CCR MONITORING WELL NETWORK REPORT AND CERTIFICATION

FOUR CORNERS POWER PLANT
FRUITLAND, NEW MEXICO

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LIST OF ACRONYMS

AMSL	Above mean sea level
APS	Arizona Public Service
CCR	Coal Combustion Residual
CFR	Code of Federal Regulations
CWTP	Combined Waste Treatment Pond
DFADA	Dry Fly Ash Disposal Area
FCPP	Four Corners Power Plant
FGD	Flue gas desulfurization
HDPE	High-density polyethylene
LAI	Lined Ash Impoundment
LDWP	Lined Decant Water Pond
NPDES	National Pollutant Discharge Elimination System
PVC	Polyvinyl chloride

1. INTRODUCTION

The Four Corners Power Plant (FCPP; the Site) is located on land leased from the Navajo Nation approximately 20 miles west of Farmington, New Mexico. The FCPP is operated by Arizona Public Service (APS). The Plant (referring to the generating units and associated structures) is located immediately south of Morgan Lake and primarily in Section 36, Township 29 North, Range 16 West on the Navajo Indian Reservation in San Juan County. The Plant is owned by APS and four other utilities.

The Plant burns low-sulfur coal in two units (Units 4 and 5) with a total net generating capacity of 1,540 megawatts. The FCPP formerly had five generating units and a capacity of 2,040 megawatts. Three generating units (Units 1, 2 and 3) were retired in December 2013 and decommissioned between 2014 and 2016.

On October 17, 2015, 40 Code of Federal Regulations (CFR) §257 (Federal Register, 2015) became effective (herein referred to as the Rule). The Rule defines the requirements for installing and operating groundwater monitoring systems at Coal Combustion Residual (CCR) disposal landfills and surface impoundments (CCR units).

This Monitoring Well Network and Certification Report documents the groundwater monitoring systems for the four existing CCR units at the FCPP. In addition, the groundwater monitoring system has been designed to address groundwater monitoring requirements for a planned 2018 expansion of one of the CCR units. The groundwater monitoring systems documented in this report meet the requirements of the Rule. This report provides certification by a qualified professional engineer that the groundwater monitoring system meets the requirements of the Rule.

2. IDENTIFICATION OF CCR UNITS

Existing and planned CCR surface impoundments and landfills addressed by this Monitoring Well Network and Certification Report are summarized in Table 2.1. These include one existing CCR multiunit (as defined in the Rule, (§257.91[d]), three existing individual CCR units and one planned CCR unit expansion. The CCR units are shown on Figures 2.1 and 2.2.

The Site comprises two distinct areas where CCR units are located. The Plant Area is located in the relatively flat-lying high ground to the south of Morgan Lake where two existing CCR units, the Upper Retention Sump and the Combined Waste Treatment Pond (CWTP), are located. The Disposal Area is located in the lower elevation ground sloping toward Chaco Wash to the west of the Plant Area where two existing CCR units, Multiunit 1 and the Dry Fly Ash Disposal Area (DFADA), are located.

For purposes of this report the term "CCR unit" is used to reference both single CCR units and the multiunit disposal facility. The boundaries of each CCR unit were determined based on available historical plans for each unit. The four existing and one planned lateral expansion CCR units are shown on Figures 2.1 and 2.2, and described in more detail below.

2.1 PLANT AREA CCR UNITS

2.1.1 Upper Retention Sump

The Upper Retention Sump is an approximately 1-acre surge pond located immediately east of the flue gas desulfurization (FGD) system for Units 4 and 5. The Upper Retention Sump is located within the Plant area in the NW ¼ of Section 36, Township 29 North, Range 16 West. FGD system discharge is transferred into the Upper Retention Sump via more than ten controlled and monitored pipes of various size and type. The contents of the pond are evacuated and reused in the FGD process through a pump chamber located at the south end of the pond. Accumulated solids in the Upper Retention Sump are periodically removed by pond dewatering excavation.

The Upper Retention Sump was constructed with a soil-cement liner on the bottom and inside slopes and is bounded on the north by a haul road embankment and on the east by a railroad embankment.

2.1.2 Combined Waste Treatment Pond (CWTP)

The CWTP is an approximately 13-acre water treatment pond located immediately east of the Plant and adjacent to Morgan Lake in the SE ¼ of Section 25 Township 29 North Range 16 West. The pond, constructed in 1978, is used as a settling and stabilization basin for bottom ash transport water and other Plant low volume wastewater flows prior to discharge to Morgan Lake

through a monitored discharge point under a National Pollutant Discharge Elimination System (NPDES) permit.

The primary source of water entering the pond is from bottom ash recovery and transport processes at Units 4 and 5 (U45). Bottom ash is hydraulically transported to the U45 hydrobins where the transport water is separated and conveyed to the CWTP. Overflow ash and other sediments settle in a series of seven separate earthen settling basins on the west edge of the CWTP footprint prior to the water decanting into the main CWTP. The decant cells are excavated periodically to remove settled solids. A fixed weir controls the water level of the CWTP and the pond drains through twin barrel gated reinforced concrete pipes (an NPDES-permitted outfall) to the cooling water discharge canal at the northeast corner of the pond.

2.2 DISPOSAL AREA CCR UNITS

2.2.1 Multiunit 1

Multiunit 1 comprises two active CCR units: the Lined Ash Impoundment (LAI) and the Lined Decant Water Pond (LDWP). The LAI and LDWP were designated Multiunit 1, as allowed under the Rule, because their configuration relative to the direction of groundwater flow makes it technically infeasible to distinguish groundwater quality differences beneath the two units.

The LAI is an approximately 129-acre surface impoundment located approximately 6,000 feet west of the Plant in the eastern ½ of Section 34, Township 29 North, Range 16 West. The LAI was constructed to receive fly ash, flue gas desulfurization (FGD) waste and other associated residuals. Solids settle and water migrates to the west side of the impoundment resulting in a deposited solids surface at a slope of approximately one percent away from the discharge location. Free and entrained water in the LAI drains through a vertical drop structure and an internal toe drain to the adjacent LDWP from which it is pumped back to the Plant for reuse as process water.

The LAI was constructed over closed Ash Ponds 4 and 5 and placed into service in 2004. The LAI is fully-lined with a single 60-mil high-density polyethylene (HDPE) geomembrane on the bottom and side slopes of the impoundment. The LAI has a maximum design capacity of 5,364 acre-feet and a maximum operating reservoir level of elevation 5275.2 feet above mean sea level (AMSL). The west and south embankments of the LAI are approximately 74 and 120 feet high, respectively, with a final minimum crest elevation of 5,280 feet AMSL. The starter dam for the west embankment was aligned with the divider dike between the underlying closed Ash Ponds 3 and 4; the west and south embankments were raised by the downstream method several times to the current and ultimate crest elevation.

The LDWP is an approximately 45-acre surface impoundment located approximately 8,000 feet west of the Plant and immediately adjacent to, and west of, the LAI in the eastern ½ of Section 34, Township 29 North, Range 16 West. Water enters the LDWP from the LAI via gravity and pumped discharge and from several other pumped water collection points within the Site boundary. Water collected in the LDWP is pumped back to the Plant for reuse as process water.

The LDWP was constructed over closed Ash Pond 3 in a single phase in 2003. The LDWP has a double liner system consisting of two 60-mil HDPE geomembranes separated by a leak detection layer and evacuation pump. The LDWP has a capacity of 435 acre-feet, a maximum operating reservoir level of 5,213.2 feet AMSL, and a final crest elevation of 5,216 feet AMSL.

2.2.2 Dry Fly Ash Disposal Area

The DFADA is a geomembrane-lined dry fly ash disposal landfill located approximately 4,000 feet west of the Plant in the SE ¼ of Section 34, Township 29 North, Range 16 West. The DFADA currently consists of three conjoined cells (DFADA 1, DFADA 2, and DFADA 3), with initial construction in approximately 2007, 2012, and 2014, respectively. An additional expansion area, DFADA 4, is planned for 2018 construction. DFADA 3 abuts the south embankment of the LAI and will eventually be filled against the LAI to an elevation approximately the same as the final crest elevation of the LAI embankment. The DFADA is filled in general accordance with a stacking plan and may be expanded laterally in the future to meet Plant needs.

The current DFADA (cells 1, 2, and 3) has an overall capacity of 3,125 acre-feet and is approximately 105 feet high. DFADA 1 was constructed with a compacted clay subgrade material overlain by a 60-mil HDPE geomembrane and a drainage layer. DFADA 2 and 3 were constructed with a composite liner system, selected in accordance with the EPA's *Guide for Industrial Waste Management* (USEPA, 2003), consisting of a geosynthetic clay liner (GCL) overlain by a 60-mil HDPE geomembrane overlain by a drainage layer. The drainage layers in each cell are connected to a leachate collection system that allows gravity drainage of leachate from waste cells to external lined ponds. The leachate collection system consists of a drainage layer, collection piping, a removal system, and a protective filter layer. Collected leachate is pumped into trucks and used for dust control on roads and other areas within the ash disposal area. Excess water can be transferred to the LDWP.

3. SITE SETTING

This section presents a summary of the climate, regional geologic setting, topography, surface water hydrology, local geology and hydrogeologic setting of the site. This information is used to document the groundwater flow direction in the uppermost aquifer and the well networks established to monitor groundwater quality in the vicinity of the CCR units at the FCPP.

3.1 CLIMATE

The FCPP is located in the northwest corner of New Mexico at an elevation of 5,100 to 5,400 feet AMSL. The area has a semi-arid climate and receives an average of 8.6 inches of precipitation per year. Summers are hot and winters are cold with typical snowfall of 12.6 inches per year. The surrounding area is characterized by arid grasslands with scattered shrubs which seldom cover the ground completely. Many areas, especially in the active areas on-site, are bare ground.

3.2 TOPOGRAPHY

Topography in the vicinity of the FCPP area is characterized by rolling terrain, with areas of steep escarpments, dissected by incised drainages and arroyos. The topography near the FCPP is relatively flat-lying to gently-sloping to the west, and to a lesser degree, to the north (see Figure 3.1). The ground surface at and near the Plant Area is relatively flat-lying and elevations are generally between 5,340 feet AMSL and 5,360 feet AMSL. The ground surface slopes to the west at approximately 20 feet per mile. Approximately 1 mile west of the Plant Area, the relatively level ground surface drops rapidly from about 5,350 feet AMSL to 5,200 feet AMSL. The topographic expression of this elevation change is an irregular cliff face marked by a series of generally east-west oriented incised drainages and steep arroyos. The Disposal Area is located below, and to the west of, the cliff face. The natural ground surface of the Disposal Area slopes to the west at approximately 100 feet per mile toward Chaco Wash.

3.3 SURFACE WATER HYDROLOGY

The main surface water bodies near the FCPP are Morgan Lake and Chaco Wash. Morgan Lake was formed by damming a westerly flowing ephemeral stream to create a cooling water source for the power plant. Morgan Lake encompasses approximately 1,287 surface acres and has a maximum storage capacity of 39,000 acre-feet water. The water level in Morgan Lake remains relatively constant at approximately 5,330 feet AMSL and is maintained by pumping from the San Juan River, via an approximately 2-½ mile pipeline. Water quality is maintained by blowdown to a regulated outfall under the NPDES permit.

The Chaco Wash (also called the Chaco River in some sources) is a waterway of the United States. The Chaco Wash is about 100 miles long and originates in the New Mexico highlands north of Gallup. The Chaco Wash is ephemeral and discharges into the San Juan River about 12 miles downstream and north from the FCPP.

Surface drainage in the Plant Area is to the north, toward Morgan Lake, and is highly modified by the Plant facilities. Morgan Lake discharges to "No Name Wash", which flows to the Chaco Wash located west of the Disposal Area. In the Disposal Area (Multiunit 1 and the DFADA), drainage is from the cliff face to the west, toward Chaco Wash. There are no active streams in the immediate Multiunit 1 and DFADA area; however, drainage and erosion features convey surface water runoff during heavy precipitation events.

3.4 REGIONAL GEOLOGIC AND HYDROGEOLOGIC SETTING

The FCPP is located on the western flank of the San Juan Basin, in the Colorado Plateau physiographic province in northwestern New Mexico. The San Juan Basin is a structural basin approximately 100 miles from north to south and 90 miles from east to west underlain by laterally extensive, gently-dipping to flat-lying sedimentary rocks of Late Cretaceous to Early Tertiary age. The northwestern boundary of the San Juan Basin is defined by the Hogback Monocline. The Hogback Monocline is a structural monocline where the generally horizontal to gently dipping Cretaceous sedimentary rock units in the area are uplifted into a one-sided fold which dips steeply (approximately 38 degrees) to the east. The resulting bedrock ridge, approximately 3 miles west of the Plant, is composed of younger rock units on the eastern flank and progressively older rock units exposed in the central and western portions of the Hogback.

In the western portion of the San Juan Basin, where the FCPP is located, the stratigraphic section consists of the following relevant Cretaceous-aged geologic units, from youngest to oldest:

- Pictured Cliffs Sandstone – The Pictured Cliffs Sandstone is a fine- to medium-grained, prominent cliff-forming marine sandstone of Late Cretaceous age. The upper portion of the Pictured Cliffs Sandstone consists of thick-bedded and cross-bedded sandstone and the lower portion of the formation consists of alternating thin beds of fine-grained to very fine-grained sandstone and silty shale. The fine-grained deposits in the lower Pictured Cliffs Sandstone constitute a transitional sequence between the Pictured Cliffs Sandstone and the underlying Lewis Shale (USGS, 1979) and regional descriptions include reference to a sandstone-mudstone interval between the main cliff-forming sandstones of the Pictured Cliffs formation and the underlying Lewis Shale. The thickness of the Pictured Cliffs Sandstone is 25 feet to nearly 300 feet (New Mexico Bureau of Mines and Mineral Resources, 1983).

- Lewis Shale – The Lewis Shale is a Late Cretaceous sandy marine shale and mudstone interbedded with thin, platy sandstone. The reported thickness of the Lewis Shale regionally is approximately 500 feet (USGS, 1979) but, in the northeastern section of the San Juan Basin, thicknesses of up to 2,400 feet have been reported (USGS, 2013).

These geologic units strike generally north-south and dip gently to the east an average of two degrees (Department of the Interior, Office of Surface Mining Reclamation and Enforcement, 2014). Unconsolidated materials overlying the bedrock units are present in some locations.

Hydrogeologic conditions in the San Juan Basin are characterized by alternating strata of relatively high and relatively low hydraulic conductivities, resulting in a sequence of consolidated rock aquifers separated by low permeability confining units. The principal water-bearing rock units in the FCPP area consist of the Cretaceous sedimentary sequence of laterally-extensive, confined, sandstone aquifers, such as the Pictured Cliffs Sandstone, separated by thick, fine-grained confining rock units, such as the Lewis Shale, that act as aquitards and inhibit flow between the sandstone aquifers. Regional groundwater flow within the sedimentary aquifers is generally from topographically high outcrop areas, where recharge occurs through infiltration, toward topographically lower discharge areas (New Mexico Bureau of Mines and Mineral Resources, 1983).

Drainages such as Chaco Wash contain water-bearing alluvium consisting of unconsolidated mixtures of gravel, sand, silt, and clay having widely variable transmissivity. In ephemeral stream channels, most recharge to the alluvium originates as stormwater or irrigation infiltration, but some recharge is also contributed from saturated bedrock units that discharge to the alluvium (New Mexico Bureau of Mines and Mineral Resources, 1983).

3.5 LOCAL GEOLOGY AND HYDROSTRATIGRAPHY

3.5.1 Local Geologic Conditions

The topographic conditions and the associated surface water hydrology described in Sections 3.2 and 3.3, respectively, result in the FCPP CCR units being located in two distinct geographic settings: 1) the high, flat ground of the Plant Area, near Morgan Lake, where the Upper Retention Sump and the CWTP are located; and 2) the lower elevation ground of the Disposal Area, where the ground slopes toward Chaco Wash and where the Multiunit 1 and the DFADA are located. These disparate settings, coupled with the low-angle easterly dip of the sedimentary rock units and the generally westerly slope of the ground surface, result in the uppermost geologic unit in the Plant Area (Upper Retention Sump and the CWTP) being different from the uppermost geologic unit in the Disposal Area (Multiunit 1 and the DFADA). Unconsolidated materials are also present in both areas.

In the Plant Area, the lower Pictured Cliffs Sandstone is the uppermost geologic unit. The Lewis Shale is present beneath the Pictured Cliffs Sandstone in the Plant Area. Construction and operations have altered the natural ground surface and the resulting disturbed ground conditions overlying the Pictured Cliffs Sandstone are not well understood. Much of the land surface is covered by buildings and pavement.

In the Disposal Area, the Lewis Shale is the uppermost geologic unit. The Lewis Shale comprises two distinct units: 1) an upper highly-weathered shale; and 2) a lower, hard unweathered shale. The weathering is likely the result of water entering and moving through joints and bedding planes in the weathered Lewis Shale where it is exposed.

The weathered Lewis Shale is highly fractured and friable. It is typically brown, reflecting oxidation of iron and minerals exposed to water. Gypsum mineralization (a relatively soluble mineral) has also been observed in the weathered Lewis Shale above the water table, suggesting more water was present in the formation in the past, likely due to a wetter climate.

The underlying unweathered Lewis Shale is less fractured, somewhat fissile, and has been consistently observed to be dry during drilling and other excavation activities. This layer is typically blue gray and lacking gypsum, reflecting a lack of oxidation and significant contact with water.

The weathered zone at the top of the Lewis Shale is thinner in the Plant Area, where it is overlain by the Pictured Cliffs Sandstone, since it has had less exposure to precipitation, erosion, and other surface processes. The top elevation of the unweathered Lewis Shale beneath the Pictured Cliffs Sandstone in the Plant Area is approximately 5,300 feet AMSL, based on geologic profiles developed for the design of the plant.

Three hydrostratigraphic units are present at the FCPP site:

1) The Pictured Cliffs Sandstone beneath the Plant Area, which constitutes the uppermost aquifer in the Plant Area;

2) The variably-saturated weathered Lewis Shale in the Disposal Area and the hydraulically-connected alluvial deposits along Chaco Wash, which together constitute the uppermost aquifer in the Disposal Area;

3) The unweathered Lewis Shale, a regionally extensive confining unit (aquitard), which forms the base of the uppermost aquifers in the Plant Area and the Disposal Area.

3.5.2 Plant Area Hydrostratigraphy - Pictured Cliffs Sandstone

The Plant Area is located on the high ground within 2,000 feet of the south shore of Morgan Lake. The Pictured Cliffs Sandstone is present from the ground surface (between approximately 5,340 feet AMSL and 5,360 feet AMSL) to approximately 5,300 feet AMSL (top elevation of the Lewis Shale in the Plant Area). Groundwater flow in the Plant Area is strongly influenced by the water level in Morgan Lake (approximately 5,330 feet AMSL) and shallow groundwater is present in the Pictured Cliffs Sandstone hydrostratigraphic unit at elevations ranging from approximately 5,330 feet AMSL to 5,335 feet AMSL (Figure 3.2).

APS has made regular measurements of groundwater elevations in wells in the Plant Area since late 2015. Groundwater elevation contour maps for the Upper Retention Sump and the CWTP are presented as Figure 3.2. Hydrographs showing groundwater elevations over the period of record for the Upper Retention Sump and the CWTP are presented as Figures 3.3 and 3.4.

Groundwater Flow Direction

Upper Retention Sump

Groundwater elevation contours based on groundwater elevations measurements in June 2016 in the Upper Retention Sump and CWTP area are presented as Figure 3.2. Groundwater elevations in the vicinity of the Upper Retention Sump ranged from 5,331.76 feet AMSL in MW-67 to 5,335.02 feet AMSL in MW-69, and are above the bottom elevation of the Upper Retention Sump. The groundwater elevations indicate groundwater mounding and radial flow in the vicinity of the Upper Retention Sump. The hydrograph for the Upper Retention Sump wells (Figure 3.3) indicates that, although groundwater elevations in MW-67 exhibit occasional spikes up to 5,340 feet AMSL, the observed radial flow is generally maintained over time.

Groundwater elevations in MW-71 and MW-72, located 1,000 feet southwest and 500 feet south of the Upper Retention Sump, respectively, were 5,331.41 feet AMSL and 5,331.90 feet AMSL, respectively. These groundwater elevations suggest that these wells may be influenced by the mounding in the vicinity of the Upper Retention Sump.

