CLOSURE PLAN
FORMER SEWAGE TREATMENT PLANT (STP) DITCHES

SOLID WASTE MANAGEMENT UNIT (SWMU) 82
U.S. Army White Sands Missile Range, New Mexico

EPA ID # NM2750211235

New Mexico Environment Department – Hazardous Waste Bureau

FINAL

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TABLES

FIGURES

DEFINITIONS

Terms used in this Closure Plan shall have the same meanings as those in the Hazardous Waste Act (HWA), Resource Conservation and Recovery Act (RCRA), and their implementing regulations unless this Closure Plan specifically provides otherwise. Where a term is not defined in the HWA, RCRA, implementing regulations, or this Closure Plan the meaning of the term shall be determined by a standard dictionary reference, EPA guidelines or publications, or the generally accepted scientific or industrial meaning of the term.

List of Abbreviations

ASTM	American Society for Testing and Materials
bgs	below ground surface
CFR	Code of Federal Regulations
CMS	Corrective Measures Study
COC	Chain-of-Custody
COPC	Contaminant of Potential Concern
DAF	Dilution Attenuation Factor
DoD	Department of Defense
DQO	Data Quality Objectives
EPA	United States Environmental Protection Agency
eV	electron volt
ft	foot/feet
ft amsl	Feet Above Mean Sea Level
gal	gallon
GPS	Global Positioning System
HWA	Hazardous Waste Act
HWMU	Hazardous Waste Management Unit
IDW	Investigation Derived Waste
L	liter
MCL	Maximum Contaminant Level
mg/L	milligrams per liter

MPL	Main Post Landfill
NMED	New Mexico Environment Department
NMSSL	New Mexico Soil Screening Level
NOD	Notice of Disapproval
PID	Photoionization Detector
QA	Quality Assurance
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
SSG	Soil Screening Guidance
SSL	Soil Screening Level
STP	Sewage Treatment Plant
SVOC	Semi-Volatile Organic Compound
SWMU	Solid Waste Management Unit
TAL	target analyte list
TCLP	Toxicity characteristic leaching procedure
USCS	Unified Soil Classification System
USGS	U.S. Geological Survey
VOC	Volatile Organic Compound
WSMR	White Sands Missile Range
WTS	White Sands Technical Services
WQCC	Water Quality Control Commission

1. INTRODUCTION

This Closure Plan describes the activities necessary to close the hazardous waste management unit (HWMU) designated as the former Sewage Treatment Plant (STP) Percolation Ditches, Solid Waste Management Unit (SWMU) 82 at U.S. Army White Sands Missile Range (WSMR or the Permittee), hereafter referred to as the “STP Ditches” or “SWMU 82.” SWMU 82 is listed in Table 4-4 of the 2009 Resource Conservation and Recovery Act (RCRA) Permit (Permit) in Appendix 4. The information provided in this Closure Plan addresses the closure requirements specified in the Code of Federal Regulations (CFR), Title 40, Part 264, Subpart G and the New Mexico Hazardous Waste Act (HWA) and is consistent with the requirements outlined in the Permit. The Permittee submitted *Revision 2 Closure Plan SWMU 82, Former Sewage Treatment Plant Percolation Ditches (CCWS-62)*, dated January 2015; this Closure Plan is based on the information contained within the Permittee’s submittal.

WSMR is a United States Army Installation Management Command (IMCOM) Installation established in 1945. WSMR is the largest land area military installation in the United States, encompassing approximately 3,200 square miles of land in Doña Ana, Socorro, Lincoln, Otero, and Sierra Counties in south-central New Mexico. The installation is approximately 99 miles long (north to south) and 25 to 40 miles wide (east to west). WSMR was established on July 9, 1945, as White Sands Proving Ground (the name was changed in 1958) to be the nation’s testing range for the newly developed missile weapons. WSMR is located in the Tularosa Basin of south-central New Mexico, and portions of WSMR extend west into the Jornada del Muerto Basin. The headquarters (Main Post) area of WSMR is located at the southwestern corner of the installation, approximately 27 miles east-northeast of Las Cruces, New Mexico, and 45 miles north of El Paso, Texas. The main entrance to WSMR is on U.S. Highway 70, east from Interstate 25 at Exit 6 (Figure 1-1).

The Former STP Percolation Ditches (SWMU 82) are located 3 miles east of the WSMR Main Post Headquarters. SWMU 82 consists of two parallel, unlined earthen ditches located east of the Main Post STP and west of the Main Post Landfill (SWMUs 86 and 87). The ditches channeled secondary-treatment effluent from the STP into a natural shallow depression (impoundment area). The ditches and impoundment area served as evaporation/percolation beds for the STP effluent. Historic records show that effluent was discharged to the ditches and impoundment from 1958 through 1986. Because of the dates of use, SWMU 82 is considered a Hazardous Waste Management Unit (HWMU) and must be closed in accordance with 40 CFR § 265. Subpart G.

2. DESCRIPTION OF THE UNIT TO BE CLOSED

SWMU 82 consists of two subparallel ditches that extend from the location of the former headgate (splitter box) to, and including, the former impoundment area. See Figure 1-2. The effluent from the STP Ditches infiltrated to groundwater.

Total cyanide was first discovered during groundwater monitoring for the nearby Main Post Landfill (MPL), SWMUs 86 and 87. The MPL accepted nonhazardous waste from 1983 until 1996. Waste disposed at the MPL generally came from Main Post headquarters and residential units as well as south range areas including the High Energy Laser Systems Test Facility, the Small Missile Range, and the launch complexes. In 1996 WSMR started contracting sanitary waste pickup to off-range disposal operations. WSMR continues to use the MPL for disposition of demolition debris and asbestos containing waste.

From 1958 through 1967 treated sewage effluent was discharged from the STP and flowed in an easterly direction following a natural drainage channel into an impoundment area. From 1967 through 1986 effluent was diverted into the drainage ditches. Evidence of the natural drainage ditch and impoundment area has largely been overprinted by eolian sands, road construction, utility construction and other activities in the vicinity of the Main Post Landfill. Sewage effluent is now discharged via pipeline (constructed in 1986) to Davies Tank, a natural depression located approximately 3 miles southeast of the STP.

The nature and distribution of cyanide and other elevated constituent concentrations in groundwater monitoring wells at the MPL suggested that the source of the contamination was the STP Ditches rather than landfill leachate from the MPL. Through a records search, WSMR determined that photographic processing wastes discharged to the sewer system from 1980 to 1985 as the likely source of cyanide in the groundwater. The source of the cyanide contaminated wastewater was the photographic processing facility where ferrous cyanide was treated with ozone to produce ferrous cyanate that was discharged to the sewer system. When the cyanate was released to the STP Ditches it reacted with sunlight which caused a chemical reaction and formed cyanide. The wastewater infiltrated to groundwater in the area of the STP Ditches.

A groundwater recharge study was conducted in 1969 (Sedillo, 1969). At the time of the study approximately 600,000 gallons per day of sewage effluent was discharged to the drainage ditches. Infiltration measurements collected during the study indicated that nearly 224 million gallons per year of effluent percolated down to the groundwater from the drainage ditches and impoundment area. A USGS study conducted in 1988 (Risser, 1988) concluded that if 30% of the total volume of water pumped from the Post Headquarters wellfield was returned to the ground by seepage from wastewater effluent, an average of 664 acre-feet (216 million gallons) of effluent per year may have recharged the aquifer.

