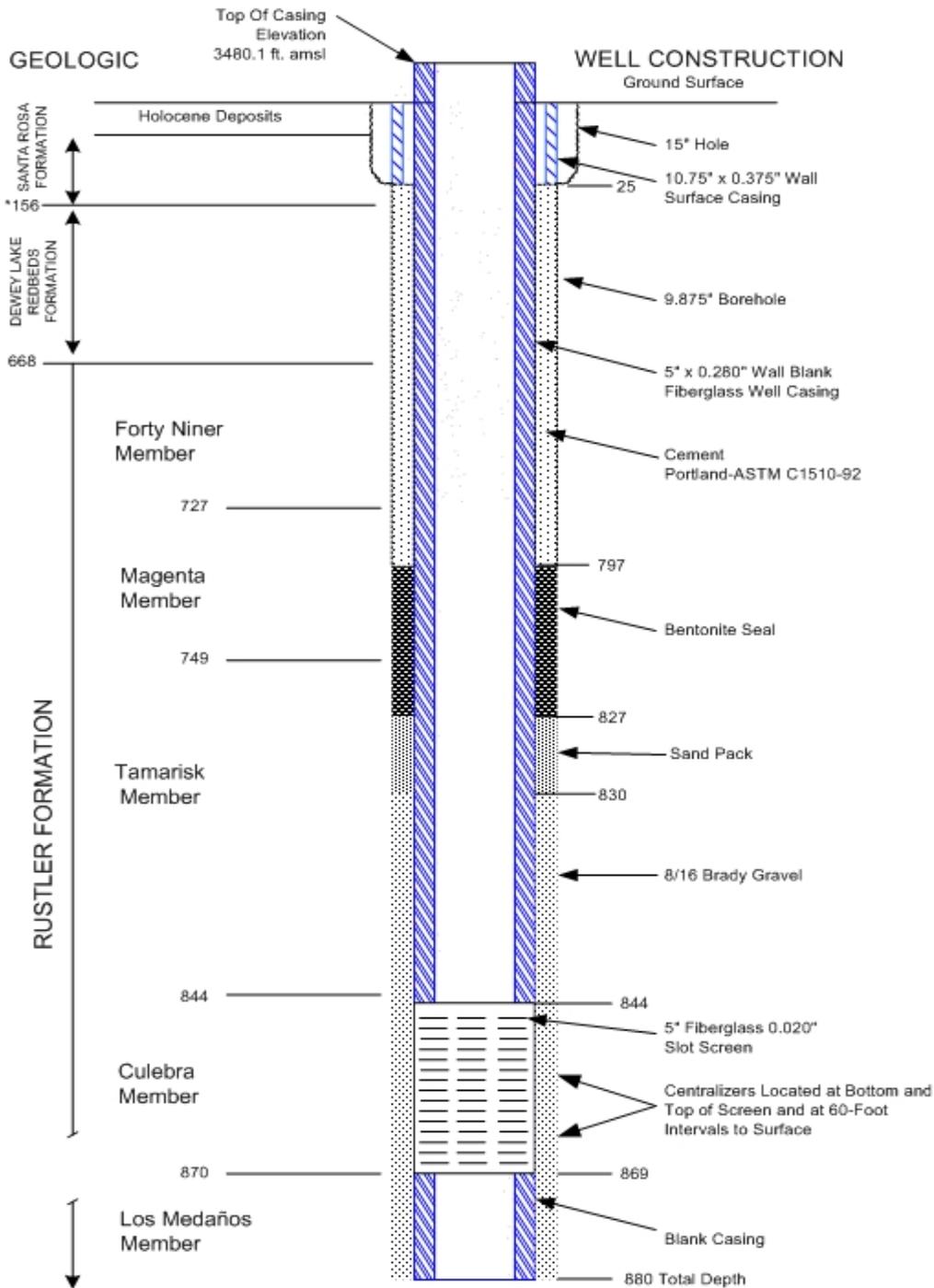


Figure L-8
As-Built Configuration of Well WQSP-2



Note: Depths in feet bgs approximate