CWTP

Groundwater elevation contours based on groundwater elevations measured in June 2016 in the Upper Retention Sump and CWTP area are presented as Figure 3.2. Groundwater elevations in the vicinity of the CWTP ranged from 5,329.48 feet AMSL in MW-63 to 5,331.07 feet AMSL in MW-65. The surface water level in the CWTP was 5,332.01 feet AMSL and the water level in the canal adjacent to the north and east sides of the CWTP was 5,328.95 feet AMSL. The canal and CWTP are in hydraulic connection with the groundwater. The groundwater elevations

indicate radially outward flow from the CWTP. The hydrograph for the CWTP wells (Figure 3.4) indicates that the outward radial flow is generally maintained over time.

3.5.3 Disposal Area Hydrostratigraphy - Weathered Lewis Shale/Alluvium

The Disposal Area is located approximately 1 mile west of the Plant on the low sloping ground surface west of the cliff face. The Disposal Area extends approximately 4,000 feet west of the cliff face and the ground surface slopes toward Chaco Wash, approximately 3,500 feet further to the west. The eroded surface of the Lewis Shale forms the sloping ground surface in the Disposal Area. Quaternary alluvium (typically sand and gravel) overlies the weathered Lewis Shale within, and along, the Chaco Wash west of the Disposal Area and tributary washes to the north and west of the Disposal Area. The alluvium contains a variable amount of groundwater, depending on its location relative to perennial reaches of Chaco Wash and sources of local recharge. Beneath the Disposal Area, the weathered Lewis Shale is variably saturated and discharges to alluvial deposits of Chaco Wash. An operational groundwater recovery trench intercepts subsurface flow at a rate of approximately 50 gallons per minute between the Disposal Area and Chaco Wash.

Hydrogeological studies conducted since the 1980s have documented the groundwater conditions in the Disposal Area. Groundwater in the weathered Lewis Shale is unconfined and occurs primarily within the fractures that are typically present along bedding planes. Shallow groundwater is present in the weathered Lewis Shale/Alluvium hydrostratigraphic unit in the Disposal Area at elevations ranging from approximately 5,240 feet AMSL to 5,100 feet AMSL (Figure 3.5).

Saturated conditions in the weathered Lewis Shale/Alluvium hydrostratigraphic unit in the Disposal Area have been documented only in the vicinity of, and to the north of, Multiunit 1 and in the downgradient groundwater recovery trench. Only unsaturated conditions have been observed in the vicinity of the DFADA. The groundwater conditions in the Disposal Area are influenced by recharge from Morgan Lake and historical unlined ponds. Transient effects on groundwater flow may be caused by intermittent flow in the blowdown channel carrying discharge from Morgan Lake, precipitation runoff events, and changes in construction and operation of the ponds and interceptor trenches. Taken together, these conditions produce: 1) a groundwater flow system that exhibits discontinuous, variably saturated, and transient conditions; and 2) areas where minimal saturated thickness and/or low permeability aquifer characteristics result in limited well yields.

Some wells, both east and west (upgradient and downgradient) from Multiunit 1, in areas where saturated conditions are generally present or may be expected, are either dry (MW-51) or do not

produce sufficient quantities of groundwater to provide water quality samples (MW-50A, MW-40R, and MW-76).

The weathered Lewis Shale/Alluviam hydrostratigraphic unit is geologically consistent between Multiunit 1 and the DFADA, where the same sequence of weathered, highly fractured Lewis Shale overlies the unweathered Lewis Shale; however, the weathered Lewis Shale is unsaturated in the vicinity of the DFADA. Site records since the 1980s have documented that wells in the weathered Lewis Shale in the DFADA area have generally been dry.

The discontinuous groundwater conditions in the weathered Lewis Shale/Alluvium hydrostratigraphic unit are believed to be influenced by Morgan Lake and other sources of recharge, and the corresponding absence of that influence in the vicinity of the DFADA. The semi-arid climate and limited watershed do not result in enough natural recharge to sustain a constant saturated zone in the weathered Lewis Shale/Alluvium hydrostratigraphic unit. There are no surface water features recharging the weathered Lewis Shale in the vicinity of, or upgradient from, the DFADA; therefore, the weathered Lewis Shale/Alluvium hydrostratigraphic unit in the vicinity of the DFADA is unsaturated. Based on groundwater conditions observed in the vicinity of closed Ash Pond 6 and Multiunit 1, however, the unit is capable of transmitting groundwater if a source of recharge is present. Unsaturated conditions have generally been observed in the DFADA area throughout the historical record.

Groundwater Flow Direction

Groundwater elevation contours based on groundwater elevation measurements in June 2016 in the Disposal Area is presented as Figure 3.5. A hydrograph showing groundwater elevations over the period of record is included as Figure 3.6. The groundwater flow direction in the Disposal Area is to the west-southwest, following the topography, as described below.

Multiunit 1

Groundwater elevations in the vicinity of Multiunit 1 ranged from 5,289.36 feet AMSL in MW-50A to 5,076.00 feet AMSL in MW-8. The weathered Lewis Shale/Alluvium hydrostratigraphic unit is unsaturated at some upgradient Multiunit 1 monitoring well locations (MW-43 and MW-51) and at some down-gradient Multiunit 1 monitoring well locations (MW-40R and MW-76).

The groundwater elevations indicate groundwater flow to the west-southwest at a gradient of 0.003 (unitless) in the vicinity of Multiunit 1. The hydrograph for the Multiunit 1 wells (Figure 3.6) indicates that the groundwater elevations and groundwater flow direction are generally consistent over time.

DFADA

The weathered Lewis Shale/Alluvium hydrostratigraphic unit is unsaturated both up- and down-gradient of the DFADA at the location of downgradient monitoring wells MW-13, MW-44, MW-10, and MW-48, and upgradient monitoring wells MW-12R and MW-55R.

The geologic setting and hydrostratigraphy is continuous between the DFADA and Multiunit 1. The presence of groundwater in the vicinity of Multiunit 1 indicates that if saturated conditions develop in the weathered Lewis Shale/Alluvium hydrostratigraphic unit in the vicinity of the DFADA, the groundwater flow direction will be to the west-southwest.

3.5.4 Unweathered Lewis Shale

The unweathered Lewis Shale hydrostratigraphic unit is present beneath the entire FCPP site, where it forms the base of the uppermost aquifers in the Plant Area and the Disposal Area. The low hydraulic conductivity and great thickness of the unweathered Lewis Shale prohibits any significant downward migration of groundwater to deeper stratigraphic units. The full thickness of the unweathered Lewis Shale has not been penetrated in any of the exploratory boreholes advanced at the Site. The deepest boreholes drilled at the FCPP, LS-1 and LS-2, each extended to total depths of 360 feet (elevation 5,008 feet AMSL and 5,037 feet AMSL, respectively), indicating that the Lewis Shale aquitard is present beneath the FCPP to at least these depths (elevations). Boring logs for LS-1 and LS-2 are included in Appendix B.

4. CCR UNIT GROUNDWATER MONITORING WELL NETWORKS

A groundwater monitoring well network was designed for each CCR unit. Where existing monitoring wells were appropriately located (horizontally and vertically), they were incorporated into the CCR groundwater monitoring well networks. New groundwater monitoring wells were installed, where needed, to supplement the existing wells and complete a monitoring well network for each CCR unit. New CCR well installation details are included in Appendix A.

The CCR monitoring well construction details are summarized in Table 4.1. The groundwater monitoring networks are capable of yielding groundwater samples from the uppermost aquifer that accurately represent 1) the quality of groundwater passing the waste boundary of the CCR unit; and 2) the quality of background groundwater unaffected by leakage from a CCR unit.

Details of the CCR groundwater monitoring well networks are presented in Sections 4.1 through 4.4.

4.1 PLANT AREA GROUNDWATER MONITORING WELL NETWORKS

4.1.1 Plant Area Background Monitoring Wells

The observed groundwater mounding and radial flow in the vicinity of the Upper Retention Sump and the CWTP suggested that the monitoring wells installed around the perimeters of these CCR units may not provide water quality samples that are representative of background conditions. Therefore, the background monitoring well was located away from the Plant Area CCR units to ensure that water quality data are representative of unimpacted groundwater quality in the Pictured Cliffs Sandstone hydrostratigraphic unit in the Plant Area.

New monitoring wells MW-71 and MW-72 were installed approximately 1,200 feet southwest and 700 feet south, respectively, of the Upper Retention Sump to monitor the background water quality. Groundwater flow directions indicate that these wells may be influenced by the mounding beneath the Upper Retention Sump, therefore, new monitoring well MW-73 was installed approximately 3,000 feet west and away from any CCR storage or disposal facilities to provide a monitoring point in the Pictured Cliffs Sandstone hydrostratigraphic unit that is unimpacted by CCR. Using a well not necessarily directly up gradient is permitted under the Rule if it allows for more accurate determination of background water quality.

4.1.2 Upper Retention Sump Downgradient Monitoring Well Network

The groundwater flow direction in the vicinity of the Upper Retention Sump is radially outward from the CCR unit. Therefore, the downgradient monitoring well network was located around the perimeter of the Upper Retention Sump. A total of five new monitoring wells surrounding the

Upper Retention Sump comprise the downgradient monitoring well network for this CCR unit. The five wells, MW-66, MW-67, MW-68, MW-60, and MW-70, are screened within the Pictured Cliffs hydrostratigraphic unit and are located as close to the Upper Retention Sump as practical.

4.1.3 CWTP Downgradient Monitoring Well Network

The groundwater flow direction in the vicinity of the CWTP is radially outward from the CCR unit. Therefore, the downgradient monitoring well network was located around the perimeter of the CWTP. A total of four new monitoring wells surrounding the CWTP comprise the downgradient monitoring well network for this CCR unit. The four wells, MW-62, MW-63, MW-64, and MW-65, are screened within the Pictured Cliffs hydrostratigraphic unit and are located as close to the CWTP boundary as practical.

4.2 DISPOSAL AREA GROUNDWATER MONITORING WELL NETWORKS

4.2.1 Disposal Area Background Monitoring Wells

The variably saturated conditions in the Disposal Area resulted in the inclusion of background monitoring wells located away from the CCR units to ensure representative water quality data in the weathered Lewis Shale/Alluvium hydrostratigraphic unit that are unimpacted by CCR. Using multiple wells and wells not necessarily directly up gradient of the CCR unit, is permitted under the Rule, if it allows for more accurate representation of background water quality.

A total of seven water table monitoring wells comprise the background well network in the Disposal Area: existing wells MW-12R, MW-43, MW-49A, MW-50A and MW-51 and new wells MW-55R and MW-74. Two of these (MW-12R and MW-49A) are close to the edges of the DFADA and Multiunit 1; water quality data indicate that these wells may be impacted by CCR. Four wells do not maintain adequate saturated thickness to sample (MW-43, MW-50A and MW-55R) or are consistently dry (MW-51), but may be useful for establishing background conditions if groundwater elevations increase in the future. One well is farther east (MW-74) and located away from any CCR storage or disposal facilities and provides a monitoring point in the weathered Lewis Shale/Alluvium hydrostratigraphic unit that is unimpacted by CCR.

4.2.2 Multiunit 1 Downgradient Monitoring Well Network

The groundwater flow direction in the vicinity of Multiunit 1 is to the west-southwest. Therefore, the downgradient monitoring well network was located along the west and southwest side of the CCR unit. A total of six monitoring wells comprise the downgradient well network for Multiunit 1: existing wells MW-7, MW-8, and MW-40R, and new wells MW-61, MW-75 and MW-76. These six wells are screened within the weathered Lewis Shale/Alluvium hydrostratigraphic unit

and are located as close to the downgradient (south and west) sides of Multiunit 1 as practical. One of these wells (MW-40R) does not maintain adequate saturated thickness to sample and one well is consistently dry (MW-76). These wells are included in the downgradient monitoring well network to allow monitoring of any transient flow conditions that may develop.

4.2.3 DFADA Downgradient Monitoring Well Network

The groundwater flow direction to the north of the DFADA, where saturated conditions exist, is to the west-southwest. It is expected that if saturated conditions develop in the vicinity of the DFADA, the groundwater flow would also be to the west-southwest. Therefore, the downgradient monitoring well network was located along the west and southwest side of the CCR unit. A total of four existing wells comprise the downgradient monitoring well network for the DFADA. Three of the four downgradient wells, MW-10, MW-13, and MW-44, are screened within the weathered Lewis Shale/Alluvium hydrostratigraphic unit; MW-48 is screened in the unweathered Lewis Shale. The existing wells included in the DFADA downgradient well network are located several hundred feet to the west (downgradient) from the DFADA boundary. The consistently dry conditions indicate that installing additional wells would not provide different results.

The four DFADA downgradient monitoring wells are dry (MW-10, MW-13, MW-44 and MW-48). The intent of the Rule is to accurately represent the quality of groundwater, if any, passing the waste boundary. The downgradient DFADA well network will be used over time to identify saturation in the weathered Lewis Shale/Alluvium hydrostratigraphic unit in the vicinity of the DFADA. If saturated conditions develop, groundwater elevations and water quality data from the DFADA well network will be evaluated to confirm whether wells are appropriately placed to meet the technical requirements of the Rule.

5. CERTIFICATION

Certification Statement 40 CFR § 257.91(f) – Design and Construction of Groundwater Monitoring Systems for the following CCR units:

- Upper Retention Sump (existing CCR Surface Impoundment)
- Combined Waste Treatment Pond (existing CCR Surface Impoundment)
- Multiunit 1 - Lined Ash Impoundment and Lined Decant Water Pond (existing CCR Surface Impoundments)
- Dry Fly Ash Disposal Areas – DFADA 1, DFADA 2, and DFADA 3 (existing CCR Landfill) and DFADA 4 (CCR Landfill Expansion)

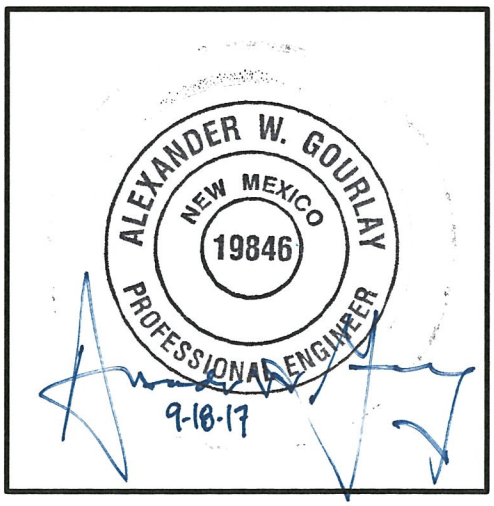
I, Alexander Gourlay, being a Registered Professional Engineer in good standing in the State of New Mexico, do hereby certify, to the best of my knowledge, information, and belief that the information contained in this certification is prepared in accordance with the accepted practice of engineering. I certify, for the above-referenced CCR Units, that the design and construction of the groundwater monitoring system as included in the CCR Monitoring Well Network Report and Certification dated September 18, 2017 meets the requirements of 40 CFR § 257.91.

ALEXANDER W. GOURLAY

Printed Name

September 18, 2017

Date



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TABLES

Table 2.1
Summary of CCR Units
Arizona Public Service
Four Corners Power Plant

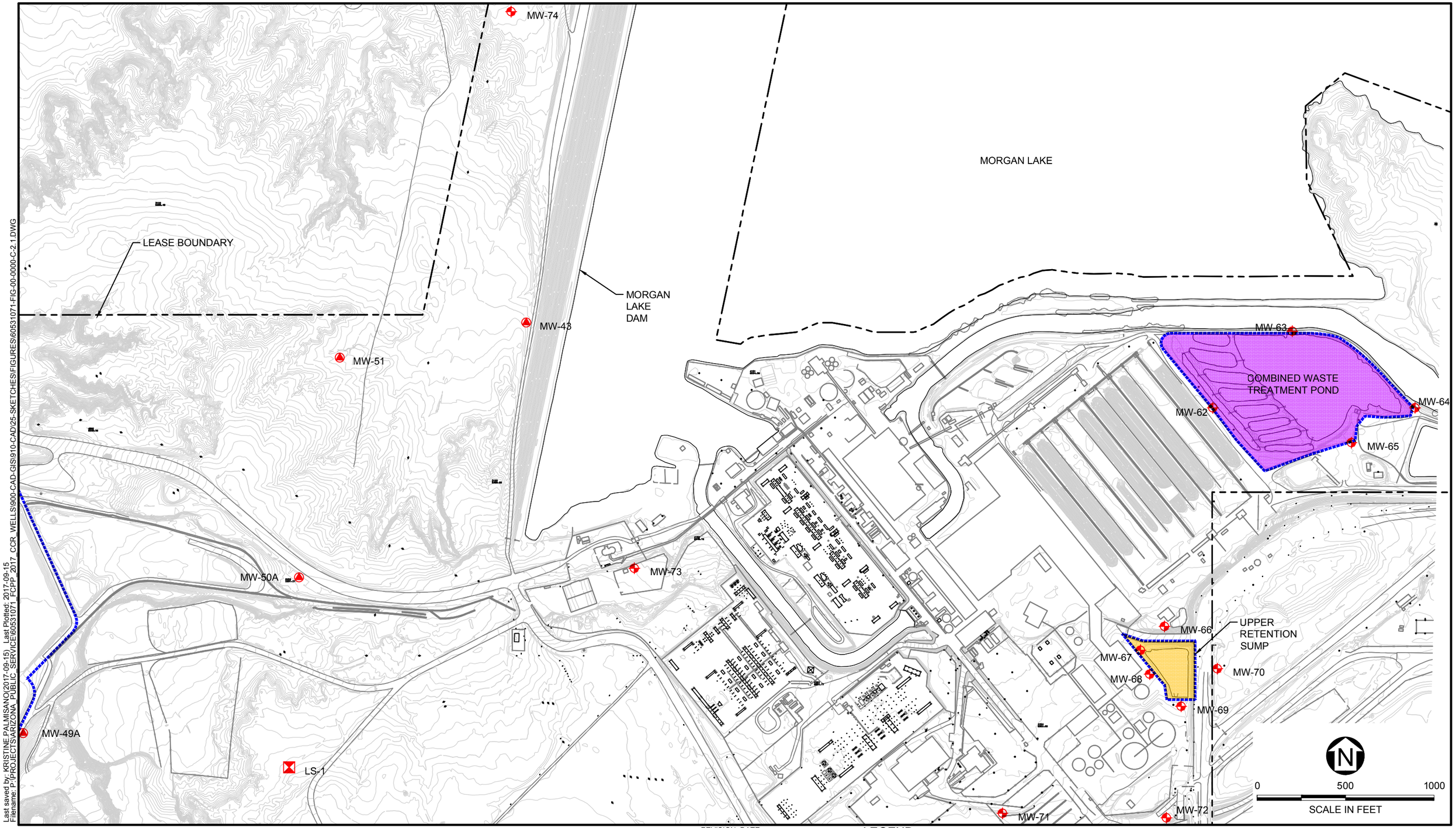
Faciltiy Name	Size (acres)	Landfill	Impoundment	Status
Upper Retention Sump	1.07		X	Active
Combined Waste Treatment Pond (CWTP)	13.7		X	Active
Lined Ash Impoundment (LAI)	75		X	Active
Lined Decant Water Pond (LDWP)	45		X	Active
DFADA, Cells #1, #2 and #3	84	X		Active
DFADA 4		X		Planned