3. SUBSURFACE CONDITIONS

3.a. Geology and Soil

3.a.i. Regional Geology

WSMR lies within the Mexican Highland Section of the Basin and Range Province. This province is characterized by a series of tilted fault blocks forming longitudinal, asymmetric ridges, or mountains, and broad intervening basins. The geology of WSMR consists predominantly of the Tularosa Basin and surrounding mountain ranges. The San Andres, San Augustin, and Oscura Mountains border the Tularosa Basin on the west, and the Sacramento Mountains form the eastern border. A narrow region of north-south–trending, large-displacement normal faulting separates the mountains from the basin resulting in the change in relief across the missile range. The majority of WSMR property, including most test facilities, is located within the Tularosa Basin (WTS, 2006). The Tularosa Basin contains thick sequences of Tertiary and Quaternary age alluvial or bolson fill deposits. These sediments, more than 5,000 feet in thickness in some areas, primarily consist of silt, sand, gypsum, and clay weathered from the surrounding mountain ranges. The average elevation of the basin floor is 4,000 feet above mean sea level, and surface features consist of flat sandy areas, sand dunes, basalt flows, and playas (dry lake beds) (WTS, 2006).

The nature of the bolson-fill deposits varies both laterally and vertically throughout the Tularosa Basin. Coarse-grained, poorly-sorted sediments deposited near mountain fronts grade into fine-grained, well-sorted sediments toward the center of the basin (Kelly, 1973). Sediments farther from the mountain fronts also contain a greater percentage of clay and gypsum. Vertically, the sediments are reported to become finer-grained and more consolidated until reaching a laterally continuous clay unit about 1,000 feet below ground surface (bgs) (Kelly and Hearne, 1976). In general, the stratigraphy is represented by unconsolidated to partially consolidated, fine- to medium-grained sand with subordinate amounts of clay. Caliche is present as discrete layers and nodules throughout the stratigraphic section. Although no faults within the basin fill are mapped within the immediate area, Quaternary faulting is known to exist within the region. These faults are reported to occur within the unconsolidated bolson sediments, trend north to south, and are most common near the mountain fronts. Orr and Myers (1986) divide the Tularosa Basin Fill deposits into five distinct mappable units that consist of the following: Coarse- to fine-grained deposits occur in gently sloping alluvial fans along the basin margin. The alluvial fans spread outward from the surrounding mountain slopes and coalesce into flat alluvial plains toward the basin interior. These fan deposits interfinger with lacustrine and alluvial deposits of the central part of the Tularosa Basin. Fine-grained sediments formed from lacustrine deposition extend throughout most of the Tularosa Basin. These deposits consist mainly of clay and evaporites with minor sand beds and occur near surface in the northern part of the basin and at depth in the southern part of the basin. Fluvial-eolian sand, gravel, and clay deposits are present in the southern part of the basin, near Fort Bliss, extending from the Organ and Franklin Mountains south to the Hueco Mountains. Gypsiferous evaporite deposits of the Lake Lucero-White Sands area occupy WSMR and areas administered by WSMR including the Lake Lucero area and the alkali flats north of Lake Lucero. These deposits occur as dense recrystallized gypsum, gypsum sand dunes, and alluvial deposits. Hard caliche (cemented with recrystallized gypsum) is present at or near surface in the dry lake gypsum deposits of the central portion of the basin. Coarse-grained deposits saturated with saline water are present in the central portion of the Tularosa Basin.

3.a.ii. Site-Specific Geology

The STP Ditches are located on the distal portion of an alluvial fan extending eastward from the Organ Mountains. Near-surface geology in the vicinity of the effluent drainage ditches and MPL consists of unconsolidated alluvial sand, gravel, and loam up to a depth of about 15 feet bgs. Below 15 feet is older Quaternary and Tertiary alluvial material, which consists of unconsolidated discontinuous deposits of gravelly sand, sandy silt and silty sand, clay, and occasional caliche seams. These sediments make up part of the alluvial fans extending into the Tularosa Basin from the Organ, San Agustin, and San Andres Mountains.

3.b. Hydrogeology

3.b.i. Regional Hydrogeology

Surface hydrogeology at WSMR is characterized by low precipitation, high evapotranspiration rates, and high soil infiltration. During the summer season, when thunderstorm activity is most common, playas within the basin may contain standing water. The arroyos that drain the surrounding mountain ranges usually contain water only following heavy precipitation events. The Tularosa Basin is a closed basin with no surface water drainage outside of WSMR (WTS, 2006). The WSMR Main Post obtains its potable water supply from an aquifer in the upper bolson deposits. The majority of the groundwater recharge to this aquifer occurs through the coarse, unconsolidated Tertiary/Quaternary alluvial fan deposits and arroyos along the eastern flank of the Organ, San Augustin, and San Andres Mountains. This aquifer consists of a wedge-shaped belt of potable water more than 30 miles long from north to south and three to five miles east of the mountain front. Groundwater in the vicinity of the Main Post is of sufficient quality (i.e., less than 1,000 milligrams per liter [mg/L] total dissolved solids [TDS]) for human consumption. McClean (1970) reported this freshwater zone extends downward to approximately 1,800 feet bgs. Recharge to the regional aquifer is from precipitation over the mountain ranges and alluvial fans, which border the bolson on the west (WTS, 2006). This precipitation infiltrates the unconsolidated, relatively coarse deposits of the alluvial fans, and the resultant groundwater flows toward the center of the Tularosa Basin, generally to the east-southeast. To the east, groundwater becomes more mineralized, primarily with sulfate and chloride, most likely due to the slow lateral migration rate of groundwater from recharge to discharge areas in the presence of readily soluble minerals in the alluvial sediments. However, groundwater flow direction within the western Tularosa Basin region is presumed to discharge to the south as underflow into the contiguous, northern Hueco basin of western Texas. Groundwater discharge to seeps or springs have not been reported within the western Tularosa Basin (WTS, 2006).

3.b.ii. Site-Specific Hydrogeology

Depth to groundwater in the vicinity of the STP ditches ranges from 250 feet bgs at the western end of the ditches to 210 feet bgs near the former impoundment areas (MEVATEC, 1997b). Mapping of the potentiometric surface in the area shows groundwater flow to the southeast (Figure 2-3). The December 2012, the groundwater gradient ranged from approximately 0.0007 feet per foot (ft/ft) southeast of the MPL to 0.02 ft/ft west of the STP.

The aquifer beneath the STP is largely unconfined, but potentiometric surface readings obtained by MEVATEC during March 1999 in three nested well groups indicated the presence of a slight downward gradient in the upper 200 feet of the saturated zone that is somewhat more pronounced between the mid- and deep-level wells (MEVATEC, 1999). Measurements collected from the nested wells from August 2010 through December 2012 confirm this observation.

3.c. Groundwater Transport

Values reported for hydraulic conductivity (K) in the area of the STP and MPL range from a basin-wide median value of 6.8 feet per day (ft/day) to a single value reported from a pump test near the STP of 3.3 ft/day (Risser, 1988). Slug tests performed by the U.S. Geological Survey (USGS) in 13 monitoring wells showed hydraulic conductivities ranging from 0.003 ft/day to 10.6 ft/day, with a geometric mean of 0.69 ft/day. The groundwater hydraulic gradient in the area of SWMU 82 is generally eastward or east-southeastward and ranges from 0.02 upgradient of the STP to 0.0007 east-southeast of the MPL based on the December 2012 potentiometric data shown on Figure 2-3. The gradient is essentially flat in the area of MPL28, MPL07, and MPL17, southeast of the impoundment area based on the December 2012 measurements. In the area of SWMU 82, calculated mean groundwater transport velocity ranges from 0.039 ft/day (approximately 14 feet per year [ft/yr]) west of the STP to 0.0014 ft/day (approximately 0.51

ft/yr) downgradient of the site. This estimate is based on the geometric mean K value of 0.69 ft/day calculated by the USGS and conservatively assumes an average aquifer porosity of 0.35:

$$v = 0.69 \times 0.02/0.35 = 0.039 \text{ ft/day}$$
$$v = 0.69 \times 0.0007/0.35 = 0.0014 \text{ ft/day}$$

At this estimated velocity, contamination at the site would likely travel less than 1 ft/yr in the area downgradient of the plume. Movement of contaminants in the aquifer may also occur in the vertical direction; however, it is estimated that due to geological stratification, K values in the vertical direction range from 10 to 1,000 times lower than the horizontal K values (Risser, 1988).