 Not to Scale

*from DOE/WIPP-95-2154

Figure L-9
As-Built Configuration of Well WQSP-3

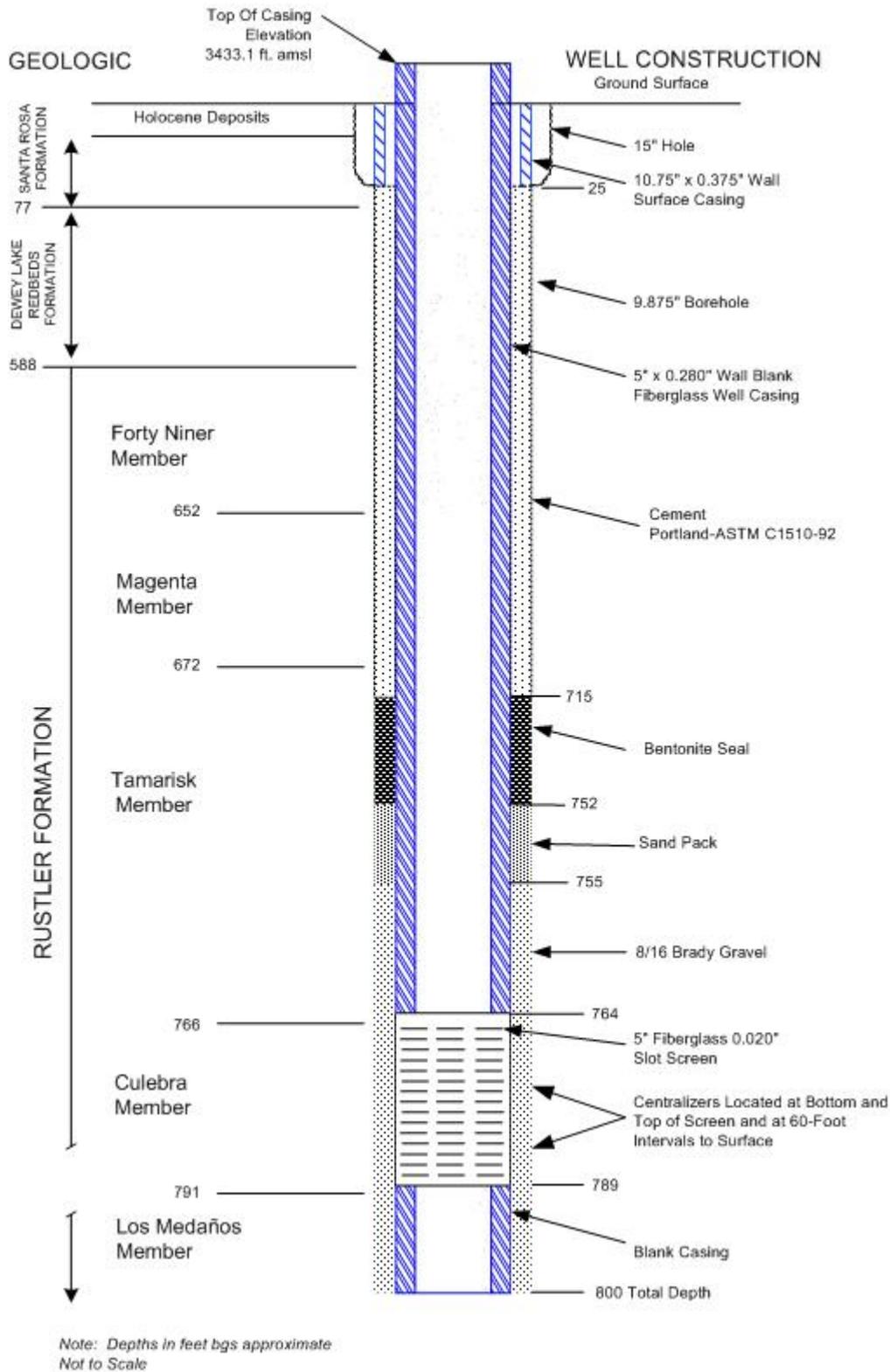
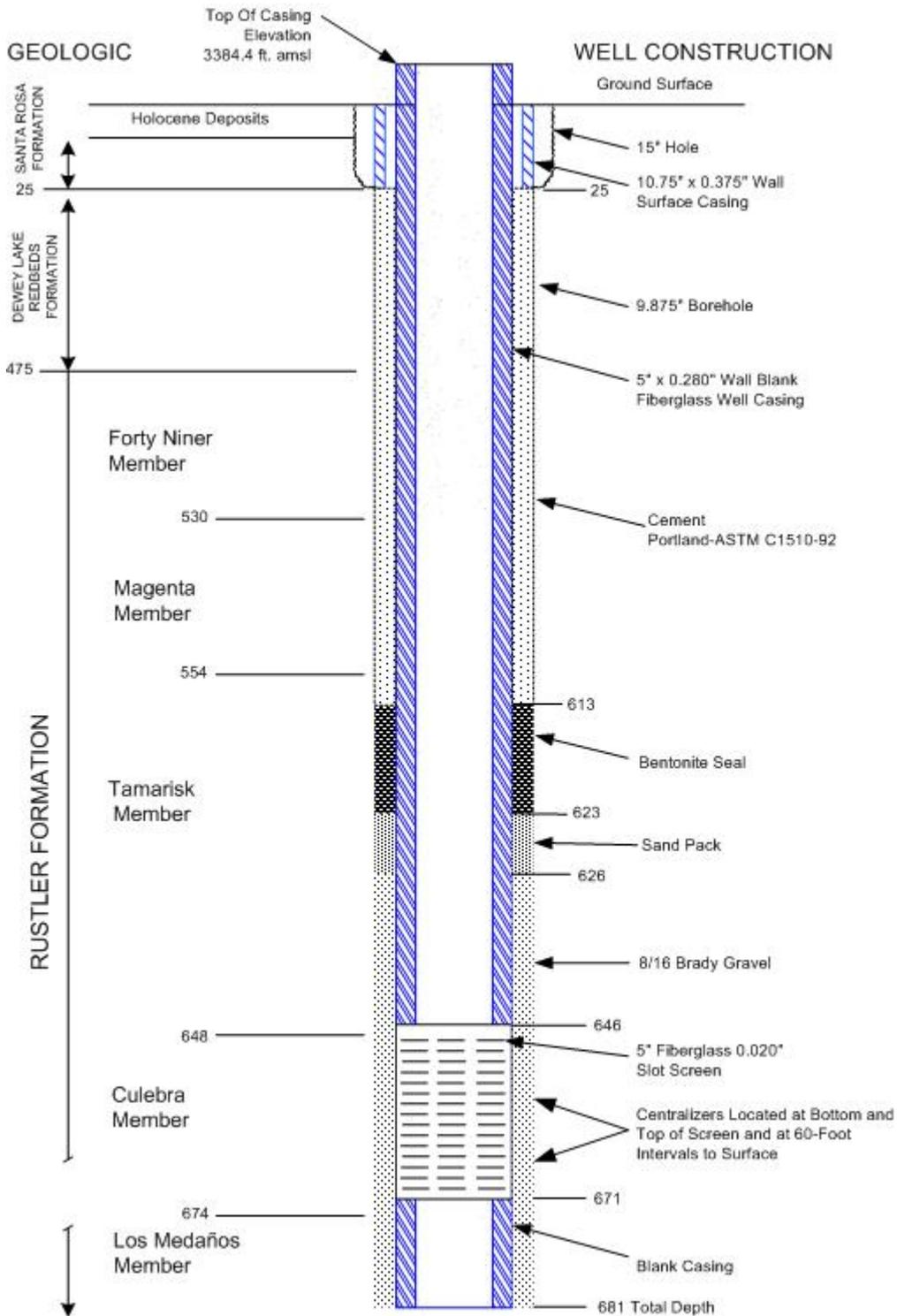
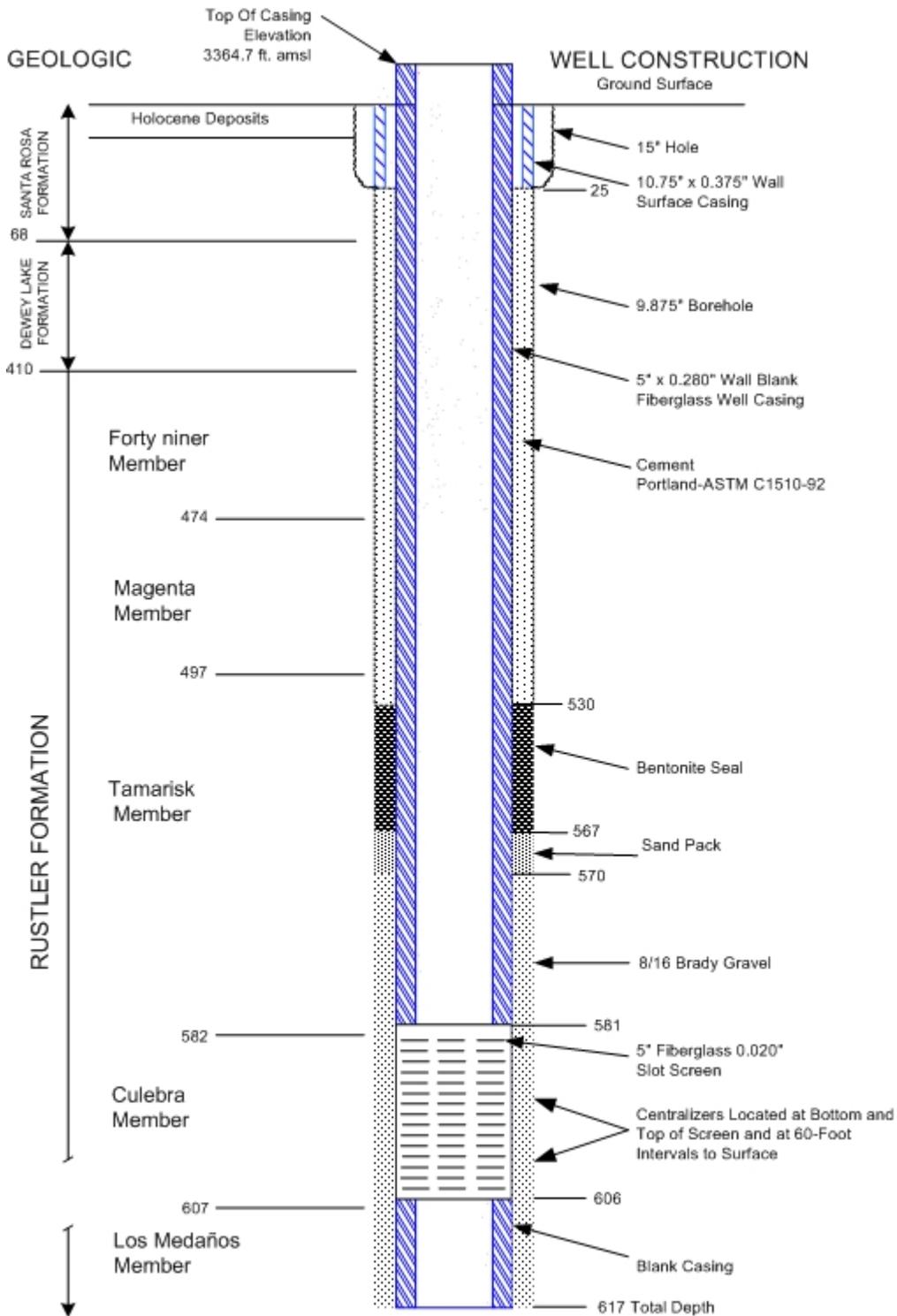