Table 4.1:
Monitoring Well Construction Details

Well	New/Exist	CCR UNIT	Date Installed	Northing	Easting	Borehole Depth (feet bgs)	Top of Screen (feet bgs)	Bottom of Screen (feet bgs)	Screen Length (feet)	Ground Surface Elevation	Top of Casing Elevation	Stick Up (feet)	Top of Screen Elevation	Bottom of Screen Elevation
MW-66	New	Upper Retention Sump	9/27/2015	2,070,329.33	2,534,260.15	33	15	25	10	5344.7	5344.69	0.0	5329.7	5319.7
MW-67	New	Upper Retention Sump	9/11/2015	2,070,194.39	2,534,124.22	31	19.6	29.6	10	5354.0	5356.42	2.4	5334.4	5324.4
MW-68	New	Upper Retention Sump	9/10/2015	2,070,059.51	2,534,176.27	30	19.0	29.0	10	5354.0	5353.58	-0.4	5335.0	5325.0
MW-69	New	Upper Retention Sump	9/9/2015	2,069,877.99	2,534,353.89	35	24.3	34.3	10	5355.3	5357.66	2.4	5331.0	5321.0
MW-70	New	Upper Retention Sump	9/30/2015	2,070,090.58	2,534,558.23	53	40	50	10	5368.6	5371.12	2.5	5328.6	5318.6
MW-71	New	Upper Retention Sump	3/1/2016	2,069,273.31	2,533,344.69	50	22.5	42.5	20	5363.6	5362.91	-0.7	5341.1	5321.1
MW-72	New	Upper Retention Sump	3/2/2016	2,069,248.07	2,534,270.98	61	50.7	60.7	10	5379.1	5381.62	2.5	5328.4	5318.4
MW-73	New	Upper Retention Sump	1/18/2017	2,070,658.00	2,531,266.17	45	28.9	43.9	15	5351.9	5353.95	2.1	5323.0	5308.0
MW-62	New	CWTP	9/28/2015	2,071,562.93	2,534,532.68	20	10	20	10	5339.4	5341.87	2.5	5329.4	5319.4
MW-63	New	CWTP	9/25/2015	2,071,996.92	2,534,981.78	20	9	19	10	5337.0	5337.02	0.0	5328.0	5318.0
MW-64	New	CWTP	9/26/2015	2,071,564.57	2,535,675.10	25	10	20	10	5337.7	5337.66	0.0	5327.7	5317.7
MW-65	New	CWTP	9/27/2015	2,071,367.36	2,535,315.81	20	8	18	10	5337.2	5339.74	2.5	5329.2	5319.2
MW-12R	Existing	Multiunit 1	3/27/2012	2,068,356.17	2,527,509.57	70	13.5	33.5	20	5261.7	5264.44	2.7	5248.2	5228.2
MW-40R	New	Multiunit 1	9/17/2015	2,069,601.83	2,523,646.84	25	14.3	24.3	10	5134.8	5137.43	2.6	5120.5	5110.5
MW-43	Existing	Multiunit 1	3/24/2012	2,072,045.99	2,530,655.84	60	16	26	10	5269.4	5271.58	2.2	5253.4	5243.4
MW-49A	Existing	Multiunit 1	5/18/2013	2,069,725.72	2,527,814.06	68	50	65	15	5281.4	5285.96	4.6	5231.4	5216.4
MW-50A	Existing	Multiunit 1	5/7/2013	2,070,606.21	2,529,372.84	63	28	43	15	5333.2	5335.67	2.5	5305.2	5290.2
MW-51	Existing	Multiunit 1	4/28/2013	2,071,847.79	2,529,602.78	80	20	30	10	5285.1	5287.52	2.4	5265.1	5255.1
MW-61	New	Multiunit 1	9/16/2015	2,068,690.79	2,523,692.19	35	24.2	34.2	10	5126.6	5129.19	2.6	5102.4	5092.4
MW-8	Existing	Multiunit 1	3/11/1987	2,067,581.98	2,523,451.56	74	27.7	47.7	20	5120.9	5122.56	1.7	5093.2	5073.2
MW-74	New	Multiunit 1	1/18/2017	2,073,802.41	2,530,570.32	40	8.1	18.1	10	5216.7	5219.09	2.4	5208.6	5198.6
MW-75	New	Multiunit 1	3/15/2017	2,068,503.98	2,523,705.35	41	29.0	39.0	10	5124.8	5126.80	2.0	5095.8	5085.8
MW-76	New	Multiunit 1	3/16/2017	2,067,954.00	2,523,375.13	33	11.8	26.8	15	5114.3	5116.23	1.9	5102.5	5087.5
MW-7	Existing	Multiunit 1	3/11/1987	2,067,347.92	2,524,866.31	60	14.7	34.7	20	5148.3	5149.32	1.0	5133.6	5113.6
MW-10	Existing	DFADA	3/12/1987	2,065,094.41	2,525,297.91	35	13	33	20	5149.7	5150.71	1.1	5136.7	5116.7
MW-13	Existing	DFADA	8/31/1987	2,066,528.21	2,525,040.92	60	34.9	54.9	20	5149.5	5150.75	1.2	5114.6	5094.6
MW-44	Existing	DFADA	3/28/2012	2,065,826.30	2,525,157.77	40	13.5	23.5	10	5145.2	5146.89	1.7	5131.7	5121.7
MW-48	Existing	DFADA	5/14/2013	2,064,927.04	2,525,190.54	80	35	60	25	5163.4	5165.96	2.5	5128.4	5103.4
MW-55R	New	DFADA	9/13/2015	2,069,601.83	2,523,646.84	95	72.9	92.9	20	5241.4	5243.96	2.6	5168.5	5148.5

Note: All elevations in feet above mean sea level (NAVD 88)
Horizontal Coordinates in feet NAD83

FIGURES



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REFERENCE:
- EXISTING WELL LOCATIONS TAKEN FROM THE MONITORING WELL INSTALLATION REPORT FIGURE 1 DATED 03-21-2014.
- NEW CCR MONITOR WELL LOCATION SURVEY PROVIDED BY SAKURA ENGINEERING AND SURVEYING ON 11-25-2015 AND 4-18-17.

DATUM: TOPOGRAPHY: PROVIDED BY APS (AERIAL MAPPING COMPANY) FLIGHT DATE MARCH 05, 2014, DATUM: NEW MEXICO STATE PLANE, TRANSVERSE MERCATOR-WEST ZONE 3003, US SURVEY FOOT, N.A.D. 1983, N.A.V.D. 88.

REVISION, DATE:
1, 9.15.2017

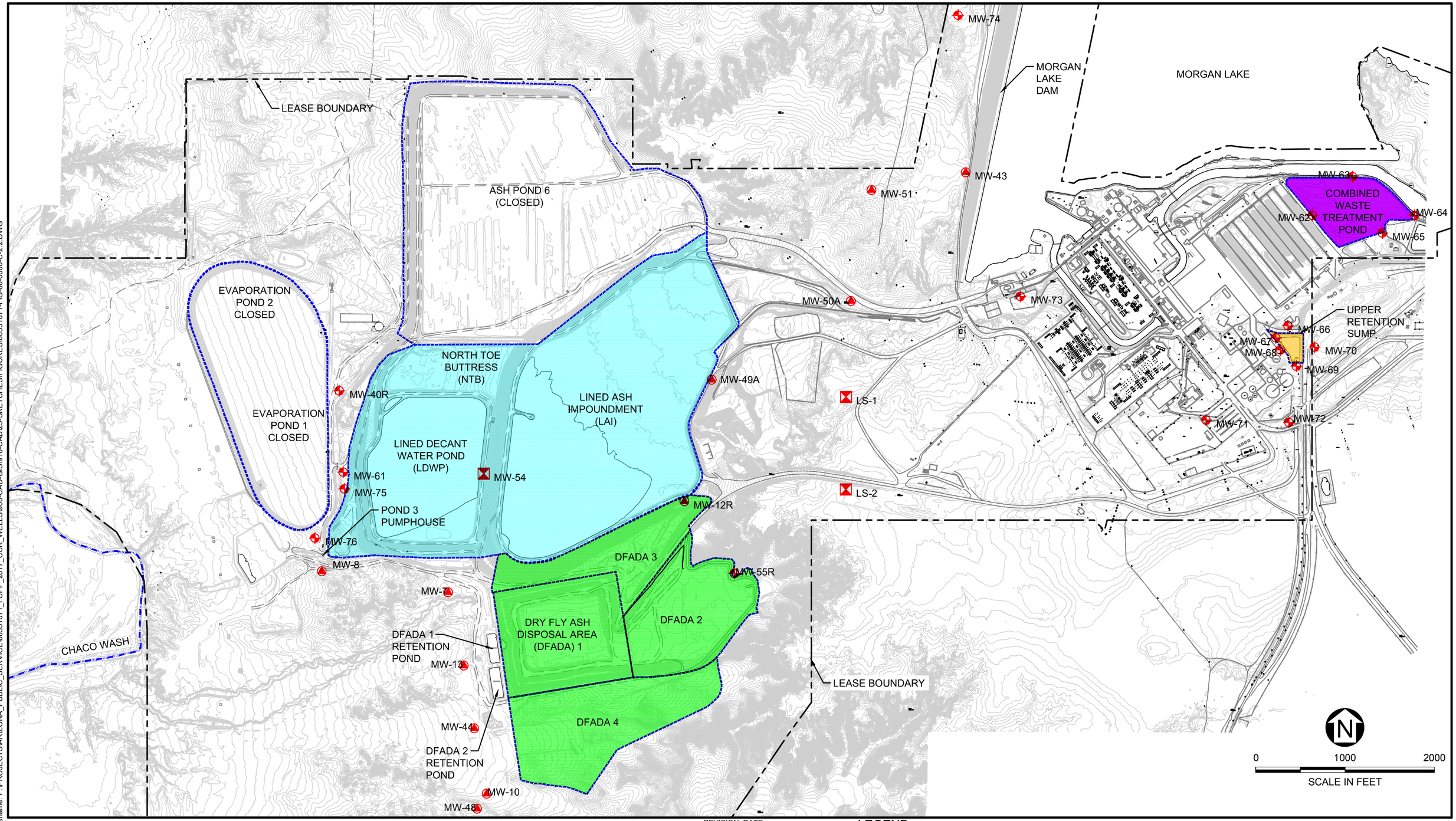
CONTROL POINT	NORTHING	EASTING	ELEVATION
EMMA	N2,066,529.495	E2,528,708.477	5382.251'
HV53	N2,070,581.505	E2,529,275.542	5331.214'
HV61	N2,070,581.682	E2,520,166.590	5085.898'

LEGEND

- New CCR Monitor Well
- Existing CCR Monitor Well
- Existing Site Monitoring Well
- CWTP
- Upper Retention Sump

AECOM

Figure 2.1
Upper Retention Sump and CWTP Locations and Boundaries
Arizona Public Service
Four Corners Power Plant



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- EXISTING WELL LOCATIONS TAKEN FROM THE MONITORING WELL INSTALLATION REPORT FIGURE 1 DATED 03-21-2014.
- NEW CCR MONITOR WELL LOCATION SURVEY PROVIDED BY SAKURA ENGINEERING AND SURVEYING ON 11-25-2015 AND 4-18-2017.

DATUM: TOPOGRAPHY: PROVIDED BY APS (AERIAL MAPPING COMPANY) FLIGHT DATE MARCH 05, 2014, DATUM: NEW MEXICO STATE PLANE, TRANSVERSE MERCATOR-WEST ZONE 3003, US SURVEY FOOT, N.A.D. 1983, N.A.V.D. 88.

REVISION, DATE:
1, 9.15.2017

CONTROL POINT	NORTHING	EASTING	ELEVATION
EMMA	N2,066,529.495	E2,528,708.477	5382.251'
HV53	N2,070,581.505	E2,529,275.542	5331.214'
HV61	N2,070,581.682	E2,520,166.590	5085.898'

LEGEND

- New CCR Monitor Well
- Existing CCR Monitor Well
- Existing Site Monitoring Well
- Chaco Wash
- CCR Multi-Unit 1
- DFADA
- CWTP
- Upper Retention Sump

AECOM

Figure 2.2
Multiunit 1 DFADA
Locations and Boundaries
Arizona Public Service
Four Corners Power Plant

Sources: USGS Topo Maps 1995
The Hogback North (West) and Fruitland (East)

0 2,500 5,000 Feet

1 inch = 2,500 feet

Figure 3.1
Site and Vicinity Topography
Arizona Public Service
Four Corners Power Plant

AECOM

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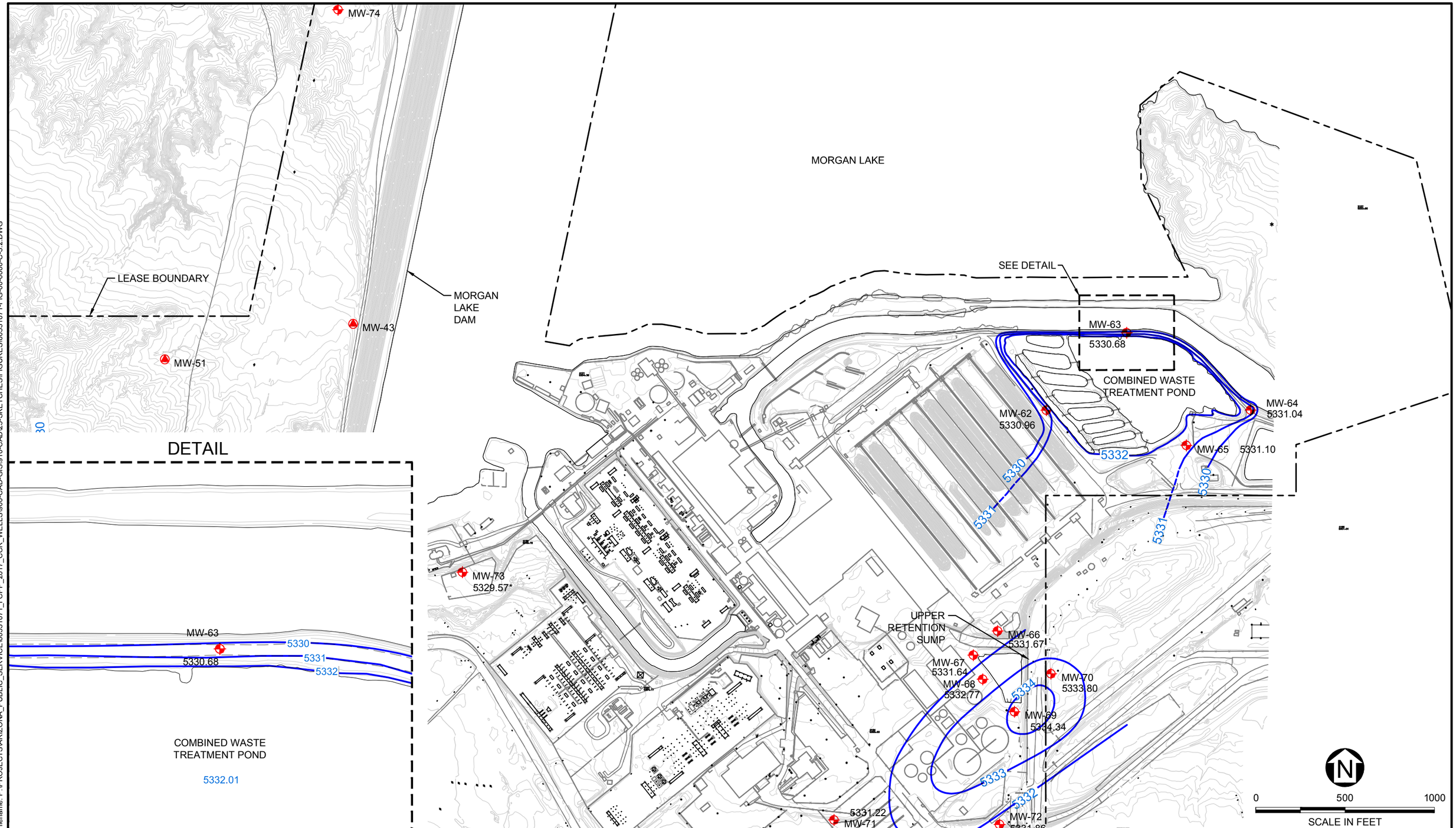

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REFERENCE:

- EXISTING WELL LOCATIONS TAKEN FROM THE MONITORING WELL INSTALLATION REPORT FIGURE 1 DATED 03-21-2014.
- NEW CCR MONITOR WELL LOCATION SURVEY PROVIDED BY SAKURA ENGINEERING AND SURVEYING ON 11-25-2015 AND 4-18-2017.

DATUM: TOPOGRAPHY: PROVIDED BY APS (AERIAL MAPPING COMPANY) FLIGHT DATE MARCH 05, 2014, DATUM: NEW MEXICO STATE PLANE, TRANSVERSE MERCATOR-WEST ZONE 3003, US SURVEY FOOT, N.A.D. 1983, N.A.V.D. 88.

CONTROL POINT	NORTHING	EASTING	ELEVATION
EMMA	N2,066,529.495	E2,528,708.477	5382.251'
HV53	N2,070,581.505	E2,529,275.542	5331.214'
HV61	N2,070,581.682	E2,520,166.590	5085.898'

REVISION, DATE:
1, 9.18.2017

LEGEND

- New CCR Monitor Well
- Existing CCR Monitor Wells
- Existing Site Monitoring Well
- Groundwater Elevation Contour
- Inferred Groundwater Elevation Contour
- Structures

* Water level measured on April 16, 2017; not used in contouring

AECOM

Figure 3.2
Groundwater Elevations June 2016
Upper Retention Sump and CWTP
Arizona Public Service
Four Corners Power Plant

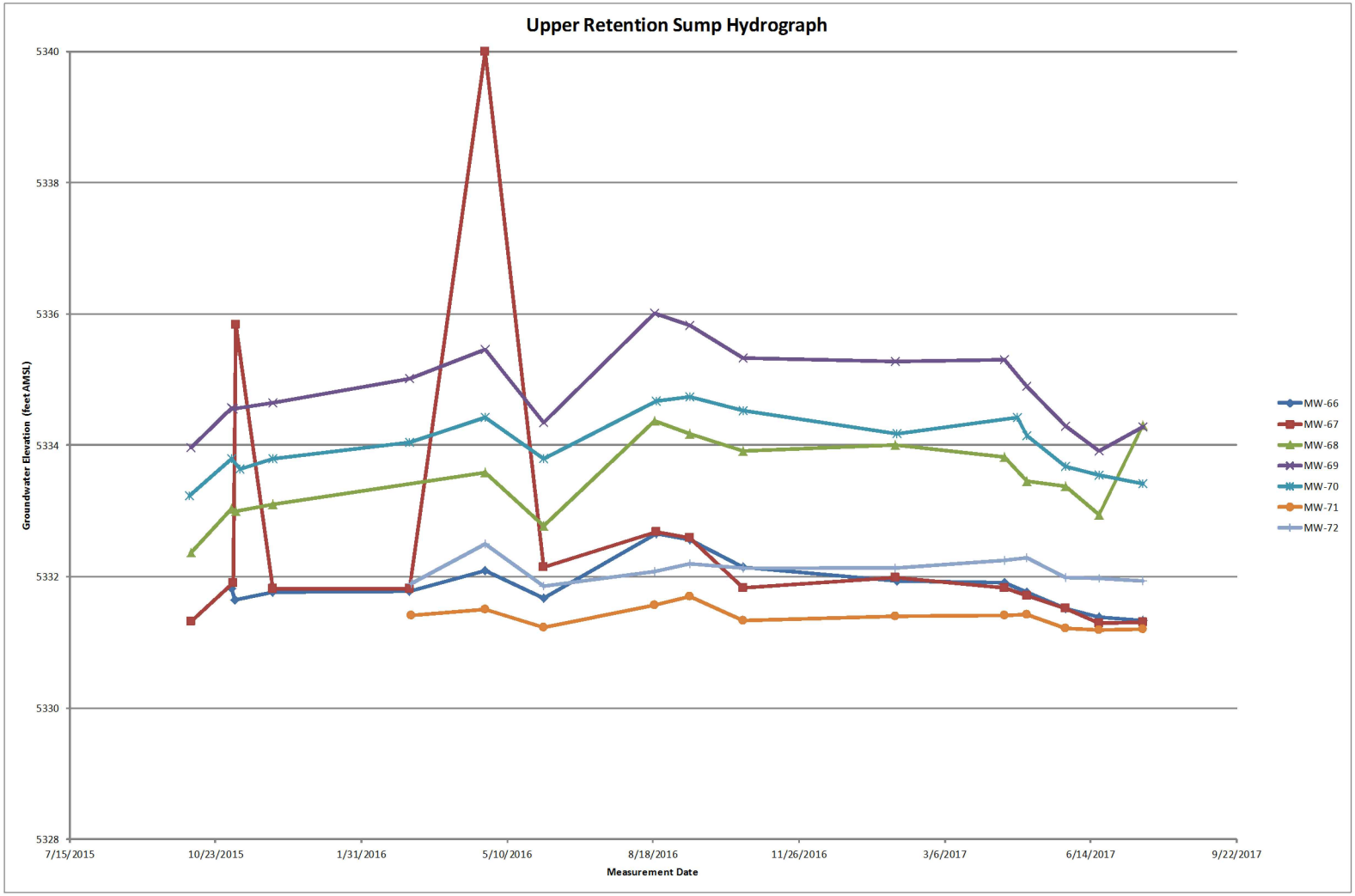

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Figure 3.3
Upper Retention Sump Hydrograph
Arizona Public Service
Four Corners Power Plant