4. GENERAL CLOSURE INFORMATION

Many of the requirements for closure have been completed at SWMU 82; therefore, this Closure Plan summarizes past cleanup activities and investigations and addresses the actions remaining to be performed. The site has been investigated, the source of cyanide has been identified and eliminated, and impacted surface soils have been removed. As part of closure additional groundwater monitoring wells must be installed and the cyanide groundwater plume must be further delineated.

Both the New Mexico Water Quality Control Commission (WQCC) limit and the EPA Maximum Contaminant Limit (MCL) for cyanide in groundwater is 0.2 mg/L. In order for SWMU 82 to be clean closed, the groundwater concentration levels for cyanide must be below these limits. The Permittee considers No Action with Monitoring as the best choice for groundwater remediation after evaluation of in situ and ex situ alternatives. No action with monitoring is considered to be protective of human health and the environment, because there are no current receptors for groundwater and there is no planned development of this groundwater. The WSMR water supply is hydraulically separated from the contaminated zone. Institutional controls supplement natural degradation processes to ensure protection of human health and the environment. Any active measures would be very costly due to the nature and extent of the contaminated groundwater and the hydrogeologic setting.

4.a. Historical Investigation and Remediation Activities

4.a.i. Phase I RCRA Facility Investigation

A Phase I investigation, conducted in 1992, included the collection of 41 surface and near-surface soil samples along the length of the percolation ditches. Chromium was the only constituent detected above applicable soil screening levels (SSLs) (the actual concentration was not specified in the report) in four 1-foot depth sampling locations. Cyanide was detected (in concentrations ranging from 0.16 to 15 mg/kg) in almost all of the samples collected from the surface and from the 1- and 2-foot bgs depth along the length of the drainages. The original natural drainage channel was not investigated as part of the investigation.

4.a.ii. Phase II RCRA Facility Investigation

Conducted in 1994, the Phase II investigation included nine soil borings advanced to 2 feet bgs along the length of the percolation ditches and two 10-ft borings located near the splitter box. Only chromium was detected above applicable SSLs in two surface samples; however, the samples contained no detected levels of chromium in the TCLP analysis. Total cyanide was detected in most of the surface soil samples with concentrations ranging from 0.73 to 8.22

mg/kg. Total cyanide was reported in one groundwater sample collected from groundwater monitoring well T29 (located approximately 100 yards northeast of the drainage ditches) at a concentration of 0.229 mg/L. The original natural drainage channel was not included in the Phase II investigation.

4.a.iii. Surface Soil Excavation

In response to the Phase I and Phase II investigation results, approximately 4,000 cubic yards of surface soil were excavated from the parallel drainage ditches and impoundment area in 1997. The excavation primarily addressed the elevated chromium concentrations in the soils. Confirmation samples were collected after the excavation and results indicated that contaminant concentrations in the samples were below the EPA human health risk screening levels (EPA, 1996). The edges of the shallow excavation were graded; there is no mention of the use of backfill.

4.b. Groundwater Monitoring

STP Ditches groundwater monitoring and groundwater monitoring at the MPL are interrelated, because of STP Ditches influence on groundwater contamination in the MPL groundwater monitoring wells. It is likely that the extent of the cyanide contamination in groundwater is a result of the mounding that occurred during active use of the STP Ditches. Treated effluent was released to the land surface from 1958 to 1986 at rates of approximately 600,000 gallons per day or 220 million gallons (600 acre-feet) per year. The discharge may have caused groundwater elevations to rise to 50 feet below the ground surface, compared to the current groundwater level of approximately 200 feet below the ground surface. Once the discharge ceased, the groundwater elevations returned to near-normal conditions. Mound-driven flow or perched system flow are two possibilities that could explain how the cyanide contaminated groundwater moved laterally from the STP Ditches at greater velocities than the current groundwater flow estimates.

Groundwater monitoring at the MPL from 1996 to 1997 included monitoring and sampling of one upgradient groundwater monitoring well (MPL-01) and three downgradient locations (MPL-02, MPL-03, and MPL-04). Total cyanide was detected in samples from both the upgradient and downgradient wells ranging from 0.23 to 0.64 mg/L. The results for TDS, chloride, sulfate, and nitrate/nitrite all exceed background for the aquifer.

The results of the MPL groundwater monitoring prompted a study to provide additional information about the extent and possible sources of cyanide in the groundwater (MEVATEC, 1997). Five groundwater monitoring wells (MPL-05 through MPL-10) were installed. Groundwater samples were collected from those wells as well as the existing groundwater monitoring wells. The study concluded that the groundwater contamination originated from the former effluent drainage ditches and impoundment areas rather than from landfill leachate.

In 1999, 17 additional groundwater monitoring wells were installed to delineate the lateral and vertical extent of groundwater contamination. Soil samples were collected at areas that may have contributed to concentrations of cyanide in groundwater. Six groundwater monitoring wells were constructed to monitor groundwater at the potentiometric surface; three at intermediate depths (top of well screen 50 to 100 feet below the potentiometric surface); and three at deeper intervals (top of well screen greater than 200 feet below the potentiometric surface). The remaining wells were installed to monitor the groundwater interface (water table) at locations peripheral to the existing well network.

Two unusual features were identified during this investigation. A sharp increase in the depth to groundwater was noted between monitoring wells on either side of a line that extends roughly north-south in the vicinity of the STP. Monitoring well MPL-26 contained a groundwater table elevation of 3885.25 ft and monitoring well MPL-25 contained a groundwater table elevation of 3825.21 ft; the wells are approximately 2000 ft apart with a 60 ft water table elevation difference.

In 2004 NMED required three additional monitoring wells to be installed and sampled and required additional monitoring and sampling of a sentinel well. The three new wells (MPL-28, MPL-29, and MPL-30) were installed in 2005 and the sentinel well (T40) was selected as the downgradient sentinel well.

4.c. Contaminant Status

The source of cyanide no longer exists. Once the photo processing facility ceased use of the ferrous cyanide and the Permittee stopped discharging waste water to the STP Ditches and conducted soil removal, the source of the cyanide was removed. Cyanide species are anionic and very soluble in water. Given the low clay content of the soils in the area of the STP and the large quantity of wastewater discharged to STP Ditches little to no cyanide likely remains in the vadose zone soils. The concentrations of cyanide detected in groundwater are relatively steady and confirm that no on-going source of contamination remains at the site.

Total cyanide is the regulated parameter and the most comprehensive indicator of contaminant occurrence. Free cyanide is one of the key measures of the progress of natural attenuation, but its presence is difficult to confirm. As free cyanide forms, it can volatilize from the groundwater system to the vadose zone. While the concentration of free cyanide fluctuates with changes in barometric pressure or other, non-chemical changes, the presence of free cyanide is evidence that natural attenuation is occurring. The occurrence and concentrations of other cyanide species, such as amendable cyanide, reveal no apparent coherent pattern or trend over time. Interactions with the vadose zone can cause fluctuations in the concentrations of the various species, so any fluctuations in the concentration of amendable or weakly associable forms will not contribute significantly to vadose zone cyanide gas concentrations. Given the depth to groundwater and the slow decline of the total cyanide groundwater concentrations, accumulation of vadose zone cyanide gas concentrations is not considered a threat to human health or the environment.