Figure L-10
As-Built Configuration of Well WQSP-4



Note: Depths in feet bgs approximate
 Not to Scale

Figure L-11
As-Built Configuration of Well WQSP-5



Note: Depths in feet bgs approximate
 Not to Scale

Figure L-12
As-Built Configuration of Well WQSP-6



CHAIN OF CUSTODY RECORD

Page ____ of ____

Project Number	Project Name:		Container Size / Request Analytes		Contract Laboratory				
	Date	Matrix	Time	Sample Number	Received By: (Signature)	Date / Time	Received By: (Signature)	Date / Time	
<p>Samplers:</p> <p>Relinquished by: (Signature)</p> <p>Relinquished by: (Signature)</p> <p>Requested Turnaround Time:</p> <p><input type="checkbox"/> Routine <input type="checkbox"/> Rush</p> <p>Sample Disposal:</p> <p><input type="checkbox"/> Return to Client <input type="checkbox"/> Disposal by Lab</p> <p>Carrier / Airbill No.:</p>									
Total Number of Containers				Received By: (Signature)		Date / Time	Received By: (Signature)		Date / Time
Sample Receipt Remarks:				Received By: (Signature)		Date / Time	Received By: (Signature)		Date / Time
Results To:				Relinquished By: (Signature)		Date / Time	Relinquished By: (Signature)		Date / Time
Special Instructions:				Received By: (Signature)		Date / Time	Received By: (Signature)		Date / Time

WHITE - Testing Laboratory
 AF - Air Filter(s)
 SF - Sediment
 YELLOW - Field copy
 AN - Animal(s)
 SO - Soil
 PINK - Record Copy
 DI - Deionized Water
 SW - Surface Water
 GW - Ground Water
 VG - Vegetation
 WP 02-EM3001, revision 00

Figure L-13
 Example Chain-of-Custody/Request for Analysis Form