AECOM

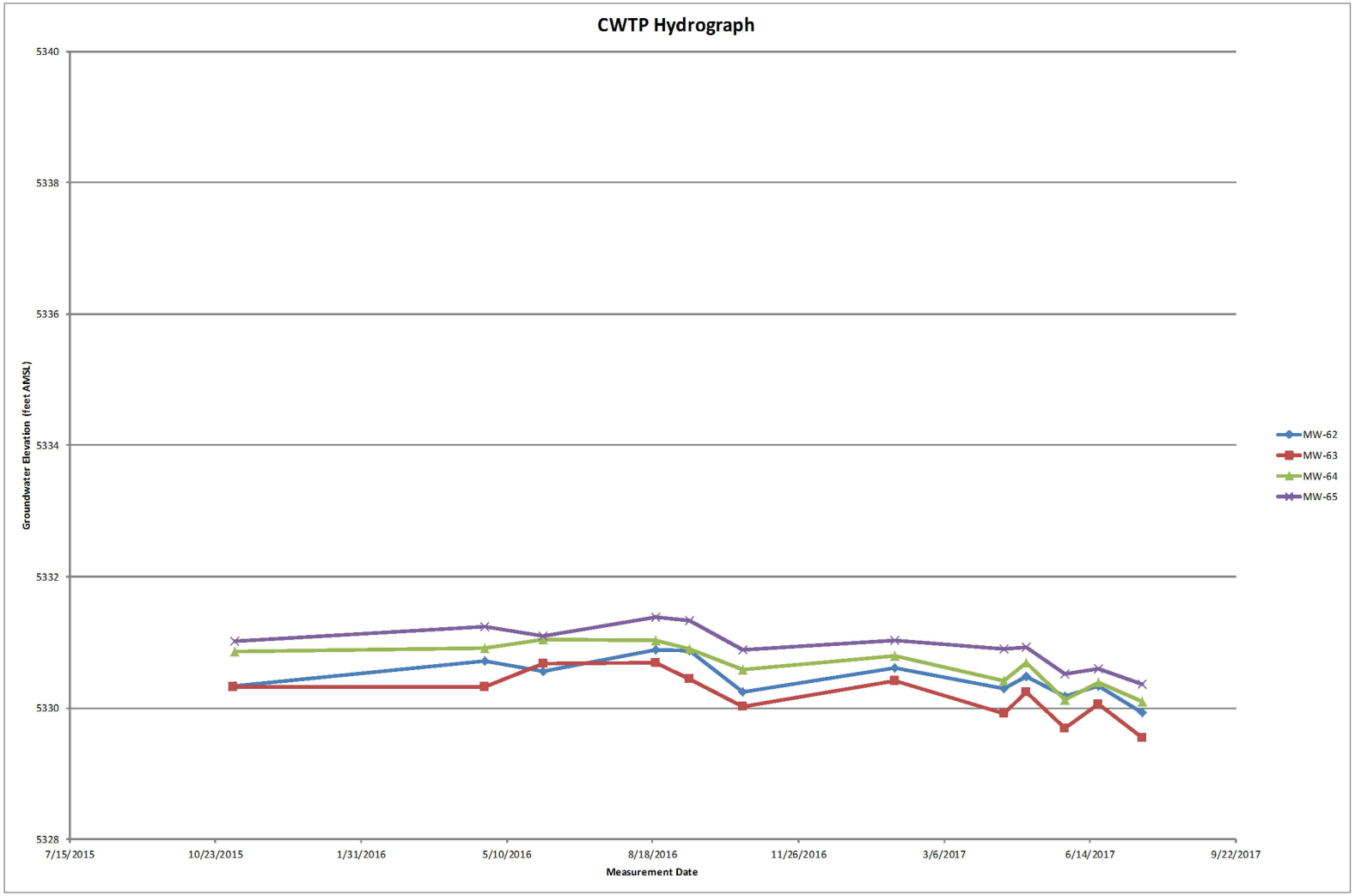

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Figure 3.4
CWTP Hydrograph
Arizona Public Service
Four Corners Power Plant

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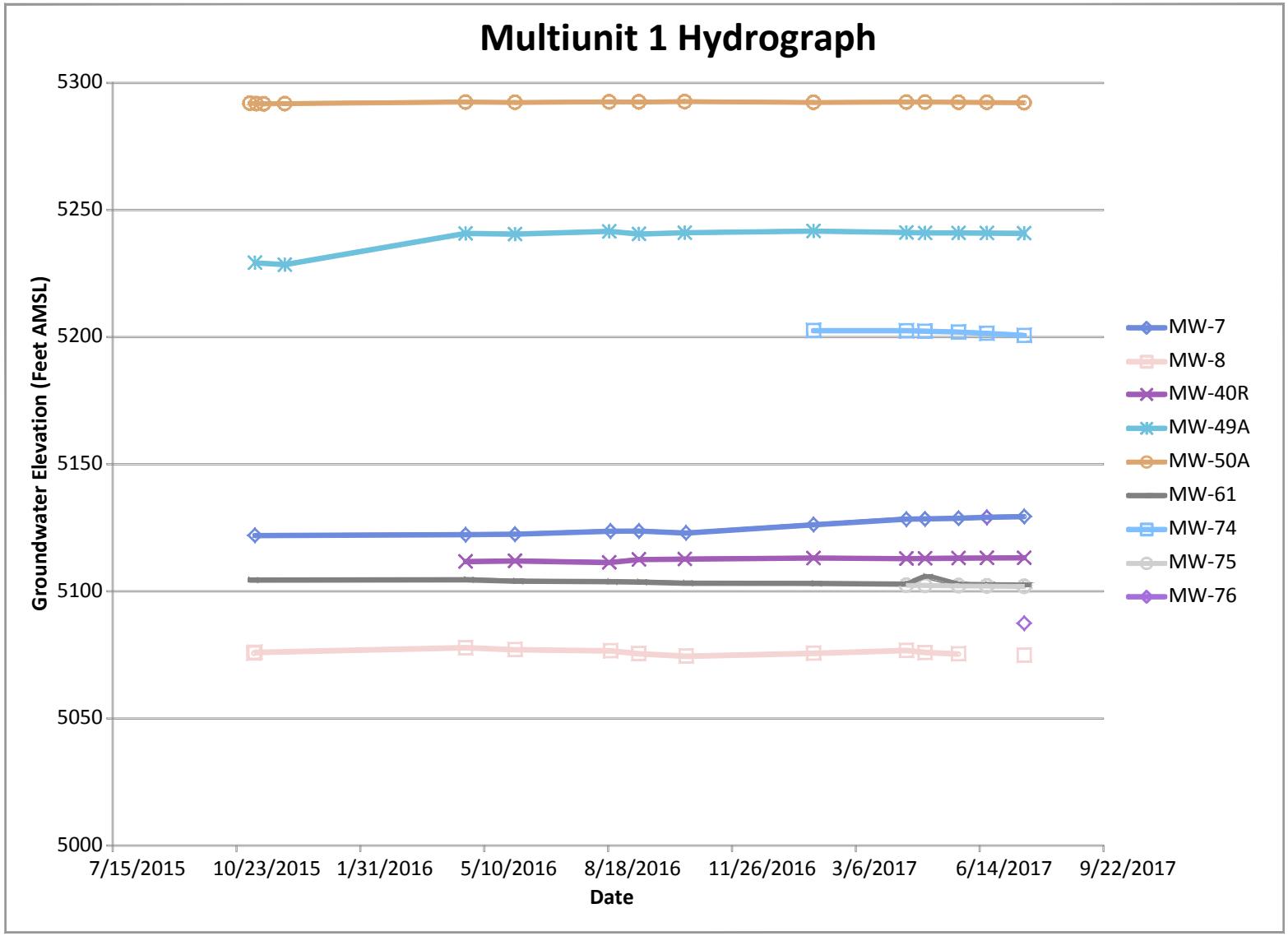

NOTE: CCR GROUNDWATER MONITORING WELLS NW-43 AND MW-51 ARE NOT INCLUDED ON HYDROGRAPH BECAUSE THEY ARE DRY.

Figure 3.6
Multiunit 1 Hydrograph
Arizona Public Service
Four Corners Power Plant

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APPENDIX A
NEW CCR WELL INSTALLATION METHODS

A. New Monitoring Well Installation

This section describes the borehole drilling and well construction of the 18 new monitoring wells installed to complete the CCR monitoring well networks. The drilling and well construction methods are described in this section. All wells were constructed according to the requirements of §257.91(e).

Eighteen new monitoring wells were installed:

- Four new monitoring wells were installed at Multiunit 1 (MW-40R, MW-61, MW-75 and MW-76).
- One new monitoring well was installed at the DFADA (MW-55R).
- Four new monitoring wells were installed at the CWTP (MW-62, MW-63, MW-64, and MW-65).
- Seven new monitoring wells were installed at the Upper Retention Sump (MW-66, MW-67, MW-68, MW-69, MW-70, MW-71, and MW-72.
- One new monitoring well was installed to monitor background water quality in the Pictured Cliffs Sandstone hydrostratigraphic unit in the Plant Area (MW-73).
- One new monitoring well was installed to monitor background water quality in the weathered Lewis Shale/Alluvium hydrostratigraphic unit in the Disposal Area (MW-74).

A-1. Borehole drilling

AECOM contracted Cascade Drilling, L.P. (Cascade), of Peoria Arizona, to drill and install the following monitoring wells:

- A total of twelve new wells (MW-40R, MW-55R and MW-61 through MW-70) were installed in September and October 2016.
- Two wells were installed in March 2016 (MW-71 and MW-72).
- Two wells were installed in January 2017 (MW-73 and MW-74).
- Two wells were installed in March 2017 (MW-75 and MW-76).

- Cascade is a New Mexico-licensed driller, certified by the Groundwater Quality Bureau with Well Driller License No. WD-1664.

The Rotosonic drilling method was used to install all new monitoring wells. The Rotosonic method was selected because the drive casing maintains borehole stability without the use of a fluid circulation system; no water or other fluids were introduced to the boreholes during drilling. The Rotosonic method also provides a continuous sample core.

The Rotosonic drilling method uses high frequency vibrations to advance the drive casing and core barrel during drilling. Depending on formation conditions, the drive casing or core barrel can be advanced independently. Once a 10-foot section has been cored, the core barrel is retrieved and the core is extruded from the core barrel into 2.5-foot long plastic containers. The drive casing is then advanced to keep the borehole open. Each boring was drilled with a 9.375-inch outside diameter (OD) drive casing and a 7.0-inch OD core barrel.

An AECOM field geologist supervised all drilling and well construction activities. The drill cores were examined and described using the Unified Soil Classification System (USCS). Stratigraphic boring logs were prepared for each soil boring and are provided in Appendix B.

Drill cuttings produced during drilling activities were spread on the ground in a thin layer at each drilling site.

A-2. Monitoring Well Construction

Cascade provided all well casing and materials. Each piece of well casing arrived on-site sealed in its factory wrapping. All casing was inspected in the field prior to placement in the well to ensure that each section was clean and undamaged. The monitoring wells were constructed inside of the drill casing to prevent borehole collapse around the well and to ensure accurate placement of the filter pack and well seal materials. Boring logs and as-built diagrams of monitoring well construction are included in Appendix B.

A-2a. Casing and Screen

Well casings and screens consisted of nominal 5-inch I.D. Schedule 80, polyvinyl chloride (PVC), with 0.020-inch, factory slotted openings. The lowermost section of screen was fitted with a threaded, stainless steel end cap.

A-2b. Filter Pack

The annulus between the boreholes and the well screens was filled with 10-20 mesh (U.S. standard sieve size) Colorado™ silica sand, except monitoring wells MW-73 through MW-76 which utilized a 20-40 mesh filter pack. The filter sand was poured between the well casing and the drill casing to form the filter pack. The required volume of filter sand was calculated in the field. The drill casing was vibrated, as necessary, to assist with settling and withdrawn incrementally as the annulus was filled. The depth to the top of the filter sand was verified using a tape measure. The filter pack was brought to a level 1 to 3 feet above the top of the screened interval.

A-2c. Casing Seals

At each monitoring well the annulus between the borehole and solid wall casing was sealed in accordance with §257.91(e). A minimum 2-foot thick bentonite pellet seal was installed above the filter pack. Water was added to the borehole and the seal was allowed to hydrate for approximately 30 minutes before installing the cement-bentonite grout seal. The grout seal consisted of Portland cement with up to 5 percent bentonite. The grout seal was emplaced using positive displacement methods and a tremie pipe.

A-2d. Surface Completion

Each PVC well casing was secured with a lockable, water-tight, expanding plug to prevent unwanted material from entering the well. Above-grade completions consisted of an 8-inch diameter, steel protective casing placed over the PVC well casing. The protective casing was set in approximately 3 feet of concrete (Sackrete™) with up to 3 feet of stickup. The surface was finished with 3 feet square concrete pad set just above ground surface. Bollards were placed around the above grade wells to provide additional protection. The bollards were constructed of 4-inch diameter low carbon steel, and extend approximately 3.5-feet above ground surface.

Monitor wells within roadways were completed using 12-inch diameter flush-mount, traffic-rated steel vaults set in approximately 2 feet of concrete. The vaults were set approximately four inches above the top of the PVC well casing.

A-3. Well Development

Cascade used a Smeal™ rig to develop the new monitoring wells and the existing wells selected for inclusion in the CCR monitoring networks. The well development process consisted of swabbing and bailing to remove sediment, followed by pumping with an electric pump. The

Cascade technician continued development on each well until the water was visually clear or the well would not yield enough water to continue. Water from the development process was containerized and then discharged to the Upper Retention Sump.

A-4. Single Well response Tests

Falling head single well response tests (slug tests) were conducted on five wells installed in the Pictured Cliffs Sandstone to measure the horizontal hydraulic conductivity of the Pictured Cliffs Sandstone. Determination of hydraulic conductivities is required by the Rule §257.91(b)(2). At each of these wells an electronic pressure transducer (Solinst™ Levelogger) was installed in the well to measure water level change over time. A cylindrical PVC slug of volume 0.4 $feet^3$ was quickly lowered into the well to create a nominally instantaneous displacement of approximately 2.8 feet. The well was allowed to recover (falling head test). A rising head test was not conducted since the well screen would become partially dewatered making the test inaccurate.

The test results were analyzed using Aqtesolv™ software. The solution method used was Bouwer and Rice (Bouwer, 1989). The measured hydraulic conductivities ranged from 1.3 to 81.4 feet/day with a geometric mean of 6 feet/day.

A-5. Surveying

Sakura Engineering & Surveying surveyed the newly installed wells in accordance with the New Mexico State Plane NAD 83 northing and easting coordinate. Sakura is a New Mexico Licensed Surveying firm. The elevations for the wells were referenced to the NAVD 88 system. The surveyed elevations were measured to the nearest 0.01 foot AMSL. The top of the PVC casing elevations were surveyed at each well. The stickup of the PVC casing was measured by AECOM at the time the wells were installed to calculate a ground surface elevation prior to concrete pad installation.

APPENDIX B
BORING LOGS AND MONITORING WELL AS-BUILT DIAGRAMS

APPENDIX B.1
NEW MONITORING WELLS

URS

Borehole: MW-40R

PROJECT: FCCP Monitoring Well Install
CLIENT: APS
LOCATION: FCCP New Mexico
URS PROJECT #: 60437300

DRILLING METHOD: RotoSonic
LOGGED BY: Dan Sola
START DATE/TIME: 9/16/2015 3:00:00 PM
FINISH DATE/TIME: 9/17/2015 11:00:00 AM

Water Level at Drilling Completion (ft bgs): Dry
Screened Interval (ft bgs): 14.3-24.3
COMMENTS:

COORDINATES (NM State):
North: 2069601.83
East: 2523646.84
TOP OF GROUND ELEVATION (NAVD88): 5134.83 feet A.S.L.

DEPTH (ft)	GRAPHIC LOG	Lithology Depth	MATERIAL DESCRIPTION	WELL INFORMATION
0		0.0		Above Ground Monument
		5.0	Sandy Clay (CL), brown, dry, some fill, some dry weathered shale	Concrete; Borehole Diameter is 9-3/8 inches
10			Shale, Clay, weathered, brown, friable, moist, trace sand, Fe staining, gypsum staining, moist	Cement Bentonite Grout; Sch 80 5-1/2 inch PVC Riser; Bentonite; 10-20 Silica Sand
20		22.5	Minor wet seams from 19-22'	Sch 80 5-1/2 inch PVC, Slot 0.020
		25.0	Shale, gray, unweathered, pulverized by hard drilling, dry	Stainless Steel End Cap

Total Depth of borehole = 25.0 feet bgs

URS

Borehole: MW-55R

PROJECT: FCCP Monitoring Well Install
CLIENT: APS
LOCATION: FCCP New Mexico
URS PROJECT #: 60437300

DRILLING METHOD: RotoSonic
LOGGED BY: Rick Smith
START DATE/TIME: 9/12/2015 8:30:00 AM
FINISH DATE/TIME: 9/13/2015 5:00:00 PM

Water Level at Drilling Completion (ft bgs): Dry
Screened Interval (ft bgs): 72.9-92.9
COMMENTS:

COORDINATES (NM State):
North: 2069601.83
East: 2523646.84
TOP OF GROUND ELEVATION (NAVD88): 5241.36 feet A.S.L.

DEPTH (ft)	GRAPHIC LOG	Lithology Depth	MATERIAL DESCRIPTION	WELL INFORMATION
0		0.0		Above Ground Monument
		3.0	0-3' Potholed	Concrete; Borehole Diameter is 9-3/8 inches
10, 20		25.0	Lean Clay (CL), fine sand, light brownish grey (10 YR 6/2), dry, very soft to firm, medium high plasticity, weak cementation, no HCL reaction, pulverized shale	Sch 80 5-1/2 inch PVC Riser
		29.0	Lean Clay (CL), fine sand, dark grayish brown (10 YR 4/2), dry, very firm, medium high plasticity, weak cementation, no HCL reaction, trace gypsum flakes, pulverized shale	
30		30.0	Limestone, grey and white, strong HCL reaction, hard	
40, 50			Lean Clay (CL), fine sand, dark grayish brown (10 YR 4/2), dry, very firm, medium high plasticity, weak cementation, no HCL reaction, trace gypsum flakes, more competent, hard shale 1-3" fragments of shale, gray (5 YR 4/1), sample is powdered shale and weak to moderately cemented fragments	Cement Bentonite Grout

URS

Borehole: MW-55R

PROJECT: FCCP Monitoring Well Install
CLIENT: APS
LOCATION: FCCP New Mexico
URS PROJECT #: 60437300

DRILLING METHOD: RotoSonic
LOGGED BY: Rick Smith
START DATE/TIME: 9/12/2015 8:30:00 AM
FINISH DATE/TIME: 9/13/2015 5:00:00 PM

DEPTH (ft)	GRAPHIC LOG	Lithology Depth	MATERIAL DESCRIPTION	WELL INFORMATION
60			Lean Clay (CL), fine sand, dark grayish brown (10 YR 4/2), dry, very firm, medium high plasticity, weak cementation, no HCL reaction, trace gypsum flakes, more competent, hard shale *(continued)*	
			Shale, Lean Clay (CL), fine sand, dark grayish brown (10 YR 4/2), dry, very firm, medium high plasticity when wetted, no HCL reaction, sample is pulverzied shale powder and moderately cemented shale fragments, 1-4" planar	
70				Bentonite
				10-20 Silica Sand
80				Sch 80 5-1/2 inch PVC, Slot 0.020
90				
		95.0		Stainless Steel End Cap

Total Depth of borehole = 95.0 feet bgs

URS

Borehole: MW-61

PROJECT: FCCP Monitoring Well Install
CLIENT: APS
LOCATION: FCCP New Mexico
URS PROJECT #: 60437300

DRILLING METHOD: RotoSonic
LOGGED BY: Dan Sola
START DATE/TIME: 9/15/2015 3:00:00 PM
FINISH DATE/TIME: 9/16/2015 11:00:00 AM

Water Level at Drilling Completion (ft bgs): 22
Screened Interval (ft bgs): 24.2-34.2
COMMENTS:

COORDINATES (NM State):
North: 2068690.79
East: 2523692.19
TOP OF GROUND ELEVATION (NAVD88): 5126.59 feet A.S.L.