The dominant processes involved in plume degradation are likely to be biological or abiotic degradation of cyanide. Dilution and dispersion are likely to attenuate cyanide concentrations as well. The collection of additional geochemical data over a longer time frame may allow a more complete demonstration of degradation processes.

4.c.i. Contaminant Movement

The average regional horizontal groundwater gradient ranges from 0.02 upgradient of the STP to 0.0007 east-southeast of the MPL. Estimated mean groundwater transport velocity ranges from approximately 14 ft/yr upgradient of the STP to approximately 0.51 ft/yr downgradient of the impoundment area. This suggests up to a few hundred feet or movement of the mass of contaminants over a 50 year period. The cyanide plume is expected to remain within the boundaries of WSMR throughout any relevant time frame (i.e., until degradation below regulatory limits are achieved). In addition, the boundary between the Tularosa Basin and the Hueco Bolson (the adjacent groundwater body) is within Fort Bliss; therefore, the affected groundwater will always be within land under federal jurisdiction. As previously discussed, there is a steep slope to the potentiometric surface to the west of the STP that seems to preclude migration of the plume in the direction of the Main Post wellfield. Monitoring of wells MPL26 and MPL25 on either side of that slope will continue as part of the proposed monitoring program and any changes to the groundwater slope will be evaluated in future monitoring reports.

4.c.ii. Geochemical Data Evaluation

Cyanide biodegradation is limited to free and weak acid dissociable cyanide. Cyanide can be used as either the sole nitrogen or the sole carbon source for microbial growth. The dominant cyanide degradation mechanism in commercial treatment systems is oxidation to separate the carbon and nitrogen, forming carbon dioxide and ammonia. Once ammonia is produced, it is then available as a nitrogen source and can be incorporated into the cell mass or as an electron donor substrate for obligate aerobic nitrifying bacteria. While the 2004 CMS (BAE Systems, 2004) indicated that it is impossible to distinguish the minor amount of nitrogen content associated with cyanide and its daughter products (e.g., ammonia) from the greater amount of nitrogen originating from recharged sewage effluent, it is possible to evaluate electron donors and biological indicators for additional evidence of biological processes supportive of cyanide degradation. In the previous sampling events biological degradation parameters such as dissolved oxygen (DO), oxidation-reduction potential (ORP), and acidity (pH), were not evaluated to determine whether anaerobic or aerobic conditions prevailed at the site. Nor were other natural attenuation parameters obtained to evaluate whether microbial processes favorable to cyanide degradation were present at the site. During the August 2010 through December 2012 sampling events, field parameters were collected and additional chemical analyses were performed to evaluate evidence supporting cyanide biodegradation. Monitoring and analysis for TOC, DO, ORP, alkalinity, conductivity and pH are included as part of the closure groundwater monitoring program. Sulfate concentrations are also elevated within the plume and most likely result from the sewage release. Because the concentrations are higher within the plume center, it is unlikely that significant sulfate reduction is present. Sulfate concentration trends will be evaluated to determine whether a downward trend in concentration develops.

4.d. Groundwater Monitoring Wells

Currently, there are a total of 26 groundwater monitoring wells in the groundwater monitoring program. See Table 1 for a list of monitoring wells. The wells are gauged and sampled semi-annually for dissolved ions, nitrate/nitrite, ammonia, total cyanide, free cyanide, target analyte list (TAL) metals, and mercury.

Groundwater monitoring wells that do not contain detectable concentrations of cyanide are MPL-11, MPL-12, MPL-18, MPL-19, MPL-21, MPL-22, MPL-23, MPL-25, MPL-26, MPL-27, SW-01, SW-02, SW-03, SW-04, and T-40. MPL-22 is an intermediate depth well, MPL-19, MPL-21, and MPL-23 are deep wells and the rest of the wells are screened at the water table.

There are three sets of nested wells: MPL-03 cluster (MPL-03, MPL-19, and MPL-20) at the center of the plume, MPL-05 cluster (MPL-05, MPL-21, MPL-22) northeast section of the plume, and MPL-10 cluster (MPL-10, MPL-23, MPL-24) northwest section of the plume. The deep nested wells do not contain detectable concentrations of cyanide. The MPL-03 cluster of wells is in the heart of the high concentration area of the cyanide plume. MPL-03 and MPL-20 are screened at the water table and intermediate depth range respectively, and concentrations of cyanide in both wells exceed the MCL. MPL-19 is a deeper well, measuring the aquifer below 200 feet. Cyanide has not been detected in this well which indicates the plume is not moving deeper in this area. The MPL-05 cluster consists of well MPL-05 which intersects the water table, MPL-22 is screened at intermediate depth, and MPL-21 is the deep well (200+ feet bgs). Well MPL-05 contains elevated concentrations of cyanide that are below the screening limits and wells MPL-21 and MPL-22 do not contain detectable concentrations of cyanide. In regard to the MPL-10 cluster, well MPL-10 is a water table monitoring well and MPL-24 is an intermediate depth well, and both contain cyanide at concentrations that exceed the MCL of 0.2 mg/L. MPL-23 is the deep well and does not contain detectable concentrations of cyanide.

The groundwater monitoring wells with concentrations of cyanide above the MCL and the WQCC limit include monitoring wells MPL-01, MPL-02, MPL-03, MPL-04, MPL-07, MPL-10, MPL-13, MPL-20, MPL-24, MPL-28, MPL-29, and MPL-30.

5. CLOSURE PROCEDURES

5.a. Installation of Additional Groundwater Monitoring Wells

Additional wells shall be installed at the following locations (see Figure 2-3 for approximate locations):

1. one approximately 1,200 feet south-southeast of MPL-30 with screened intervals intersecting the water table;
2. one approximately 1,200 feet east of MPL-07 with screened intervals intersecting the water table to further characterize the extent of cyanide south and east of MPL-17; and
3. a set of nested monitoring wells approximately 1,200 feet north-northeast of the MPL-10/MPL-24 cluster at a depth similar to MPL-10 and MPL-24 to further evaluate cyanide concentrations to the north and west of MPL-10 nested wells.

The wells shall be added to the current monitoring program and sampled on a quarterly basis for one year. Depending on the results of the first year of sampling, the wells may be sampled semi-annually thereafter. If implementation of the well installation is not completed during closure, then the Permittee must propose to complete the well installation in the Post-Closure Care Plan. Based on the results of the sampling of the monitoring wells, installation of additional monitoring wells may be required under Post-Closure Care.

Additionally, wells MPL-08, MPL-11, MPL-12, MPL-14, MPL-27, and SMW-02 must be added to the monitoring for groundwater level and field parameter measurements only (see Table 1).