DEPTH (ft)	GRAPHIC LOG	Lithology Depth	MATERIAL DESCRIPTION	WELL INFORMATION
0		0.0		Above Ground Monument
			Sandy Lean Clay (CL), trace gravel, dry, medium plasticity when wetted, shale fragments, light brown	Concrete Borehole Diameter is 9-3/8 inches
10		12.0		Cement Bentonite Grout
			Shale fragments, Clay (CL), dry, mottled brown-black in shale fragments, Fe stained, brachiopods, slightly moist at 14'	Sch 80 5-1/2 inch PVC Riser
20			Moist, mottled brown-black, brachiopod impression at 21', friable, weathered, breaks by hand, iron oxide staining	Bentonite 10-20 Silica Sand
			More competent shale, larger fragments, oxidized, mottled, some gypsum staining, moist	
30			Highly weathered, water in seams at 31' and 33'	Sch 80 5-1/2 inch PVC, Slot 0.020
		35.0		Stainless Steel End Cap

Total Depth of borehole = 35.0 feet bgs

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URS

Borehole: MW-62

PROJECT: FCCP Monitoring Well Install
CLIENT: APS
LOCATION: FCCP New Mexico
URS PROJECT #: 60437300

DRILLING METHOD: RotoSonic
LOGGED BY: Leah Wills
START DATE/TIME: 9/27/2015 3:05:00 PM
FINISH DATE/TIME: 9/28/2015 10:30:00 AM

Water Level at Drilling Completion (ft bgs): 10
Screened Interval (ft bgs): 10-20
COMMENTS:

COORDINATES (NM State):
North: 2071562.93
East: 2534532.68
TOP OF GROUND ELEVATION (NAVD88): 5339.37 feet A.S.L.

DEPTH (ft)	GRAPHIC LOG	Lithology Depth	MATERIAL DESCRIPTION	WELL INFORMATION
0		0.0		Above Ground Monument
			Silty Sand (SM), yellowish brown (10 YR 5/4), fine sand, medium dense, dry, moderate HCL reaction	Concrete Borehole Diameter is 9-3/8 inches Bentonite
			Silty Sand (SM), dark grayish brown (10 YR 4/2), fine sand, dense, moist, strong HCL reaction, some clay	Sch 80 5-1/2 inch PVC Riser
10			Very dark gray (10 YR 3/1), with brown mottling	10-20 Silica Sand
			Lean Clay with Sand (CL), dark gray (10 YR 4/1) with light brown mottling, fine sand, high plasticity, stiff, wet	Sch 80 5-1/2 inch PVC, Slot 0.020
20		20.0		Stainless Steel End Cap

Total Depth of borehole = 20.0 feet bgs

URS

Borehole: MW-63

PROJECT: FCCP Monitoring Well Install
CLIENT: APS
LOCATION: FCCP New Mexico
URS PROJECT #: 60437300

DRILLING METHOD: RotoSonic
LOGGED BY: Leah Wills
START DATE/TIME: 9/25/2015 10:37:00 AM
FINISH DATE/TIME: 9/25/2015 1:30:00 PM

Water Level at Drilling Completion (ft bgs): 9
Screened Interval (ft bgs): 9-19
COMMENTS:

COORDINATES (NM State):
North: 2071996.92
East: 2534981.78
TOP OF GROUND ELEVATION (NAVD88): 5337.02 feet A.S.L.

DEPTH (ft)	GRAPHIC LOG	Lithology Depth	MATERIAL DESCRIPTION	WELL INFORMATION
0				
			Sandy Clay (CL), dark yellowish brown (10 YR 4/4), fine to coarse sand, medium plasticity, soft, dry, strong HCL reaction	Flush Mount Cover Concrete Borehole Diameter is 9-3/8 inches Bentonite
			Wet	Sch 80 5-1/2 inch PVC Riser 10-20 Silica Sand
10			3" layer of coarse gravel at 10.5'	
				Sch 80 5-1/2 inch PVC, Slot 0.020
20		20.0		Stainless Steel End Cap

Total Depth of borehole = 20.0 feet bgs

URS

Borehole: MW-64

PROJECT: FCCP Monitoring Well Install
CLIENT: APS
LOCATION: FCCP New Mexico
URS PROJECT #: 60437300

DRILLING METHOD: RotoSonic
LOGGED BY: Leah Wills
START DATE/TIME: 9/25/2015 3:30:00 PM
FINISH DATE/TIME: 9/26/2015 10:10:00 AM

Water Level at Drilling Completion (ft bgs): 8.5
Screened Interval (ft bgs): 10-20
COMMENTS:

COORDINATES (NM State):
North: 2071564.57
East: 2535675.1
TOP OF GROUND ELEVATION (NAVD88): 5337.66 feet A.S.L.

DEPTH (ft)	GRAPHIC LOG	Lithology Depth	MATERIAL DESCRIPTION	WELL INFORMATION
0				
			0-5' airknifed, fill material, fine clayey sand (SC)	Flush Mount Cover Concrete Borehole Diameter is 9-3/8 inches Bentonite
			Clayey Sand (SC), light olive brown (2.5 YR 5/4), fine sand, soft, moist, strong HCL reaction	Sch 80 5-1/2 inch PVC Riser 10-20 Silica Sand
10			12'-14' olive gray (5 YR 5/2)	Sch 80 5-1/2 inch PVC, Slot 0.020
			moist-wet	
20				Stainless Steel End Cap
		25.0		Hole Cave

Total Depth of borehole = 25.0 feet bgs

URS

Borehole: MW-65

PROJECT: FCCP Monitoring Well Install
CLIENT: APS
LOCATION: FCCP New Mexico
URS PROJECT #: 60437300

DRILLING METHOD: RotoSonic
LOGGED BY: Leah Wills
START DATE/TIME: 9/27/2015 11:50:00 AM
FINISH DATE/TIME: 9/27/2015 2:30:00 PM

Water Level at Drilling Completion (ft bgs):8.98
Screened Interval (ft bgs): 8-18
COMMENTS:

COORDINATES (NM State):
North: 2071367.36
East: 2535315.81
TOP OF GROUND ELEVATION (NAVD88): 5337.24 feet A.S.L.

DEPTH (ft)	GRAPHIC LOG	Lithology Depth	MATERIAL DESCRIPTION	WELL INFORMATION
0				Above Ground Monument
			Silty Sand (SM), light olive brown (2.5 YR 5/4), fine sand, soft to medium dense, dry, slight HCL reaction	Concrete Borehole Diameter is 9-3/8 inches Bentonite Sch 80 5-1/2 inch PVC Riser 10-20 Silica Sand
			5'-7.5' olive brown (2.5 YR 4/3)	
			7.5'-10' Dense	
10				
			Wet at 13'	Sch 80 5-1/2 inch PVC, Slot 0.020
				Stainless Steel End Cap
20		20.0		Hole Slough

Total Depth of borehole = 20.0 feet bgs

URS

Borehole: MW-66

PROJECT: FCCP Monitoring Well Install
CLIENT: APS
LOCATION: FCCP New Mexico
URS PROJECT #: 60437300

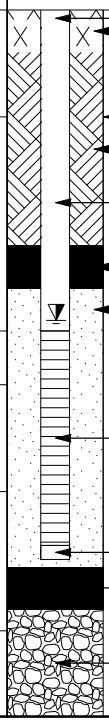
DRILLING METHOD: RotoSonic
LOGGED BY: Leah Wills
START DATE/TIME: 9/26/2015 11:10:00 AM
FINISH DATE/TIME: 9/27/2015 10:00:00 AM

Water Level at Drilling Completion (ft bgs): 14.5
Screened Interval (ft bgs): 15-25
COMMENTS:

COORDINATES (NM State):
North: 2070329.33
East: 25342260.15
TOP OF GROUND ELEVATION (NAVD88): 5344.69 feet A.S.L.

DEPTH (ft)	GRAPHIC LOG	Lithology Depth	MATERIAL DESCRIPTION
0			
		0	0-5' airknifed
		5.0	Sandy Silt (ML), yellowish brown (10 YR 5/4), fine sand, medium dense, dry, no HCL reaction
10		15.0	Sandstone fragments from 14'-15'
		17.5	Sandy Silt (ML), brown (10 YR 5/3), fine to medium sand, hard, dry, very strong HCL reaction, with cementation and sandstone fragments
20		22.5	Weathered Shale, Lean Clay (CL), brown (10 YR 5/3), medium stiff, fine sand, moist, low plasticity, some cementation, dark brown/black mottling at 20'
		29.0	Solid Sandstone, coarse grained, dry, light gray (10 YR 7/2)
30		33.0	Weathered Shale, Lean Clay (CL), brown (10 YR 5/3), fine sand, medium to high plasticity, soft to stiff, moist, no HCL reaction, moderately cemented fragments

WELL INFORMATION



Total Depth of borehole = 33.0 feet bgs

URS

Borehole: MW-67

PROJECT: FCCP Monitoring Well Install
CLIENT: APS
LOCATION: FCCP New Mexico
URS PROJECT #: 60437300

DRILLING METHOD: RotoSonic
LOGGED BY: Rick Smith
START DATE/TIME: 9/11/2015 7:40:00 AM
FINISH DATE/TIME: 9/11/2015 1:30:00 PM

Water Level at Drilling Completion (ft bgs): 19.8
Screened Interval (ft bgs): 19.64-29.64
COMMENTS:

COORDINATES (NM State):
North: 2070194.39
East: 2534124.22
TOP OF GROUND ELEVATION (NAVD88): 5354.02 feet A.S.L.

DEPTH (ft)	GRAPHIC LOG	Lithology Depth	MATERIAL DESCRIPTION	WELL INFORMATION
0				Above Ground Monument
			0-7.5' Airknifed	Concrete; Borehole Diameter is 9-3/8 inches
		7.5	Silty Sand (SM), fine sand, brownish yellow (10 YR 6/6), moist, loose, no HCL reaction, some weakly cemented fragments; driller notes competent sandstone	Cement Bentonite Grout; Sch 80 5-1/2 inch PVC Riser
10				
		17.5	Sandy Silt (ML), fine sand, light yellowish brown (2.5 YR 6/4), moist, loose sample, no HCL reaction	Bentonite; 10-20 Silica Sand
20				
		22.0		
		23.0	Sandy Silt (ML) as above, some thin layers (2-4mm) of dark brown silt with opaque crystals, no HCL reaction, yellowish orange mottling	
		26.0	Sandy Silt (ML), fine sand, light yellowish brown (2.5 YR 6/4), moist, loose sample, no HCL reaction, yellowish orange mottling	Sch 80 5-1/2 inch PVC, Slot 0.020
			Silt with Sand (ML), brown (10 YR 5/3) and brown (10 YR 5/8), fine sand, some clay, moist, loose sample, slightly platy, weakly cemented, no HCL reaction	
30		30.0		Stainless Steel End Cap
		30.5	Lean Clay with Sand (CL), brown (10 YR 5/3), fine sand, very moist, medium stiff, low plasticity	
		31.0	(Sandstone) Silty Sand (SM), light grey (10 YR 7/2) to very pale brown (10 YR 7/4), fine sand, with black subrounded grains, dense, moderately cemented, thinly bedded (1-2mm), moderate HCL reaction	

Total Depth of borehole = 31.0 feet bgs

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URS

Borehole: MW-68

PROJECT: FCCP Monitoring Well Install
CLIENT: APS
LOCATION: FCCP New Mexico
URS PROJECT #: 60437300

DRILLING METHOD: RotoSonic
LOGGED BY: Rick Smith
START DATE/TIME: 9/10/2015 10:00:00 AM
FINISH DATE/TIME: 9/10/2015 1:40:00 PM

Water Level at Drilling Completion (ft bgs): 20.5
Screened Interval (ft bgs): 19.04-29.04
COMMENTS:

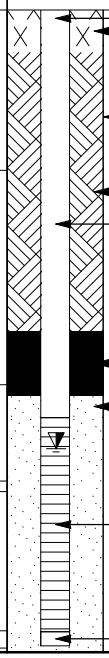
COORDINATES (NM State):
North: 2070059.51
East: 2534176.27
TOP OF GROUND ELEVATION (NAVD88): 5353.95 feet A.S.L.

DEPTH (ft)	GRAPHIC LOG	Lithology Depth	MATERIAL DESCRIPTION
0			
			0-7.5' Air knifed
		7.5	
10			Silty Sand (SM), brownish yellow (10 YR 6/6), fine sand, moist, loose, no HCL reaction, some weakly cemented fragments; driller notes competent sandstone
		17.5	
20			Sandy Silt (ML), light yellowish brown (2.5 YR 6/4), fine sand, moist, loose sample, moderately cemented per driller, no HCL reaction
		22.0	
		22.5	As above, strongly cemented, moderate HCL reaction
			Sandy Silt (ML), yellowish brown (10 YR 5/6), loose sample, moderately cemented per driller, no HCL reaction
		29.0	
30		29.8	Silt (ML), dark grayish brown (10 YR 4/2) with yellowish brown (10 YR 5/8) mottling, fine sand, trace clay, moist, firm
		30.0	

Cemented layer, moderate to strong HCL reaction, wet from 29.6'-29.8'

Total Depth of borehole = 30.0 feet bgs

WELL INFORMATION



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URS

Borehole: MW-69

PROJECT: FCCP Monitoring Well Install
CLIENT: APS
LOCATION: FCCP New Mexico
URS PROJECT #: 60437300

DRILLING METHOD: RotoSonic
LOGGED BY: Rick Smith
START DATE/TIME: 9/9/2015 10:30:00 AM
FINISH DATE/TIME: 9/9/2015 4:15:00 PM

Water Level at Drilling Completion (ft bgs): 21.24
Screened Interval (ft bgs): 24.32-34.32
COMMENTS:

COORDINATES (NM State):
North: 2069877.99
East: 2534353.89
TOP OF GROUND ELEVATION (NAVD88): 5355.26 feet A.S.L.

DEPTH (ft)	GRAPHIC LOG	Lithology Depth	MATERIAL DESCRIPTION	WELL INFORMATION
0				Above Ground Monument
			0-7.5' air knifed	Concrete
		7.5		Borehole Diameter is 9-3/8 inches
10			Silty Sand (SM), brownish yellow (10 YR 6/6), fine sand, moist, loose, some weak cementation, no HCL reaction	Cement Bentonite Grout
				Sch 80 5-1/2 inch PVC Riser
20			Light yellowish brown (2.5 YR 6/4); driller notes competent sandstone	
		22.5		Bentonite
			Sandy Silt (ML), light yellowish brown (2.5 YR 6/4), fine sand, moist, loose sample, moderately cemented, no HCL reaction	10-20 Silica Sand
		26.0	25'-26' cemented layer, grey (10 YR 6/1), moderate HCL reaction	
30			Sandy Silt (ML), yellowish brown (10 YR 5/6), fine sand, moist, loose sample, moderately cemented per driller, trace yellowish brown (10 YR 5/8) mottling, trace black staining or organics 1-2 mm thick	Sch 80 5-1/2 inch PVC, Slot 0.020
			No mottling or organics from 30'-35'	
		35.0		Stainless Steel End Cap

Total Depth of borehole = 35.0 feet bgs

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URS

Borehole: MW-70

PROJECT: FCCP Monitoring Well Install
CLIENT: APS
LOCATION: FCCP New Mexico
URS PROJECT #: 60437300

DRILLING METHOD: RotoSonic
LOGGED BY: Leah Wills
START DATE/TIME: 9/28/2015 4:30:00 PM
FINISH DATE/TIME: 9/30/2015 1:00:00 PM

Water Level at Drilling Completion (ft bgs): 37.89
Screened Interval (ft bgs): 40-50
COMMENTS:

COORDINATES (NM State):
North: 2070090.58
East: 2534558.23
TOP OF GROUND ELEVATION (NAVD88): 5368.62 feet A.S.L.

DEPTH (ft)	GRAPHIC LOG	Lithology Depth	MATERIAL DESCRIPTION	WELL INFORMATION
0				Above Ground Monument
		2.5	0-2.5' Air Knifed	Concrete
		9.0	Silty Sand (SM), yellowish brown (10 YR 5/4), fine sand, dry, loose to medium dnese, moderate HCL reaction, some weakly cemented fragments	Borehole Diameter is 9-3/8 inches
10		17.5	Sandy Silt (ML), dark yellowish brown (10 YR 4/4), dry, cemented, no HCL reaction, hard and crumbly Changes to dark grey from 12'-13.5'	Sch 80 5-1/2 inch PVC Riser
20		26.0	Sandy Silt (ML), very pale brown (10 YR 7/4), fine sand, dry, few weakly cemented fragments, dry, loose, moderate HCL reaction	Cement Bentonite Grout
30			Sandy Silt (ML), light yellowish brown (10 YR 6/4), fine to medium sand, some clay, moist, loose sample, weakly cemented, no HCL reaction	Bentonite
40				10-20 Silica Sand
		48.0		Sch 80 5-1/2 inch PVC, Slot 0.020
50		53.0	Weathered Shale, very dark brown grayish (10 YR 3/2), some lighter brown mottling, dry, medium to high plasticity when wetted, planar shale fragments, moderately cemented, no HCL reaction	Stainless Steel End Cap

Total Depth of borehole = 53.0 feet bgs

URS

Borehole: MW-71

PROJECT: FCCP Monitoring Well Install
CLIENT: APS
LOCATION: FCCP New Mexico
URS PROJECT #: 60437300

DRILLING METHOD: RotoSonic
LOGGED BY: Rick Smith
START DATE/TIME: 2/29/2016 2:00:00 PM
FINISH DATE/TIME: 3/1/2016 12:50:00 PM

Water Level at Drilling Completion (ft bgs): 31.5
Screened Interval (ft bgs): 22.54-42.54
COMMENTS:

COORDINATES (NM State):
North: 2069273.31
East: 2533344.69
TOP OF GROUND ELEVATION (NAVD88): 5363.62 feet A.S.L.

DEPTH (ft)	GRAPHIC LOG	Lithology Depth	MATERIAL DESCRIPTION	WELL INFORMATION
0				
		8.0	Silty Sand (SM), light yellowish brown (2.5 6/4), fine sand, trace fine gravel (0-4'), moist, loose, slight HCL reaction Hand auger to 3 ft, refusal 5-8 ft strong brown	Flush Mount Cover Concrete Borehole Diameter is 9-3/8 inches
10		19.0	Poorly Graded Sand with Silt (SP-SM), very pale brown (10 YR 7/4), fine sand, moist, loose to medium dense, moderate HCL reaction	Sch 80 5-1/2 inch PVC Riser Cement Bentonite Grout
20		20.0	Clayey Sand (SC), very pale brown (10 YR 7/4), fine sand, dry, dense, moderately cemented, strong HCL reaction	Bentonite 10-20 Silica Sand
		29.0	Sandy Silt (ML), strong brown (7.5 YR 5/6), fine sand, moist, loose to medium dense, weakly cemented, slight HCL reaction	
30		32.0	Lean Clay with Sand (CL), dark greyish brown (10 YR 4/2), fine sand, moist, soft to medium stiff, platy, no HCL reaction, weathered shale	
		33.0	Silty Sand (SM), moderately cemented	Sch 80 5-1/2 inch PVC, Slot 0.020
40		44.0	Sandy Shale and Sandy Silt (ML), strong brown, interbedded	Stainless Steel End Cap
50		50.0	Lean Clay with Sand (CL), weathered Lewis Shale, dark grey (2.5YR 4/1), slightly moist, very firm	Bentonite Hole Slough

Total Depth of borehole = 50.0 feet bgs

URS

Borehole: MW-72

PROJECT: FCCP Monitoring Well Install
CLIENT: APS
LOCATION: FCCP New Mexico
URS PROJECT #: 60437300

DRILLING METHOD: RotoSonic
LOGGED BY: Rick Smith
START DATE/TIME: 3/1/2016 3:00:00 PM
FINISH DATE/TIME: 3/2/2016 3:55:00 PM

Water Level at Drilling Completion (ft bgs): 49.72
Screened Interval (ft bgs): 50.74-60.74
COMMENTS:

COORDINATES (NM State):
North: 2069248.07
East: 2534270.98
TOP OF GROUND ELEVATION (NAVD88): 5379.09 feet A.S.L.

DEPTH (ft)	GRAPHIC LOG	Lithology Depth	MATERIAL DESCRIPTION	WELL INFORMATION
0				Above Ground Monument
		5.0	Silty Sand (SM), grey (7.5 YR 5/1), fine sand, trace fine gravel, dry, loose	Concrete
10			Poorly Graded Sand with Silt (SP-SM), very pale brown ad yellowish brown (10YR 7/4, 5/6), fine sand, slightly moist, loose to medium dense, some cemented layers (1-4' thick), with slight HCL reaction	Borehole Diameter is 9-3/8 inches Sch 80 5-1/2 inch PVC Riser
20				Cement Bentonite Grout
30				
40				Bentonite
50				10-20 Silica Sand
		53.0		
		54.0	Lean Clay with Sand (CL), dark greyish brown (10YR 4/2), fine sand, dry, hard, cemented, with strong HCL reaction	
		56.0	Clayey Sand (SC), grey (10 YR 5/1), fine sand, moist, loose to medium dense, low plasticity	Sch 80 5-1/2 inch PVC, Slot 0.020

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URS

Borehole: MW-72

PROJECT: FCCP Monitoring Well Install
CLIENT: APS
LOCATION: FCCP New Mexico
URS PROJECT #: 60437300

DRILLING METHOD: RotoSonic
LOGGED BY: Rick Smith
START DATE/TIME: 3/1/2016 3:00:00 PM
FINISH DATE/TIME: 3/2/2016 3:55:00 PM

DEPTH (ft)	GRAPHIC LOG	Lithology Depth	MATERIAL DESCRIPTION	WELL INFORMATION
60		60.0	Silty Sand (SM), greyish brown (7.5 YR 5/2), fine sand, moist, loose to medium dense, some moderate cementation, no HCL reaction *(continued)*	Stainless Steel End Cap

Total Depth of borehole = 61.0 feet bgs

AECOM
7720 N. 16th St.
Phoenix, AZ 85020
Telephone: 602-371-1100

WELL NUMBER MW-73

CLIENT APS
PROJECT NAME APS Four Corners
PROJECT NUMBER 60531071
PROJECT LOCATION Four Corners Power Plant
DATE STARTED 1/17/2017 **COMPLETED** 1/18/2017
GROUND ELEVATION 5351.9 ft **HOLE SIZE** 10 inches
DRILLING CONTRACTOR Cascade Drilling
GROUND WATER LEVELS:
DRILLING METHOD Rotosonic/Continuous Core (LS-600)
AT TIME OF DRILLING 22.00 ft / Elev 5329.90 ft
LOGGED BY R. Smith **CHECKED BY** F. Ackerman
AT END OF DRILLING 21.75 ft / Elev 5330.15 ft
NOTES Screened 28.8 to 43.8 feet bgs
AFTER DRILLING 21.80 ft / Elev 5330.10 ft

DEPTH (ft)	SAMPLE TYPE NUMBER	REMARKS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	WELL DIAGRAM
0		HAND AUGER TO 5 FEET WELL BUILT USING 5-INCH SCHEDULE 80 PVC WITH 0.010-INCH SLOT SCREEN	SM		0.0 (SM) **SILTY SAND** Fine sand, gray (Gley, 6/n), moist, loose, coal ash.	5351.9 Capped riser and well vault 2 feet above grade.
5					7.5	5344.4
10			SP-SM		(SP-SM) **POORLY GRADED SAND WITH SILT** Fine sand, very pale brown (10YR, 7/4), moist, loose to medium dense, weakly cemented lenses.	Hydrated Portland Cement - Bentonite grout 1 to 20 feet.
15						
20					22.0 Possible water lense at 22 feet, 2-3mm gypsum.	5329.9
25			SP-SM		(SP-SM) **POORLY GRADED SAND WITH SILT** Very pale brown (10YR, 7/4), loose to medium dense, moist. Driller notes mud on shoe at 24 feet.	3/8-inch Bentonite chips 20 to 25 feet.
30						
35			SC		34.0 (SC) **CLAYEY SAND** Fine sand, gray (5YR, 5/1), moist, loose to medium dense, some moderately cemented lenses 1 to 2 inches thick.	5317.9 20-40 Colorado Silica Sand filter pack. Screened 28.8 to 43.8 feet.
40					42.0	5309.9
45			SC		(SC) **CLAYEY SAND** Shale. Fine sand, gray (5YR, 5/1), moist, medium dense, some platy layers, moderately cemented. 45.0	5306.9 Stainless steel end cap.

Bottom of borehole at 45.0 feet.

GENERAL BH / TP / WELL - GINT STD US LAB.GDT - 18/8/17 09:22 - P:\PROJECTS\ARIZONA_PUBLIC_SERVICE\60531071_FCPP_2017_CCR_WELLS\400-TECHNICAL\432-WELL INSTALLATION 2\GINT\MW-73 MW-74, MW-75, MW-76.GPJ

AECOM
7720 N. 16th St.
Phoenix, AZ 85020
Telephone: 602-371-1100

WELL NUMBER MW-74

CLIENT APS
PROJECT NAME APS Four Corners
PROJECT NUMBER 60531071
PROJECT LOCATION Four Corners Power Plant
DATE STARTED 1/18/2017 **COMPLETED** 1/19/2017
GROUND ELEVATION 5216.7 ft **HOLE SIZE** 10 inches
DRILLING CONTRACTOR Cascade Drilling
GROUND WATER LEVELS:
DRILLING METHOD Rotosonic/Continuous Core (LS-600)
AT TIME OF DRILLING 14.00 ft / Elev 5202.70 ft
LOGGED BY R. Smith **CHECKED BY** F. Ackerman
AT END OF DRILLING 14.15 ft / Elev 5202.55 ft
NOTES Screened 8.1 to 18.1 feet bgs
AFTER DRILLING 14.15 ft / Elev 5202.55 ft

DEPTH (ft)	SAMPLE TYPE NUMBER	REMARKS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	WELL DIAGRAM
0						Capped riser and well vault 2 feet above grade.
		HAND AUGER TO 5 FEET WELL BUILT USING 5-INCH SCHEDULE 80 PVC WITH 0.010-INCH SLOT SCREEN	SM		(SM) **SILTY SAND** Fine sand, very pale brown (10YR, 7/4), moist, loose.	Hydrated Portland Cement - Bentonite grout 1 to 6.5 feet. 3/8-inch Bentonite chips 6.5 to 7.5 feet.
5						
10						
15					Very moist to wet 13 feet to 15 feet.	20-40 Colorado Silica Sand filter pack. Screened 8.1 to 18.1 feet.
				15.0	5201.7	
			SC		(SC) **CLAYEY SAND** Weathered Shale. Fine grained sand, dark yellowish brown (10YR, 4/4), medium dense, moist, some gypsum, mottled.	Stainless steel end cap.
20						
25						
30						3/8-inch Bentonite chips to bottom.
35						
				37.0	5179.7	
40				40.0	**SHALE** Becoming unweathered and less mottled at 37 feet. Gray (5YR, 5/1), slightly moist to dry, dense, moderately cemented, unweathered at 39.5 feet.	5176.7

Bottom of borehole at 40.0 feet.

GENERAL BH / TP / WELL - GINT STD US LAB.GDT - 18/8/17 09:22 - P:\PROJECTS\ARIZONA_PUBLIC_SERVICE\60531071_FCPP_2017_CCR_WELLS\400-TECHNICAL\432-WELL INSTALLATION 2\GINT\MW-73 MW-74, MW-75, MW-76.GPJ

AECOM
7720 N. 16th St.
Phoenix, AZ 85020
Telephone: 602-371-1100

WELL NUMBER MW-75

CLIENT APS
PROJECT NAME APS Four Corners
PROJECT NUMBER 60531071
PROJECT LOCATION Four Corners Power Plant
DATE STARTED 3/15/2017 **COMPLETED** 3/15/2017
GROUND ELEVATION 5124.8 ft **HOLE SIZE** 9.25 inches
DRILLING CONTRACTOR Cascade Drilling
GROUND WATER LEVELS:
DRILLING METHOD Rotosonic/Continuous Core (LS-600)
AT TIME OF DRILLING 25.00 ft / Elev 5099.80 ft
LOGGED BY R. Smith **CHECKED BY** F. Ackerman
AT END OF DRILLING 37.00 ft / Elev 5087.80 ft
NOTES Screened 24.02 to 39.02 feet bgs
AFTER DRILLING 21.82 ft / Elev 5102.98 ft

DEPTH (ft)	SAMPLE TYPE NUMBER	REMARKS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	WELL DIAGRAM
0		HAND AUGER TO 6 FEET WELL BUILT USING 5-INCH SCHEDULE 80 PVC WITH 0.010-INCH SLOT SCREEN	ML		(ML) **ASH** Gray.	Capped riser and well vault 2.15 feet above grade.
3.0						5121.8
5			SC		(SC) **CLAYEY SAND** Fine sand and silt, brown (10YR, 5/3), slightly moist, dense, low plasticity, flecks of gypsum, weathered Lewis Shale. Sand 60%. Silt/Clay 40%.	
10						Hydrated Portland Cement - Bentonite grout 1 to 19 feet.
15					Fine mottling at 16 feet.	
20.0						5104.8
20			CL		(CL) **LEAN CLAY with SAND** Fine sand, dark yellowish brown (10YR, 4/4), moist, very firm, low plasticity, mottled, some gypsum, weathered Lewis Shale.	3/8-inch Bentonite chips 19 to 22 feet.
25					Fines 80%. Sand 20%. Water on tools at 25 feet. No water on tools 26 to 37 feet.	
30						20-40 Colorado Silica Sand filter pack. Screened 24.02 to 39.02 feet
35						
38.0					Very moist 37 to 38 feet.	5086.8
40			CL		(CL) **SHALE** Gray, hard.	Stainless steel end cap
40.5						5084.3

Bottom of borehole at 40.5 feet.

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AECOM
7720 N. 16th St.
Phoenix, AZ 85020
Telephone: 602-371-1100

WELL NUMBER MW-76

CLIENT APS
PROJECT NAME APS Four Corners
PROJECT NUMBER 60531071
PROJECT LOCATION Four Corners Power Plant
DATE STARTED 3/15/2017 **COMPLETED** 3/16/2017
GROUND ELEVATION 5114.3 ft **HOLE SIZE** 9.25 inches
DRILLING CONTRACTOR Cascade Drilling
GROUND WATER LEVELS:
DRILLING METHOD Rotosonic/Continuous Core (LS-600)
AT TIME OF DRILLING 16.00 ft / Elev 5098.30 ft
LOGGED BY R. Smith **CHECKED BY** F. Ackerman
AT END OF DRILLING ---
NOTES Screened 11.8 to 26.8 feet bgs
AFTER DRILLING --- Dry.

DEPTH (ft)	SAMPLE TYPE NUMBER	REMARKS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	WELL DIAGRAM
0						Capped riser and well vault 2.2 feet above grade.
		HAND AUGER TO 6 FEET WELL BUILT USING 5-INCH SCHEDULE 80 PVC WITH 0.010-INCH SLOT SCREEN	SC		(SC) **CLAYEY SAND** Fine sand and silt, brown (10YR, 5/3), dry, dense, low plasticity, flecks of gypsum, weathered Lewis Shale. Fine sand 60%. Silt/Clay 40%. Some moisture starting at 12 feet.	Hydrated Portland Cement - Bentonite grout 1 to 7.5 feet. 3/8-inch Bentonite chips 7.5 to 10 feet.
15.0			CL		(CL) **LEAN CLAY** Fine sand, brown (10YR, 5/3), moist, very firm, low plasticity, mottled, some gypsum flecks, weathered Lewis Shale. Fine sand 10-15%. Very moist 16 to 18 feet. Very little moisture 25 to 26.5 feet.	Screened 11.8 to 26.8 feet. 20-40 Colorado Silica Sand filter pack.
26.5			CL		(CL) **SHALE** Gray, hard.	Stainless steel end cap
32.5						

5099.3 — 5087.8 — 5081.8

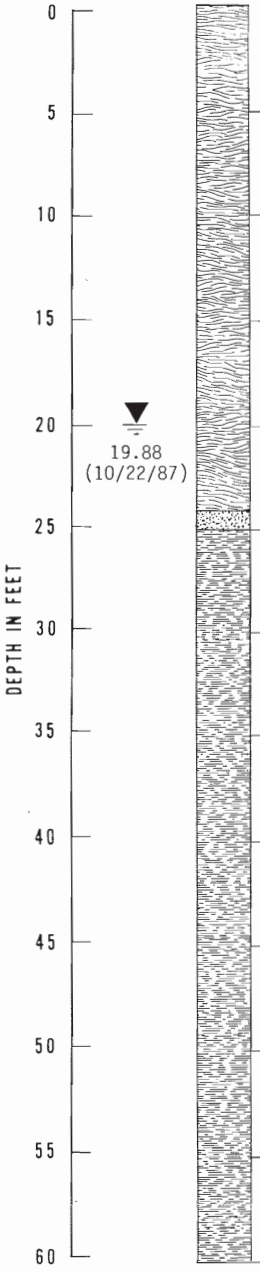
Bottom of borehole at 32.5 feet.

GENERAL BH / TP / WELL - GINT STD US LAB.GDT - 18/8/17 09:22 - P:\PROJECTS\ARIZONA_PUBLIC_SERVICE\60531071_FCPP_2017_CCR_WELLS\400-TECHNICAL\432-WELL INSTALLATION 2\GINT\MW-73 MW-74, MW-75, MW-76.GPJ

APPENDIX B.2
EXISTING MONITORING WELLS

LITHOLOGIC LOG

SURFACE ELEVATION 5146.62 FT.
MEASURING POINT 5148.52 FT.



SILTY CLAY, LIGHT BROWN, CONTAINS GYPSUM CLASTS

SILTY CLAY, LIGHT BROWN, CONTAINS PETRIFIED WOOD AND GYPSUM

SILTY CLAY, LIGHT BROWN, DAMP

AS ABOVE

SANDSTONE TO SILTY CLAY. POOR SAMPLE. WATER ENCOUNTERED AT 21-22 FEET. TOP OF LESS WEATHERED BEDROCK AT 24.5 FEET

SHALE, GRAY TO BROWNISH GRAY, MODERATELY WEATHERED, HEMATITE STAINED AND CEMENTED, FISSILE

SILTY SHALE, GRAY, OIL FILM ON WATER COMING OUT OF HOLE

SILTY SHALE, GRAY

AS ABOVE

AS ABOVE

AS ABOVE

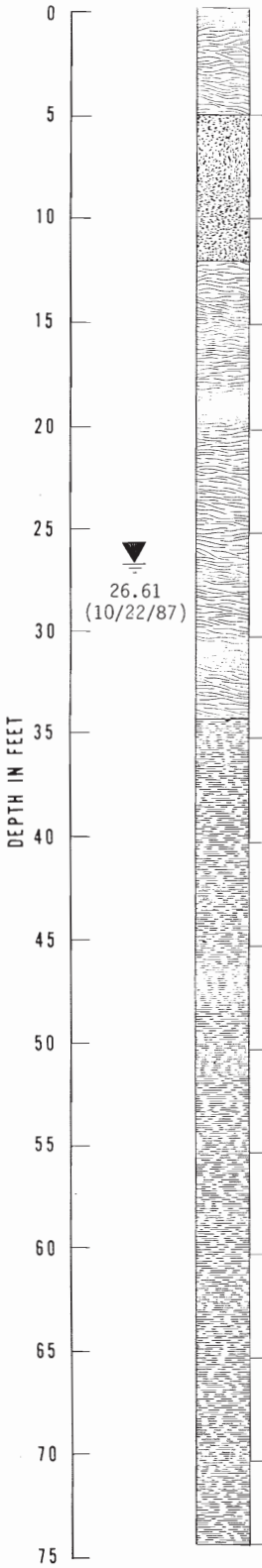
AS ABOVE.

BORING TERMINATED AT 60 FEET ON 3/11/87.
NOTE: LITHOLOGIC LOG IS BASED ON RESULTS FROM THE 1st HOLE THAT WAS DRILLED. A 2nd HOLE, OFFSET BY 15 FEET, WAS DRILLED FOR CONSTRUCTING THE MONITOR WELL.

BORING MW-7

LITHOLOGIC LOG

SURFACE ELEVATION 5118.95 FT.
MEASURING POINT 5120.95 FT.



SANDY CLAY, LIGHT BROWN, VERY FINE-GRAINED. SOME SANDSTONE CLASTS

SANDSTONE, BUFF-BROWN, BREAKS EASILY, FINE-GRAINED

SANDSTONE TO SILTY CLAY, BUFF TO GRAY; SANDSTONE AS ABOVE. GYPSUM CRYSTALS PRESENT

SILTY SHALE, BUFF-GRAY, WEATHERED GYPSUM FRAGMENTS

AS ABOVE

AS ABOVE

AS ABOVE. TURNING TO GRAY SHALE, WEATHERED, TOP OF UNWEATHERED BEDROCK IS AT 34 FEET

SHALE, GRAY, UNWEATHERED

AS ABOVE

AS ABOVE

AS ABOVE

AS ABOVE

AS ABOVE

AS ABOVE

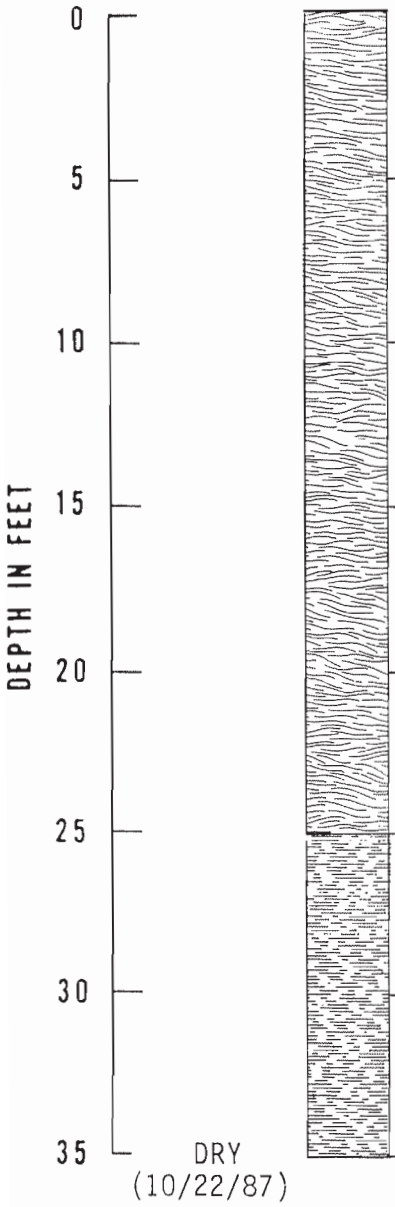
AS ABOVE

BORING TERMINATED AT 74 FEET ON 3/11/87.
NOTE: LITHOLOGIC LOG IS BASED ON RESULTS FROM THE 1st HOLE THAT WAS DRILLED. A 2nd HOLE, OFFSET BY 35 FEET, WAS DRILLED FOR CONSTRUCTING THE MONITOR WELL.

BORING MW-8

LITHOLOGIC LOG

SURFACE ELEVATION	5147.38 FT.
MEASURING POINT	5148.88 FT.



SILTY SHALE, BROWN-GRAY, WEATHERED. SOME GYPSUM. SOME MOISTURE. FINE-GRAINED

AS ABOVE

AS ABOVE

AS ABOVE. MORE WEATHERED SHALE FRAGMENTS

MOSTLY WEATHERED SHALE, GRAY-BROWN, SOME GYPSUM. TOP OF UNWEATHERED BEDROCK AT 25 FEET

SHALE, GRAY, SLIGHTLY WEATHERED TO UNWEATHERED.

SHALE, GRAY, UNWEATHERED

BORING TERMINATED AT 35 FEET ON 3/12/87.

BORING MW-10

URS
7720 North 16th Street STE 100
Phoenix, AZ

Borehole: MW-12R

PROJECT: Four Corners Power Plant
CLIENT: APS
LOCATION: Fruitland, NM
URS PROJECT #: 23446275

DRILLING METHOD: Rotosonic
LOGGED BY: Derrick Maurer
START DATE/TIME: 3/26/2012 2:53:00 PM
FINISH DATE/TIME: 3/27/2012 1:20:00 PM

COMMENTS: Surveyed by Souder, Miller and Associates: June 2012 PVC and steel casing were extended ten feet on 4/23/12

COORDINATES (NAD83):
North: 2068356.17
East: 2527509.566
TOP OF GROUND ELEVATION (NAVD88): 5261.71feet A.S.L.