5.a.i. Groundwater Monitoring Well Drilling and Installation

Groundwater monitoring well installation shall be conducted in accordance with Appendix 6, Section 6.3 of the Permit (NMED, 2009a). Groundwater monitoring wells shall be drilled using

Air Rotary Casing Hammer (ARCH) techniques with a minimum 8 in diameter borehole. Monitoring wells shall utilize 4- in inside diameter, schedule 40, polyvinyl chloride (PVC) well casing with 20-ft long PVC 0.010-slot well screens appropriate for the lithologic conditions installed within the borehole. The wells shall be screened across the water table, with a minimum 5 ft of screen above the water and 15 ft below. Actual depth of the screened interval shall be determined in the field. The bottom of the well screen shall be capped using either a flush threaded end cap or slip cap that is secured with stainless steel screws. Well casing and screen shall be installed through the drill pipe and centered in the borehole. Monitoring well installation procedures are detailed as follows:

1. Appropriate personal protective equipment shall be worn in accordance with the Site Safety and Health Plan.
2. The borehole will be drilled to the total depth for the well to be installed using an ARCH drilling rig. Temporary surface casing to the water table will be used to stabilize the upper portion of the drill hole and be pulled back as filter pack and bentonite-cement grout are installed.
3. The appropriate depth of the boring will be determined in the field and is dependent on water table depth. When groundwater is encountered during drilling, drilling will cease, and the water level will be allowed to equilibrate for approximately one hour to determine the water table elevation.
4. If the boring is advanced beyond the bottom of the proposed sump elevation by more than 10 ft, the borehole will be backfilled with filter pack material to an elevation approximately 5 ft below the bottom of the sump.
5. The well will be constructed within the borehole using a 1-ft sump, 20 ft of Schedule 40, PVC, 0.010-in, slotted screen, and Schedule 40, PVC blank casing to the top of the well stick-up. The top of the screened interval will be approximately 5 ft above the existing water table.
6. While slowly removing the drill casing from the borehole, the borehole annular space will be backfilled from a maximum of 2 ft and minimum of 0.5 ft below the bottom of the sump to a minimum of 2 ft above the well screen with a filter pack (10/20 silica sand). A 1- to 2-ft layer of chemically inert fine sand (20/40 sand) will be placed directly above the filter pack. The filter pack will be placed using a tremie pipe to avoid bridging and ensure a continuous filter pack throughout the screened interval of the well. The well may be gently surged to breakup bridging and ensure complete placement of the filter pack around the well screen.
7. Next, a bentonite chip seal will be installed for a minimum thickness of 5 ft. The bentonite chips will be hydrated with potable water every 1-ft lift to ensure a competent seal. The thickness of the seal will be dependent on the lithology of the aquifer formation such that the bentonite seal extends from the top of the filter pack to within 5 ft of the most fine-grained unit above the well screen.
8. A 20 percent, high-solids, bentonite, grout mixture will be installed over the bentonite seal using a tremie pipe. The mixture will consist of 20 percent by weight of sodium bentonite powder. The bentonite grout will be installed to within 5 ft of the surface.
9. To the surface, a cement/bentonite grout mixture will be installed over the highsolids bentonite grout using a tremie pipe. The mixture will consist of 94 pounds of Portland

cement to 7 gallons of approved water and 3 percent by weight of sodium bentonite powder.

10. Surface completions for the wells will follow Appendix 6, Section 6.3.6 of the Permit and will follow requirements for either flush mount or above ground completions.
11. The well will be equipped with a security lock. All locks will be keyed alike. The well will be tagged with a corrosion-resistant, identification stamped on the protective casing that identifies the well number, depth, date of installation, and the adjusted top of casing elevation. The well also will be clearly designated as a monitoring well. If the completion is above ground, the protective casing will be coated with protective paint as required by the base.

5.a.ii. Groundwater Monitoring Well Development

Groundwater monitoring well development shall follow guidelines outlined in Appendix 6, Section 6.3.5 of the Permit (NMED, 2009a). Following construction, each well will be developed to maximize yield and minimize turbidity of the water. Wells will be initially developed using a bailer and vented surge block. Pumps may also be used to develop the well. Well development will not commence until the grout seal has been in place and allowed to set-up for a minimum of 48 hours but no longer than 7 days after placement of the casing collar. During development, a minimum of five well bore volumes plus filter pack volume or water will be removed. In addition, any water added during drilling or construction will be included in the volume to be removed (five times the volume of potable water added). During well development, the discharged water will be sampled for turbidity, pH, temperature, and specific conductance. Wells will be considered adequately developed when the water produced is sand free and clear (turbidity <10 nephelometric turbidity units) and pH, temperature, and specific conductance have stabilized to plus or minus 10 percent between two consecutive readings. If water is introduced to a borehole during well drilling and completion, then the same or greater volume of water will be removed from the well during development. In addition, the volume of water withdrawn from a well during development will be recorded.

5.b. Logging of Soil Borings

As the new groundwater monitoring wells are advanced, detailed soil borings shall be produced in accordance with Permit Section 5.2.2.c (Logging of Soil/Rock and Sediment Samples). Soil cores shall be examined visually and the soils shall be described according to the Unified Soil Classification System (USCS), American Society of Testing and Materials (ASTM) Standard D 2487 and D2488 at 10 feet above the estimated water table and then continuously to ten feet below the water table. A detailed log of each boring shall be recorded in the field by a qualified geologist or engineer.

6. GROUNDWATER SAMPLING AND ANALYSIS PLAN

Data collected as part of the groundwater monitoring for the STP Ditches will be used to also monitor the Main Post Landfill. Specifically, groundwater monitoring wells MPL-01, MPL-02, MPL-03, and MPL-04 are used to monitor the MPL groundwater monitoring.

All groundwater monitoring shall be conducted in accordance with Permit Section 5.2.2.h (Groundwater Monitoring).

6.a. Groundwater Monitoring and Sampling

Table 1 lists the wells currently included in the groundwater monitoring program at SWMU 82, and Table 2 summarizes the required water sample chemical analyses.

Monitoring equipment to be used includes various nitrogen gas-powered bladder pumps and controllers for low-flow sampling. Discharge tubing is dedicated to each well, separately bagged and labelled between events. For the shallower wells, pumps with disposable bladders are used so that only new parts contact the sample. For the deeper wells (greater than 300ft) a high-lift bladder pumps are used and decontaminated between wells.

Groundwater samples shall be obtained from each well after a sufficient amount of water has been removed from the well casing to ensure that the sample is representative of formation water. Groundwater samples shall be obtained using methods approved by NMED within twenty-four hours of the completion of well purging. Sample collection methods shall be documented in the field monitoring reports. The samples shall be transferred to appropriate, clean, laboratory-prepared containers provided by the analytical laboratory. Sample handling and chain-of-custody procedures are described in Permit Appendix Section 5.2.2.j. Decontamination procedures shall be established for reusable water sampling equipment as described in Permit Appendix Section 5.2.3. Groundwater samples intended for metals analysis shall be submitted to the laboratory as total metals samples. If required by NMED, the Permittee shall obtain groundwater samples for dissolved metals analysis to be filtered using disposable in-line filters with a 0.45 micron or other mesh size approved by NMED.

The Permittee shall submit all samples for laboratory analysis to accredited contract laboratories. The laboratories shall use the most recent EPA and industry-accepted extraction and analytical methods for chemical analyses for target analytes as the testing methods for each medium sampled. The Permittee shall use the most sensitive laboratory methods (with the lowest detection limits) available unless specific conditions preclude their use.

6.a.i. Quality Assurance/Quality Control Sampling

Field QA/QC samples shall be collected at the frequencies described below in general accordance with Permit Appendix 5.2.2.i.

Equipment rinsate blanks shall be obtained for chemical analysis at the rate of five percent but no fewer than one rinseate blank per sampling day. Equipment rinsate blanks shall be collected at a rate of one per sampling day if disposable sampling apparatus is used. Rinsate samples shall be generated by rinsing deionized water through unused or decontaminated sampling equipment. The rinsate sample then shall be placed in the appropriate sample container and submitted with the groundwater or surface water samples to the analytical laboratory for the appropriate analyses

6.a.ii. Decontamination Procedures

All down-hole boring equipment and all reusable sampling equipment will be decontaminated in accordance with the procedures in Appendix 5, Section 5.2.3 of the Permit prior to use at each boring and sampling effort. Decontamination will be conducted at a designated on-site location. The decontamination area will be lined with polyethylene sheeting to contain incidental spills.