DEPTH (ft)	Lithology Depth	MATERIAL DESCRIPTION	WELL INFORMATION
0		Sand, gray (7.5YR 5/1), fine to medium grain, dry, trace gravels and soft ash	Cement Grout (0-8 ft bgs)
	8.0		
	8.5	Clay, wet	4.5 inch diameter sch. 80 pvc riser (0-13.5 ft bgs)
10		Weathered Shale, brown (7.5YR 4/4), dry, completely weathered, iron oxide staining	Bentonite Seal (8-13 ft bgs)
20			Filter Pack (10-20 Silica Sand) (13-34 ft bgs)
		DTW = ND	4.5 inch diameter sch. 80 PVC 0.020 slot screen (13.5-33.5 ft bgs)
		DTW = ND (1 hour)	
30		Visible water 30-34 ft bgs wet in fractures	
	34.0		
	35.0	DTW = ND (mud on probe and sounder tape up to 31 ft bgs waited overnight)	
		Limestone, greenish gray (10B 6/1), fine, completely weathered, iron oxide staining	
		Weathered Shale, brown (7.5YR 4/4), dry, completely weathered, iron oxide staining	
40			
50			Bentonite Chips (34-70 ft bgs)
60			
		Transition from weathered shale to unweathered shale	
	63.0		
		Unweathered Shale, blueish gray (10B 6/1), dry, hard, fine, unweathered	

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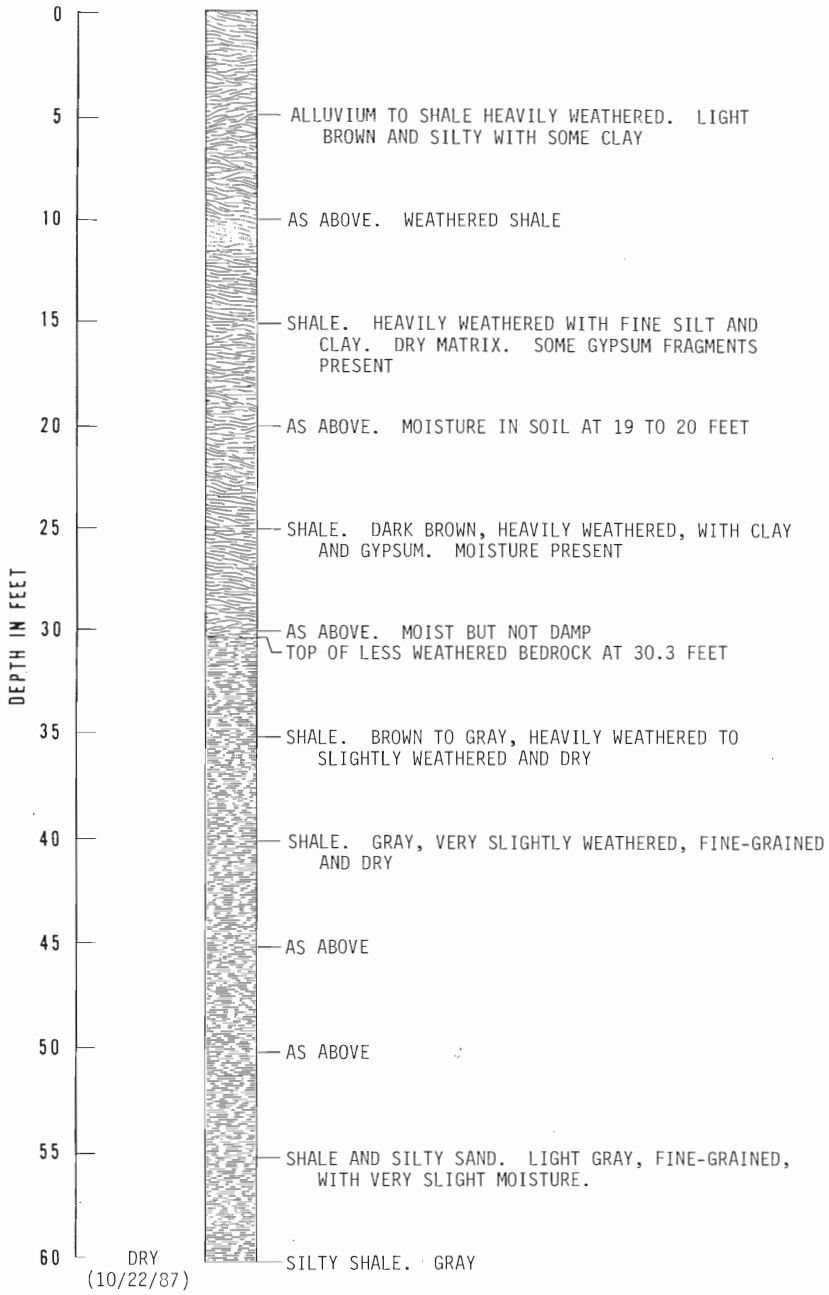
LITHOLOGIC LOG

SURFACE ELEVATION 5147.39 FT.
MEASURING POINT 5149.14 FT.



BORING TERMINATED AT 60 FEET ON 8/31/87.

BORING MW-13

URS

Borehole: MW-40

PROJECT: Four Corners Power Plant
CLIENT: APS
LOCATION: Fruitland, NM
URS PROJECT #: 23446244

DRILLING METHOD: Roto Sonic
LOGGED BY: Derrick Maurer
START DATE/TIME: 3/25/2012 8:20:00 AM
FINISH DATE/TIME: 3/25/2012 1:50:00 PM

DEPTH (ft)	GRAPHIC LOG	Lithology Depth	MATERIAL DESCRIPTION	WELL DIAGRAM
0			WEATHERED SHALE, completely weathered, brown (7.5YR 5/4), gypsum, dry	Cement/Grout
10				Bentonite Seal (Hole Plug 3/8")
				Filter Pack (10-20 Silica Sand)
20			Damp to wet, no visible water in core, core barrel had wet spot at approximately 19-20 ft bgs	Screen (Sch. 80 PVC slot 0.020)
		23.0	UNWEATHERED SHALE, unweathered, laminated, blueish gray (10B 5/1), hard, dry, fossils/shells observed in sheet like fractures DTW = ND (2 hours)	
30				
40				Backfill (Bentonite Chips 3/8")
50		50.0		

DTW = ND (30 minutes)

Total Depth of borehole = 50.0 feet.

URS
7720 North 16th Street STE 100
Phoenix, AZ

Borehole: MW-43

PROJECT: Four Corners Power Plant
CLIENT: APS
LOCATION: Fruitland, NM
URS PROJECT #: 23446275

DRILLING METHOD: Rotosonic
LOGGED BY: Derrick Maurer
START DATE/TIME: 3/23/2012 4:50:00 PM
FINISH DATE/TIME: 3/24/2012 12:05:00 PM

COMMENTS: Surveyed by Souder, Miller and Associates: June 2012

COORDINATES (NAD83):
North: 2072045.99
East: 2530655.841
TOP OF GROUND ELEVATION (NAVD88): 5269.42feet A.S.L.

DEPTH (ft)	GRAPHIC LOG	Lithology Depth	MATERIAL DESCRIPTION	WELL INFORMATION
0			Weathered Shale, brown (7.5YR 5/4), dry, completely weathered	Cement Grout (0-10 ft bgs)
			Caliche, light brown (7.5YR 6/3), dry, hard, gypsum	4.5 inch diameter sch. 80 pvc riser (0-16 ft bgs)
10			Weathered Shale, brown (7.5YR 5/4), dry, completely weathered	
			Caliche, gray (7.5YR 6/1), dry, hard	Bentonite Seal (10-15.5 ft bgs)
			Weathered Shale	Filter Pack (10-20 Silica Sand) (15.5-27 ft bgs)
20			Damp	4.5 inch diameter sch. 80 PVC 0.020 slot screen (16-26 ft bgs)
			DTW = ND (overnight)	
		27.0	Unweathered Shale, blueish gray (10B 5/1), damp, hard, laminated	
30			DTW = ND	
			DTW = ND (35 minutes)	
40				Bentonite Chips (27-60 ft bgs)
50				
60		60.0	DTW = ND (1.5 hours)	

Total Depth of borehole = 60.0 feet

URS
7720 North 16th Street STE 100
Phoenix, AZ

Borehole: MW-44

PROJECT: Four Corners Power Plant
CLIENT: APS
LOCATION: Fruitland, NM
URS PROJECT #: 23446275

DRILLING METHOD: Rotosonic
LOGGED BY: Derrick Maurer
START DATE/TIME: 3/27/2012 4:20:00 PM
FINISH DATE/TIME: 3/28/2012 1:00:00 PM

COMMENTS: Surveyed by Souder, Miller and Associates: June 2012

COORDINATES (NAD83):
North: 2065826.301
East: 2525157.767
TOP OF GROUND ELEVATION (NAVD88): 5145.15feet A.S.L.

DEPTH (ft)	GRAPHIC LOG	Lithology Depth	MATERIAL DESCRIPTION	WELL INFORMATION
0		2.0	(SM) Silty Sand, brown, fine grain, dry, some gravel	Cement Grout (0-8 ft bgs)
			Weathered Shale, brown, damp, completely weathered, gypsum, iron oxide staining	4.5 inch diameter sch. 80 pvc riser (0-13.5 ft bgs)
10				Bentonite Seal (8-13 ft bgs)
			DTW = ND (overnight)	Filter Pack (10-20 Silica Sand) (13-24.5 ft bgs)
20		23.0		4.5 inch diameter sch. 80 PVC 0.020 slot screen (13.5-23.5 ft bgs)
			Unweathered Shale, blueish gray (10B 5/1), dry, hard, unweathered, laminated, sheet fractures, small fossils	
30			DTW = ND (30 minutes) DTW = ND (1 hour)	Bentonite Chips (24.5-40 ft bgs)
40		40.0	DTW = ND	

Total Depth of borehole = 40.0 feet

URS
7720 North 16th Street STE 100
Phoenix, AZ

Borehole: MW-48

PROJECT: FCCP Monitoring Well Install
CLIENT: APS
LOCATION: FCCP New Mexico
URS PROJECT #: 23446329

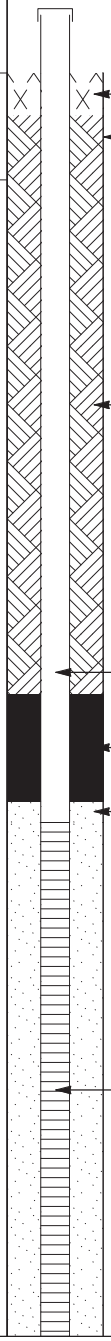
DRILLING METHOD: Rotosonic
LOGGED BY: Miles Hearn
START DATE/TIME: 5/13/2013 9:10:00 AM
FINISH DATE/TIME: 5/14/2013 9:00:00 AM

Water Level at Drilling Completion (ft bgs): Dry
COMMENTS:

COORDINATES (NAD83):
North: 2064927.037
East: 2525190.543
TOP OF GROUND ELEVATION (NAVD88): 5163.43 feet A.S.L.

DEPTH (ft)	GRAPHIC LOG	Lithology Depth	MATERIAL DESCRIPTION
0		0.0	
			(SW) Gravelly Sand, brown, dry, alluvium
		5.0	
			Unweathered Lewis Shale, blue-gray, dry, competent
10			
20			
30			Highly competent 5"-10" solid cores
40			
50			Very competent

WELL INFORMATION



REPORT APS-FCPP-REV1 | PROJECT O:\GINT6\WRES GINT\PROJECTS\APS-FCPP\APS FCPP 2013 MWS.GPJ | LIBRARY APS FCPP-2012.GLB | PRINTED 6/13/14

URS
7720 North 16th Street STE 100
Phoenix, AZ

Borehole: MW-48

PROJECT: FCCP Monitoring Well Install
CLIENT: APS
LOCATION: FCCP New Mexico
URS PROJECT #: 23446329

DRILLING METHOD: Rotosonic
LOGGED BY: Miles Hearn
START DATE/TIME: 5/13/2013 9:10:00 AM
FINISH DATE/TIME: 5/14/2013 9:00:00 AM

DEPTH (ft)	GRAPHIC LOG	Lithology Depth	MATERIAL DESCRIPTION	WELL INFORMATION
60			Unweathered Lewis Shale, blue-gray, dry, competent *(continued)*	End Cap 8.3-inch Diameter Borehole
70				Bentonite Backfill
80		80.0	TD=80 ft. bgs, groundwater not encountered	

Total Depth of borehole = 80.0 feet

URS
7720 North 16th Street STE 100
Phoenix, AZ

Borehole: MW-49A

PROJECT: FCCP Monitoring Well Install
CLIENT: APS
LOCATION: FCCP New Mexico
URS PROJECT #: 23446329

DRILLING METHOD: Rotosonic
LOGGED BY: Miles Hearn
START DATE/TIME: 5/17/2013 4:20:00 PM
FINISH DATE/TIME: 5/18/2013 12:00:00 PM

Water Level at Drilling Completion (ft bgs): Dry
COMMENTS:

COORDINATES (NAD83):
North: 2069725.717
East: 2527814.06
TOP OF GROUND ELEVATION (NAVD88): 5281.38 feet A.S.L.

DEPTH (ft)	GRAPHIC LOG	Lithology Depth	MATERIAL DESCRIPTION	WELL INFORMATION
0		0.0		
			Ash, gray, dry	Concrete; 9.5-inch Diameter Borehole
			Moist	
10			Some orange staining	
20				Cement Grout
30				
			Wet	Sch 80 4-inch PVC Riser
40				Bentonite
		43.5	(CH) Fat clay aquitard	
		45.5	Weathered Lewis Shale, completely weathered, mostly clay, brown, moist	Cement Grout; Bentonite; 8-12 Silica Sand
50			Highly weathered, brown, high clay content, moist	Sch 80 4-inch PVC Slot 0.020-inch

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URS
7720 North 16th Street STE 100
Phoenix, AZ

Borehole: MW-49A

PROJECT: FCCP Monitoring Well Install
CLIENT: APS
LOCATION: FCCP New Mexico
URS PROJECT #: 23446329

DRILLING METHOD: Rotosonic
LOGGED BY: Miles Hearn
START DATE/TIME: 5/17/2013 4:20:00 PM
FINISH DATE/TIME: 5/18/2013 12:00:00 PM

DEPTH (ft)	GRAPHIC LOG	Lithology Depth	MATERIAL DESCRIPTION	WELL INFORMATION
60			Weathered Lewis Shale, completely weathered, mostly clay, brown, moist *(continued)*	9.5-inch Diameter Borehole
		62.5	Unweathered Lewis Shale, blue-gray, highly fractured, moist	End Cap
		68.0	Dry TD=68 ft. bgs, groundwater not encountered	Bentonite Backfill

Total Depth of borehole = 68.0 feet

9.5-inch Diameter Borehole

URS

7720 North 16th Street STE 100
Phoenix, AZ

Borehole: MW-50A

PROJECT: FCCP Monitoring Well Install
CLIENT: APS
LOCATION: FCCP New Mexico
URS PROJECT #: 23446329

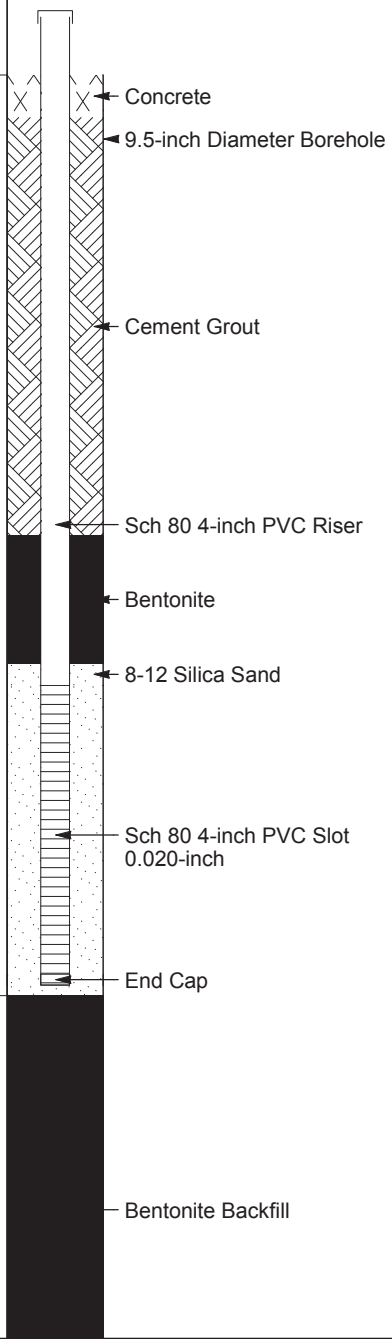
DRILLING METHOD: Rotosonic
LOGGED BY: Miles Hearn
START DATE/TIME: 5/7/2013 7:40:00 AM
FINISH DATE/TIME: 5/7/2013 3:15:00 PM

Water Level at Drilling Completion (ft bgs): Dry
COMMENTS:

COORDINATES (NAD83):
North: 2070606.207
East: 2529372.844
TOP OF GROUND ELEVATION (NAVD88): 5333.2 feet A.S.L.

DEPTH (ft)	GRAPHIC LOG	Lithology Depth	MATERIAL DESCRIPTION
0		0.0	
			Weathered Lewis Shale, green-brown, highly weathered, almost completely weathered, dry
10			Mostly brown to green, more competent layers of unbroken shale, dry
20			
30			Less competent, pieces of shale
40		43.0	
			Unweathered Lewis Shale, blue-gray, competent, dry
50			

WELL INFORMATION



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URS
7720 North 16th Street STE 100
Phoenix, AZ

Borehole: MW-50A

PROJECT: FCCP Monitoring Well Install
CLIENT: APS
LOCATION: FCCP New Mexico
URS PROJECT #: 23446329

DRILLING METHOD: Rotosonic
LOGGED BY: Miles Hearn
START DATE/TIME: 5/7/2013 7:40:00 AM
FINISH DATE/TIME: 5/7/2013 3:15:00 PM

DEPTH (ft)	GRAPHIC LOG	Lithology Depth	MATERIAL DESCRIPTION	WELL INFORMATION
60			Unweathered Lewis Shale, blue-gray, competent, dry *(continued)*	9.5-inch Diameter Borehole
		63.0	TD= 63 ft. bgs, groundwater not encountered	

Total Depth of borehole = 63.0 feet

URS
7720 North 16th Street STE 100
Phoenix, AZ

Borehole: MW-51

PROJECT: FCCP Monitoring Well Install
CLIENT: APS
LOCATION: FCCP New Mexico
URS PROJECT #: 23446329

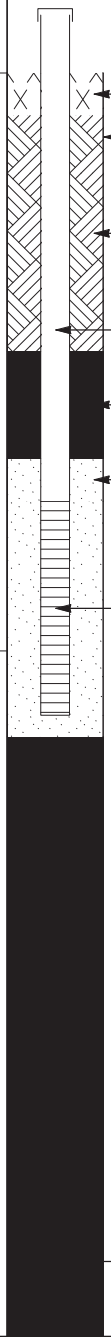
DRILLING METHOD: Rotosonic
LOGGED BY: Miles Hearn
START DATE/TIME: 4/26/2013 2:10:00 PM
FINISH DATE/TIME: 4/28/2013 9:00:00 AM

Water Level at Drilling Completion (ft bgs): Dry
COMMENTS:

COORDINATES (NAD83):
North: 2071847.788
East: 2529602.779
TOP OF GROUND ELEVATION (NAVD88): 5285.14 feet A.S.L.

DEPTH (ft)	GRAPHIC LOG	Lithology Depth	MATERIAL DESCRIPTION
0		0.0	
			Weathered Lewis Shale, gray-green, dry, mostly weathered with some intact layers around 1" thick
10			
20			3" layers of highly competent shale, gray-brown
		27.0	
			Unweathered Lewis Shale, blue-gray, dry, highly competent layers 3"-10", separated by less competent layers
30			
40			
			Lighter in color, highly competent, light gray
			Back to blue-gray
50			
			Shale, blue-gray, unweathered, competent to highly competent, dry

WELL INFORMATION



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URS
7720 North 16th Street STE 100
Phoenix, AZ

Borehole: MW-54

PROJECT: FCCP Monitoring Well Install
CLIENT: APS
LOCATION: FCCP New Mexico
URS PROJECT #: 23446329

DRILLING METHOD: Rotosonic
LOGGED BY: Miles Hearn
START DATE/TIME: 5/19/2013 8:00:00 AM
FINISH DATE/TIME: 5/20/2013 12:15:00 PM

Water Level at Drilling Completion (ft bgs): Dry
COMMENTS:

COORDINATES (NAD83):
North: 2068675.59
East: 2525262.965
TOP OF GROUND ELEVATION (NAVD88): 5218.38 feet A.S.L.

DEPTH (ft)	GRAPHIC LOG	Lithology Depth	MATERIAL DESCRIPTION	WELL INFORMATION
0		0.0		
			Ash, gray, moist	Concrete 9.5-inch Diameter Borehole
10				
			Wet Moist	
20				
			Wet	
30				Sch 80 4-inch PVC Riser Cement Grout
40				
			Moist	
			Wet	
50			Gray, wet	
			Moist	

REPORT APS-FCPP-REV1 | PROJECT O:\GINT6\WRES GINT\PROJECTS\APS-FCPP\APS FCPP 2013 MWS.GPJ | LIBRARY APS FCPP-2012.GLB | PRINTED 6/13/14

URS
7720 North 16th Street STE 100
Phoenix, AZ

Borehole: MW-54

PROJECT: FCCP Monitoring Well Install
CLIENT: APS
LOCATION: FCCP New Mexico
URS PROJECT #: 23446329

DRILLING METHOD: Rotosonic
LOGGED BY: Miles Hearn
START DATE/TIME: 5/19/2013 8:00:00 AM
FINISH DATE/TIME: 5/20/2013 12:15:00 PM

DEPTH (ft)	GRAPHIC LOG	Lithology Depth	MATERIAL DESCRIPTION	WELL INFORMATION
60			Ash, gray, moist *(continued)*	
		65.0		
			(CH) Fat clay aquitard, wet	
70				Bentonite
			Moist	
		74.0		
			Weathered Lewis Shale, brown, highly weathered, high clay content, dry	8-12 Silica Sand
80				
				Sch 80 4-inch PVC Slot 0.020-inch
			Moist	
90				
		91.5		End Cap
			Unweathered Lewis Shale, blue-gray, dry, competent	
100			Highly competent	9.5-inch Diameter Borehole
				Bentonite Backfill
110				
120				
		125.0	TD=125 ft. bgs, groundwater not encountered	

Total Depth of borehole = 125.0 feet

1 December 2003
AMEC Job No. 3-517-000131

Attention: Ms. Debbie Tenbrink
Mr. Carl D. Woolfolk
Mr. John Boyer

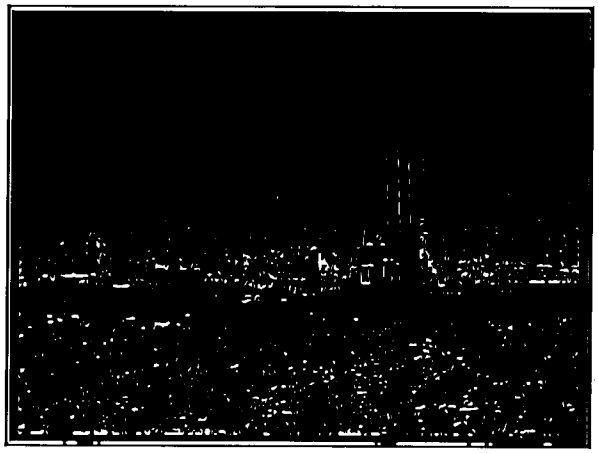
Arizona Public Service Company.
P.O. Box 355, M.S. 4901
Fruitland, New Mexico

RE: INSTALLATION OF LEWIS SHALE MONITOR WELLS
APS FOUR CORNERS POWER PLANT
NEAR FRUITLAND, NEW MEXICO

Dear Ms. Tenbrink

In accordance with your request, AMEC has completed the installation of two monitor wells near the Four Corners Power Plant. The scope of work as defined in the APS Request for Proposal (RFP) was completed on October 16, 2003. The object of this project was to install up to four new groundwater monitor wells in conjunction with the construction of ash-disposal ponds located southwest of the power plant. The wells are intended to intercept potential up-gradient groundwater associated with Morgan Lake.

AMEC mobilized to the site on November 13, 2003. Mr. Carl D. Woolfolk and Mr. John Boyer with APS and Mr. Jim Criss, with AMEC toured the project area and identified the drilling locations. Rainbow Drilling mobilized to the site on November 14 and installed conductor casing at both drilling locations. As specified, the conductor casing consisted of a 20' length of 8" OD steel pipe. The casing was installed with approximately 2.5' of the pipe above the surface to provide for an exterior well protective casing. Following a brief discussion of project logistics, Mr. Ellis Lorimor, crew chief with Rainbow Drilling, agreed to advance the first boring at location LS-1 prior to LS-2. Borehole/Monitor well locations are shown in Figure 1.



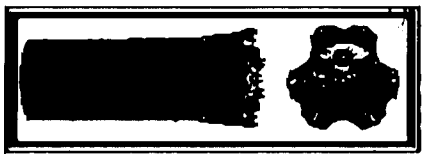
Schramm T660WS Drill Rig at Borehole/Monitor Well Location LS-1

Drilling at the LS-1 location began on 14 October 2003 at approximately 8:30 hours, and total depth (360') was reached at approximately 14:15 hours (10/14/03). Drill cuttings were sampled at 10' intervals between 10-feet below ground surface (bgs) and 360-feet bgs. Samples were collected using a wire strainer or a plastic bucket. They were containerized in a plastic sample bag, which was marked with the boring number and approximate depth. Evidence of water bearing formation was not observed during the drilling program; however, a monitor well was subsequently installed in the boring.

The monitoring well was constructed from threaded, 4-inch diameter, Schedule 80 PVC pipe. A twenty-foot screen section of 4-inch diameter Schedule 80 PVC (0.010-inch slot) was approximately

2 feet above the bottom of the borehole. Silica sand (10/20) was used as screen pack and brought to 5 feet above the screened section. Cement-bentonite slurry was injected via tremie pipe above screen pack. The well casing was positioned approximately 1 foot below the top of the conductor casing. A steel locking cap was fitted over the top of the conductor casing. The well installation was completed at approximately 19:00 hours on 14 October 2003. Well completion schematics as well as boring logs are attached.

Drilling at the LS-2 location began at approximately 11:30 hours on 15 October 2003, and a total depth of 360' was reached at approximately 4:30 hours (10/15/03). The monitoring well at LS-2 was installed on 15 October 2003. The monitoring well at LS-2 was constructed similar to the LS-1 Monitor well. Construction diagrams and boring logs are attached.



Rotary Percussion Bit

Both wells were drilled with a truck mounted Schramm T660WS top head Rotadrill®. A rotary percussion bit was used in combination with dual-wall drill steel (20' section-lengths). Drill cuttings were continuously removed from the borehole with high-pressure air injection. With the exception of the first 40' of LS-1, both wells were drilled with air only. The injection of water to assist in cutting removal was used at LS-1 for the initial 40'. LS-2 was completed with air injection only. By using high-pressure air, water encountered at any depth in the borings would have been obvious. At the completion of each 20' drill run, air was injected into the boring to determine if water was present in the formation. Water was not detected in either of the borings; however, LS-1 and LS-2 were completed as monitor wells.

Geologic conditions at the LS-1 drill site were slightly different than initially expected. Originally, the Picture Cliffs Sandstone geologic unit was expected between ground surface and approximately 140-feet bgs and the Lewis Shale geologic unit was expected below the sandstone. Instead, the Lewis Shale geologic unit was encountered from approximately 10-feet to 360-feet bgs. The upper 10 feet, above the Lewis Shale, consisted of fine-grained sandstone (silty/clayey sand). The break between this weathered sandstone layer and the Lewis Shale was not sharp but appeared to be interbedded from approximately 10-feet to 15-feet bgs.

The Lewis Shale in the upper 150' of the LS-1 boring contained occasional fine sand and was predominantly dark gray with occasional light gray stringers. The formation appeared to be highly weathered through about 150'. Bedding became thicker and less weathered with depth. A small seam of gypsum was encountered at approximately 120'. The seam was less than 2 inches thick and was not observed at any other depths in the boring.

Another discrepancy in the expected geological conditions at the site was a 1 to 2 foot thick layer of limestone encountered between 230 and 235 feet below the surface. The limestone was fine grained and moderately weathered. The contact between the Lewis Shale and the limestone was sharp and occurred within the uniform shale bed. The Lewis Shale continued below the limestone layer from 235 to 360 feet bgs.

Geologic conditions encountered at LS-2 differed from LS-1 in that the Pictured Cliffs Sandstone geologic unit was encountered in the upper 20 feet of the boring. The sandstone consisted of very fine- to fine-grained sand with some calcareous cementing. At approximately 15 feet below the surface thin beds of silt and clay were encountered. In addition, small gypsum crystals in thin lenses

between bedding planes were observed. This sandstone unit consists of alternating thin beds of yellowish-gray to moderate brown fine-grained sandstone and light to dark gray silty shale.

The Lewis Shale formation was encountered at approximately 25 feet below the surface and continued to 360 feet in this boring. The shale encountered in LS-2 was consistent with the shale observed in LS-1. A 1- to 2-foot thick layer of limestone was encountered at approximately 210 feet bgs in LS-2. This limestone layer is assumed to be continuous with that found in LS-1.

Because the drilling method used is not conducive to collecting undisturbed samples, the referred depths are approximate to within a two to three foot interval.

The general dip of the formations encountered in both borings is assumed to dip approximately 1 degree in an eastward direction. Although a direct correlation of the individual beds in the two borings could not be made, the bedding in the borings suggests dips of somewhat less than 1 degree to the east and south. If water, originating from Morgan Lake, were infiltrating into either the Picture Cliffs or Lewis Shale formations it would most likely have been intercepted.

Should any questions arise concerning this letter, please do not hesitate to call the undersigned.

Respectfully submitted,

AMEC Earth & Environmental, Inc.

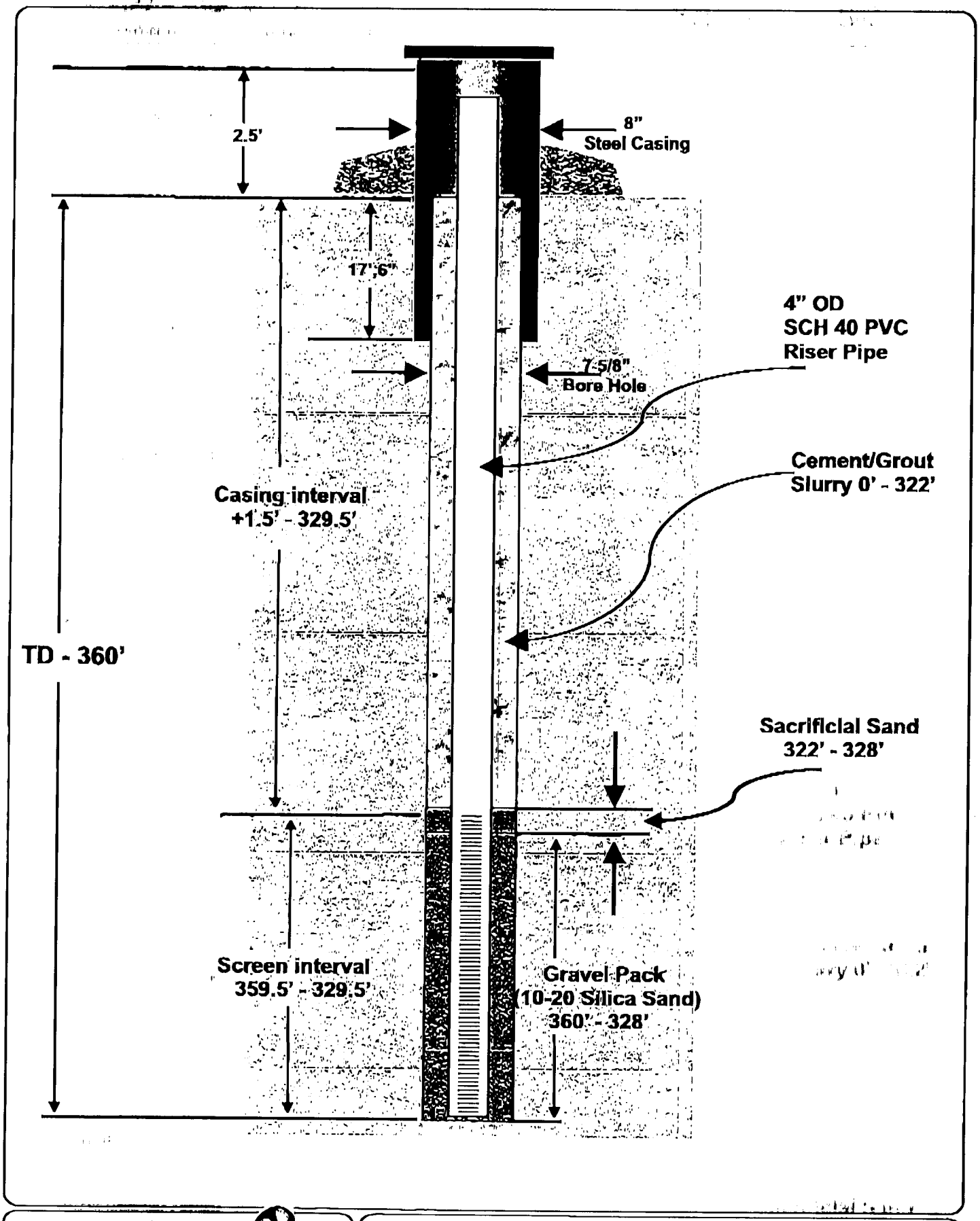
James E. Criss
Project Manager

Peter Guerra
Senior Project Manager

JEC:rrk

copies: Addressee (1)

AMEC Earth & Environmental Inc.
8519 Jefferson, N.E.
Albuquerque, New Mexico 87113
Telephone: 505/821-1801
Fax: 505/821-7371
www.amec.com

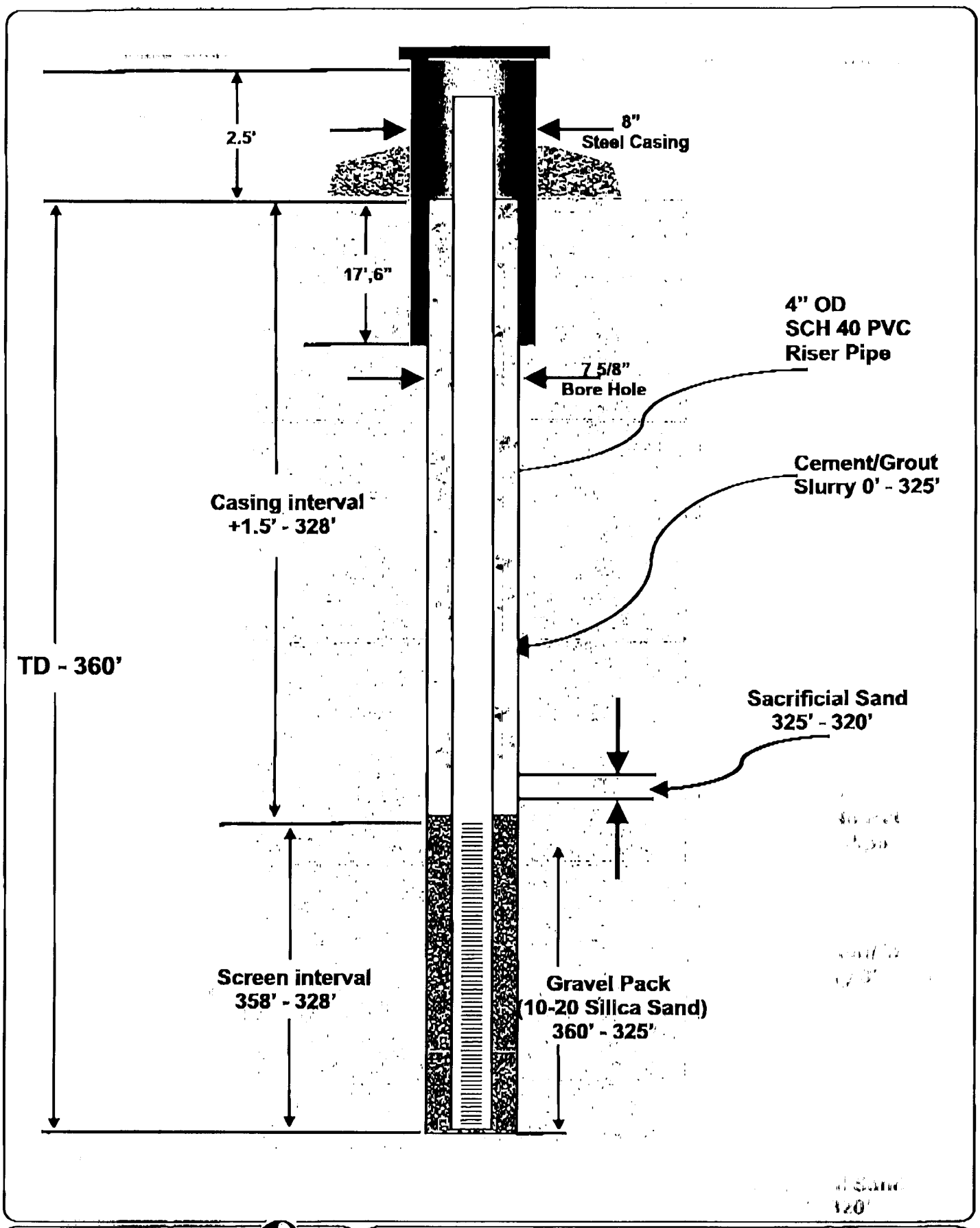


amec

Project Number 3-517-000131 October 2003

Four Corners Power Plant
Arizona Public Service Company
Monitor Well Installation
Fruitland, New Mexico

Monitor Well
Schematic LS-1



amec

Project Number 3-517-000131 October 2003

Four Corners Power Plant
Arizona Public Service Company
Monitor Well Installation
Fruitland, New Mexico

Monitor Well
Schematic LS-2

Project Name: APS Four Corners Power Plant Project Number: 3-517000131 Page: 1 of 1	BOREHOLE LOG	amec

BOREHOLE: LS-1 DIAMETER: 8" OD
LOCATION: N 36°41'08.3" W 108°29'39.3"
DRILL METHODS: Duel tube-RV-Circ
DRILL RIG TYPE: Schram T 660WS

LOGGED BY: Jim Criss
DRILLING DATE: 10 October 2003
DRILLER: Ellis Lorimor.
DRILL COMPANY: Rainbow Drilling, Inc.

DEPTH TO WATER: N/A
STABILIZATION TIME: N/A

REFERENCE POINT DESCRIPTION: GPS.
REFERENCE POINT ELEVATION: ~

SAMPLE NO.	DEPTH, BGS (ft)	Blows/ft		SAMPLE DESCRIPTION	STRATUM	NOTES
	0-20			Interbeded Sandstone and Clay - 1/8 inch Coal Seams. Sandstone is very fine with some calcarious cementation		
	20-40			Same as above		
	40-60			Lewis Shale formation: Shale with considerable silt, occasional fine sand. Predominately dark gray with occasional sight gray stringers.		
	60-80			Same as above with less silt and no sand.		
	80-100			Same as above		
	100-120			Lewis Shale formation: Highley weathered, thick bedding, relatively soft, light gray to black.		
	120-140			Same as above		
	140-160			Same as above		
	160-180			Same as above		
	180-200			Same as above		
	200-220			Same as above		
	220-240			1 to 2 foot layer of limestone. Very fractured, thinly beded, very hard, gray. 230'-232'		
	240-280			Lewis Shale formation: somewhat carbonaceous, slightly to moderately weathered, very fractured, laminated, soft to moderately hard, brown to gray to black.		
	280-300			Same as above		
	300-320			Same as above		
	320-340			Same as above		
	340-360			Same as above. Total Depth 160'		

Project Name: APS Four Corners Power Plant	BOREHOLE LOG	amec
Project Number: 3-517000131		
Page: 1 of 1		

BOREHOLE: LS-2 DIAMETER: 8' OD
LOCATION: N 36°40'57.8" W 108°29'39".2"
DRILL METHODS: Duel tube-RV-Circ
DRILL RIG TYPE: Schram T 660WS

LOGGED BY: Jim Criss
DRILLING DATE: 10 October 2003
DRILLER: Ellis Lorimor.
DRILL COMPANY: Rainbow Drilling, Inc.

DEPTH TO WATER: N/A
STABILIZATION TIME: N/A

REFERENCE POINT DESCRIPTION: GPS.
REFERENCE POINT ELEVATION: ~

SAMPLE NO.	DEPTH, BGS (ft)	Blows/ft		SAMPLE DESCRIPTION	STRATUM	NOTES
	0-20			Pictured Cliffs Sandstone: Fine, very weathered, moderately hard, brown		
	20-40			Same as above		
	40-60			Lewis Shale formation: Shale with considerable silt, occasional fine sand. Predominately dark gray with occasional sight gray stringers.		
	60-80			Same as above with less silt and no sand. Considerable gypsom in joints. Moderately to slightly weathered.		
	80-100			Same as above		
	100-120			Lewis Shale formation: Highley weathered, thick bedding, relatively soft, light gray to black.		
	120-140			Same as above		
	140-160			Same as above		
	160-180			Same as above		
	180-200			Same as above		
	200-220			1 to 2 foot layer of limestone. Very fractured, thinly beded, very hard, gray. 210'-212'		
	220-240			Lewis Shale formation: somewhat carbonaceous, slightly to moderately weathered, very fractured, laminated, soft to moderately hard, brown to gray to black		
	240-280			Same as above		
	280-300			Same as above		
	300-320			Same as above		
	320-340			Same as above		
	340-360			Same as above. Total Depth 160'		