Larger drilling equipment that may come in contact with the borehole will be decontaminated using high-pressure water wash. All decontamination fluids shall be contained on site pending testing for disposal.

To the extent possible, disposable sampling equipment will be used to collect soil and groundwater samples. All reusable equipment (e.g., split barrel samplers, sampling spoons) will be decontaminated using the following procedures:

1. Brush equipment with a wire or other suitable brush, if necessary, to remove large particulate matter;
2. Rinse with potable tap water;
3. Wash with nonphosphate detergent (e.g.,Liqui-Nox®);
4. Rinse with tap water
5. Double rinse with deionized water.
6. All decontamination solutions shall be collected and stored temporarily in drums
7. Decontamination procedures and the cleaning agents used will be documented in the daily field log.

6.a.iii. Instrument Calibration

Field instruments will be calibrated to the manufacturer's specifications in accordance with Permit Appendix 5, Section 5.2.4d. Calibration checks will be conducted at a minimum of every 4 hours during field activities. If the calibration check indicates that the measurements are off by more than five percent of the gas standard's concentration, the instrument will be re-calibrated until the measurement is within five percent of the standard. All calibration data will be recorded in the field logbook. If field equipment becomes inoperable, it will no longer be used, and a properly calibrated replacement instrument will be used.

6.a.iv. Documentation

All field activities will be recorded in the field log book and/or on appropriate forms, as required in Appendix 5, Section 5.2.6.a of the Permit. The daily record of field activities shall include:

- Site or unit description
- Date
- Time of arrival and departure
- Field sampling team members, including subcontractors and visitors
- Weather conditions
- Daily activities and times conducted
- Observations
- Record of samples collected with sample designations and locations specified
- Photographic log
- Field monitoring data, including health and safety monitoring if conditions arise that require modifications to required work
- Equipment used and calibration records
- List of additional data sheets and maps completed
- An inventory of wastes generated and the method of storage and disposal
- Signature of personnel completing the field record.

6.a.v. Management of Investigation Derived Wastes

IDW expected to be generated during the sampling activities include drill cuttings, decontamination fluids, and miscellaneous wastes such as used disposable sampling equipment, plastic sheeting and personal protective equipment (PPE).

All purged groundwater and decontamination water shall be temporarily stored at satellite accumulation areas or transfer stations in labeled 55-gallon drums, less-than-90-day storage areas or other containers approved by NMED until proper characterization and disposal can be arranged. The methods for disposal of purge/decontamination water shall be approved by NMED prior to removal from the temporary storage area. Disposable materials shall be handled as described in Permit Appendix Section 5.2.5.

6.b. Groundwater Monitoring Well Survey

After the installation of the new groundwater monitoring wells, a qualified surveyor shall survey the new wells as well as all of the groundwater monitoring wells in the monitoring program in accordance with Permit Section 5.2.2.f (Sample Point and Structure Location Surveying). An additional reason to re-survey the monitoring well network is to investigate the drop off in groundwater elevation to the west of STP Ditches (illustrated by the elevation difference between MPL-025 and MPL-026). As part of the Closure Report the Permittee shall discuss the drop off and any conclusions drawn from the survey.

7. CLOSURE REPORT

A Closure Report shall be submitted to NMED that describes all closure actions and groundwater monitoring results in accordance with the reporting requirement outlined in Permit Appendix 7, Section 7.3.

8. CLOSURE PERMFORMANCE STANDARD

SWMU 82 must be closed to meet the performance standards in 40 CFR § 265.111 and in accordance with RCRA Permit Part IV (Closure of Hazardous Waste Management Units). As specified in 40 CFR § 265.111, the unit must be closed in a manner that: minimizes the need for further maintenance; and controls, minimizes or eliminates, to the extent necessary to protect human health and the environment, post-closure escape of hazardous waste, hazardous constituents, leachate, contaminated run-off, or hazardous waste decomposition products to the ground or surface waters or to the atmosphere; and comply with the closure requirements of 40 CFR § 264 Subpart G. If the Permittee is unable to achieve clean closure, the NMED will require submittal of a post-closure care plan.

9. CLOSURE SCHEDULE

Closure activities must begin no later than 90 days after approval of this plan. All closure activities must be completed within 180 days after beginning closure. The final submittal of the closure report must be submitted to NMED 60 days after completing closure. In the event that closure of SWMU 82 cannot proceed according to schedule, NMED must be notified in accordance with the extension request requirements in 40 CFR § 264.113(b) and comply with the applicable closure requirements in 40 CFR § 264.113(b)(1) and (2).

10. CERTIFICATION OF CLOSURE

Closure of SMWU 82 shall be deemed complete when within 60 days of completion of closure: 1) closure has been completed in accordance with this Closure Plan and been certified by an independent, professional engineer licensed in the State of New Mexico; and 2) a closure report including closure certification as required by 40 CFR § 264.115, has been submitted to, and approved by, the Department.

11. SURVEY PLAT

In accordance with the requirements of 40 CFR 264.116 which is incorporated herein by reference. The Permittee shall comply with all the requirements of 40 CFR 264.116 in submitting the survey plat. A survey plat and closure certifications will be provided by WSMR to satisfy the requirements of 40 CFR 264.115 and 264.116. As WSMR is the governing land-use authority, filing with the NMED and WSMR real property and master planning departments will satisfy the requirements of 40 CFR 264.119.

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WSMR, see White Sands Missile Range.

WTS, see White Sands Technical Services, LLC.

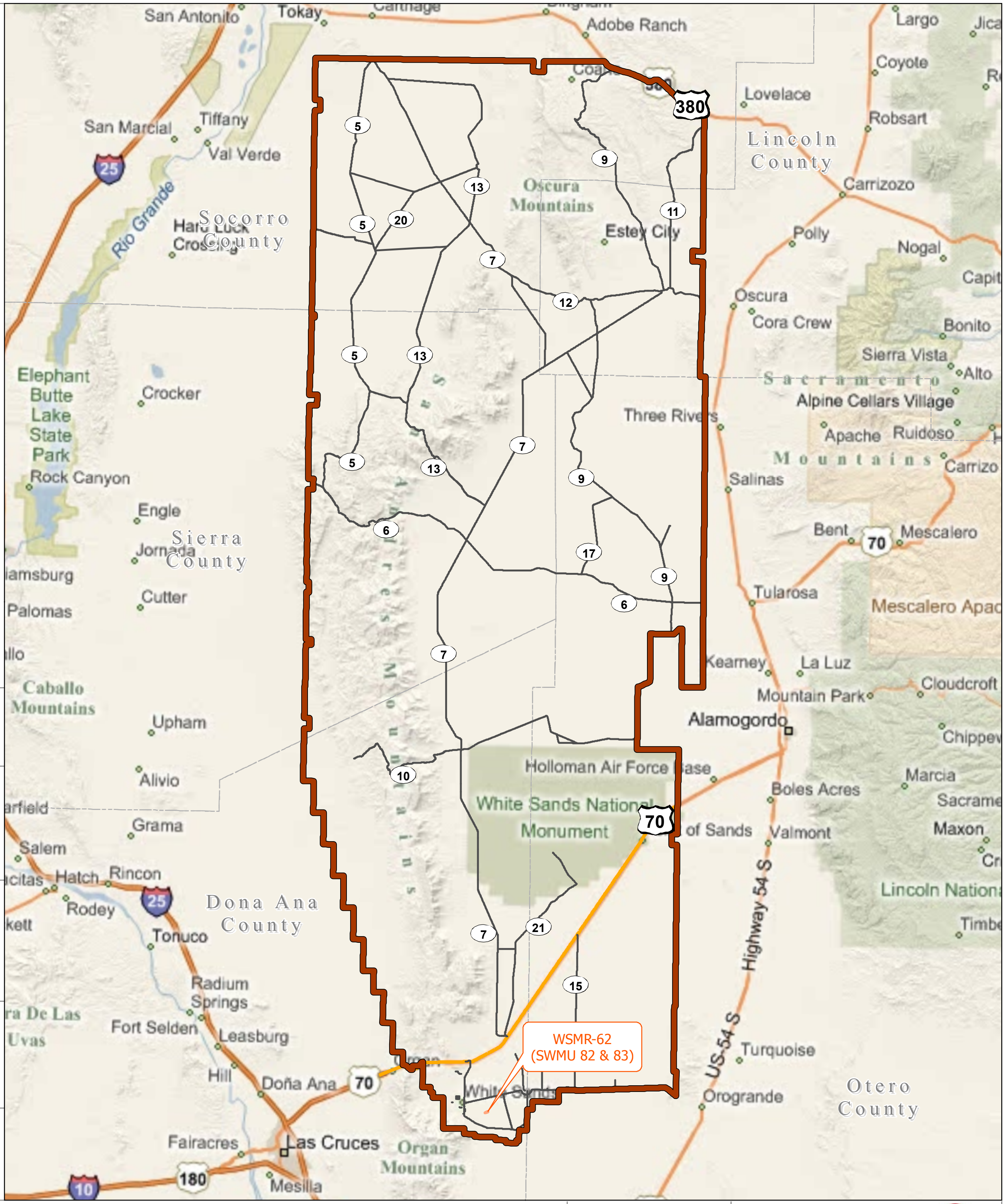
Table 1 Groundwater Monitor Program Wells

Well ID	Type	Depth Category	Schedule	Notes
MPL-01	Center plume	Interface	Semi-annual (SA)	Required for landfill monitoring program
MPL-02	Center plume	Interface	SA	Required for landfill monitoring program
MPL-03	Center plume	Interface	SA	Part of southern nested well group for landfill monitoring program
MPL-04	Center plume	Interface	SA	Required for landfill monitoring program
MPL-05	Center plume	Interface	SA	
MPL-06	Plume edge	Interface	SA	
MPL-07	Center plume	Interface	SA	
MPL-08			Annual (A)	Groundwater level and field parameters only
MPL-10	Center plume	Interface	SA	
MPL-11			A	Groundwater level and field parameters only
MPL-12			A	Groundwater level and field parameters only
MPL-13	Plume edge	Interface	SA	
MPL-14			A	Groundwater level and field parameters only
MPL-16	Plume edge	Interface	SA	
MPL-17	Plume edge	Interface	SA	
MPL-18	Plume edge	Interface	SA	
MPL-19	Center plume	Deep-level	SA	
MPL-20	Center plume	Mid-level	SA	
MPL-21	Center plume	Deep-level	SA	
MPL-22	Center plume	Mid-level	SA	
MPL-23	Center plume	Deep-level	SA	
MPL-24	Center plume	Mid-level	SA	
MPL-25	Plume edge	Interface	SA	
MPL-26	Upgradient	Interface	SA	
MPL-27			A	Groundwater level and field parameters only
MPL-28	Center plume	Interface	SA	
MPL-29	Center plume	Interface	SA	
MPL-30	Center plume	Interface	SA	
SMW-01	Upgradient	Mid-level	SA	
SMW-02			A	Groundwater level and field parameters only

Well ID	Type	Depth Category	Schedule	Notes
SMW-03			A	Groundwater level and field parameters only
SMW-04	Upgradient	Interface	SA	
T-40	Downgradient	Interface	SA	
New Well 1 ID TBD	Plume edge		Quarterly for 1st year and Semi-annual after	
New Well 2 ID TBD	Plume edge		Quarterly for 1st year and Semi-annual after	
New Wells 3 ID TBD	Plume edge	Nested	Quarterly for 1st year and Semi-annual after	
New Well ID TBD				If exceedance of nitrate occurs (>10mg/L) MPL-06 must install MW downgradient (Approval w/Modifications for MPL; October 14, 2014)

Table 2 Groundwater Analytical Program

Parameter	Reference Method	Method Type
	Field Parameters	
pH	SM 4500-H B	Field/Probe
Conductivity	SM 2510 B	
Turbidity	SM 2130 B	
Dissolved Oxygen	SM 4500-0 G	
Temperature	SM 2550 B	
Oxidation Reduction Potential	SM 2580B	
	Cyanide	
Total and amendable	SM 4500-CN C, E and SM 4500-CN G	Distillation
Free	EPA 9213	Electrode
	Other Analyses	
Dissolved Ions		
Chloride Fluoride Sulfate	EPA 300.0	Ion chromatography
Orthophosphate	SM 4500	Distillation
Nutrients		
Ammonia (NH3+NH4)	EPA 350.1	Colorimetric column
Nitrate/Nitrite (NO3+NO2)	EPA 353.3	
Water Quality		
pH Specific Conductance Total Dissolved Solids Bicarbonate & Carbonate (alkalinity)	EPA 150.1 EPA 120.1 EPA 160.1 EPA 310.1	Electrometric Conductivity meter Gravimetric Titrimetric
	Total Metals	
Antimony, Barium, Beryllium, Cadmium, Calcium, Chromium, Cobalt, Copper, Lead, Magnesium, Manganese, Nickel, Potassium, Selenium, Silver, Sodium, Thallium, Tin, Vanadium, Zinc	EPA 6010A	ICP emission spectroscopy
Mercury (total)	EPA 7471A	Atomic absorption cold vapor



LEGEND

- WSMR INSTALLATION
- ENVIRONMENTAL RESTORATION AREA
- 70 US HIGHWAY
- 7 FEDERAL ROUTE
- 25 INTERSTATE HIGHWAY

N

WGS 84 UTM ZONE 13N
METERS

0 5 10 20
Kilometers
0 5 10
Miles

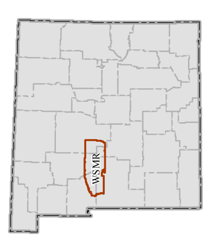


FIGURE 1-1

GENERAL AREA LOCATION MAP
CLOSURE PLAN
SWMU 82 (CCWS-62)

WHITE SANDS MISSILE RANGE, NM

LEGEND

- MAJOR ROAD
- ARTERIAL ROADS
- STRUCTURES
- SWMU 82 (CCWS-62)

CCWS = Compliance-Related Cleanup Waste Site
STP = Sewage Treatment Plant
SWMU = Solid Waste Management Unit
WSMR = White Sands Missile Range

0 0.175 0.35 0.7
Kilometers

0 0.1 0.2 0.4
Miles

N

WGS 84 UTM ZONE 13N
METERS

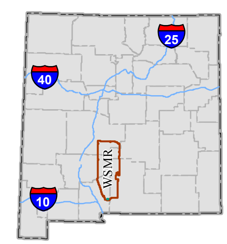


FIGURE 1-2

SITE LOCATION MAP
CLOSURE PLAN
SWMU 82 (CCWS-62)

WHITE SANDS MISSILE RANGE, NM

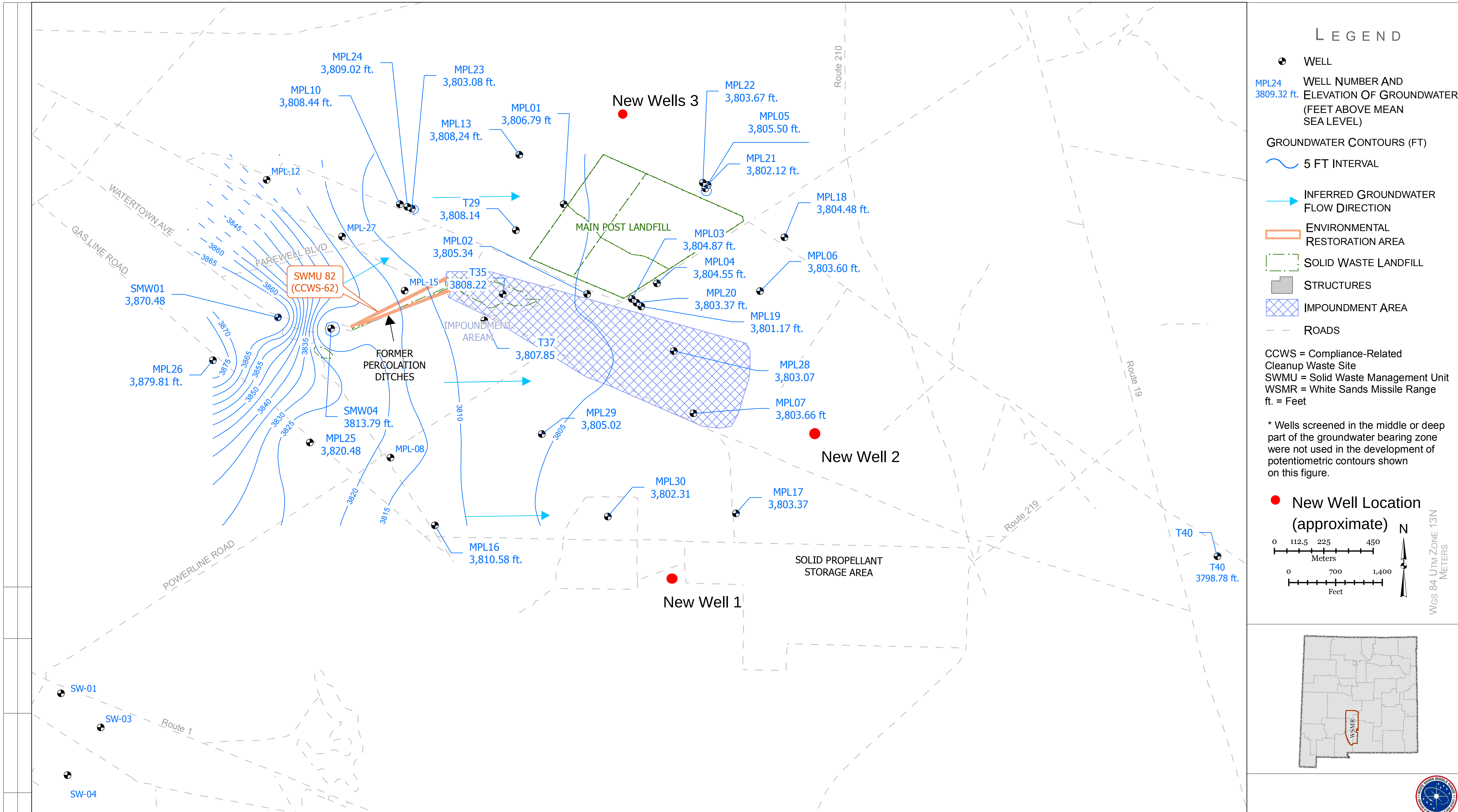


FIGURE 2-3
GROUNDWATER POTENTIOMETRIC SURFACE MAP (APRIL 2014)
SWMU 82 (CCWS-62)
CLOSURE PLAN FOR
FORMER STP PERCOLATION DITCHES
WHITE SANDS MISSILE RANGE, NM

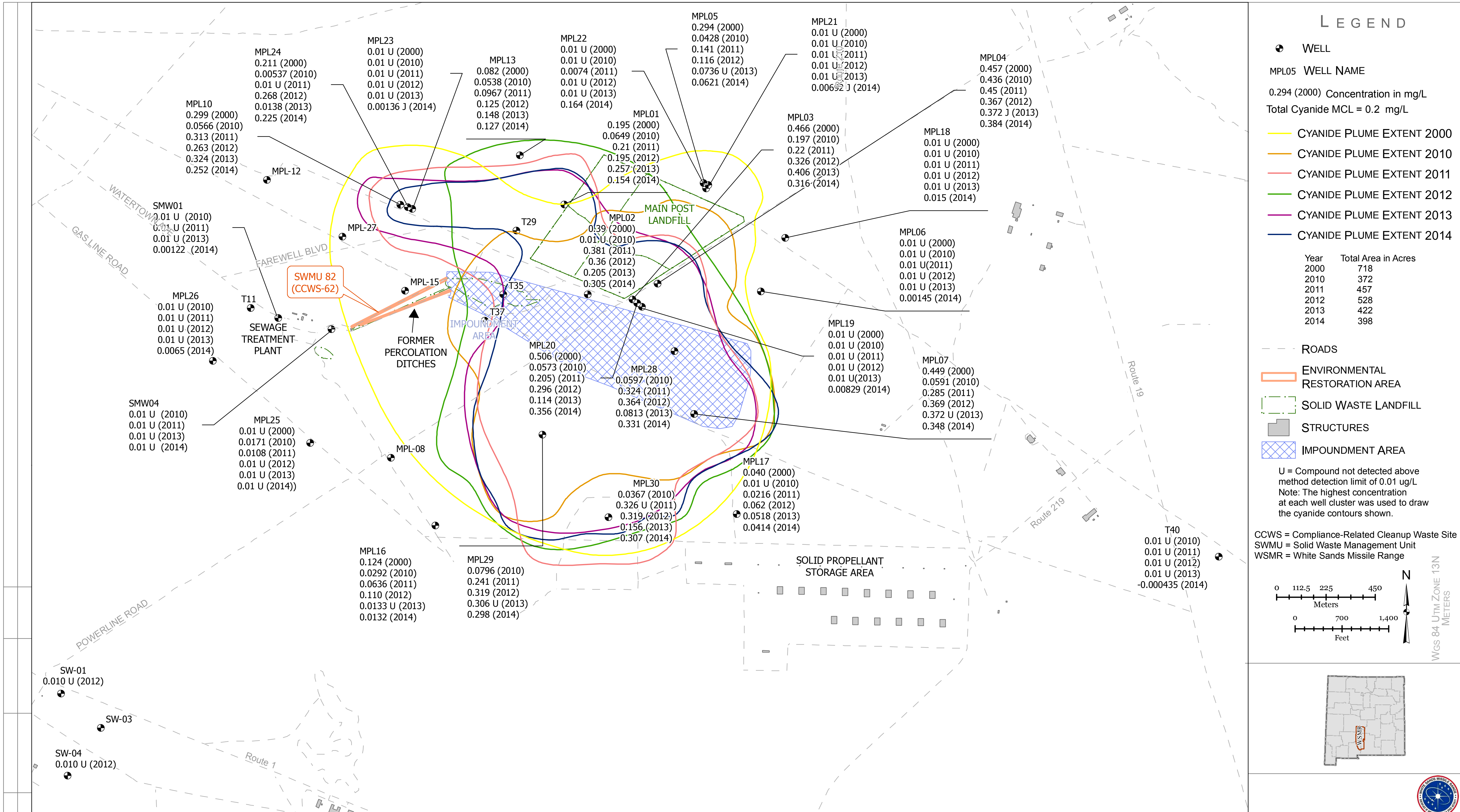


Figure 2-6

Total Cyanide Plume Comparison
SWMU 82 (CCWS-62)
Closure Plan For
Former STP Percolation Ditches

White Sands Missile Range, NM