Introduction

Between 1971 and 2006, the Mohave Generating Station (Site), located in Laughlin, Nevada, was operated by Southern California Edison (Edison). The electrical generating process required the burning of coal to produce steam for the electrical turbines. The waste stream from the incineration of coal includes ash materials that require disposal. A naturally occurring canyon south of the plant, locally known as Ash Canyon, was selected to be the repository for ash material from the plant. A dam was constructed at the bottom of the canyon to capture and contain material mobilized by erosional processes potentially occurring during infrequent, high-intensity rain events typical to the arid environment.

The Mohave Ash Canyon Ash Disposal Facility was placed into service in 1971 with a projected capacity of 9.5 million cubic yards. The capacity projection was later increased to 21.5 million cubic yards based on a more accurate survey and by increasing the final elevation of the top of the disposal area. Approximately 8.5 million cubic yards of fill was placed in Ash Canyon throughout the operation of the plant. The landfill was operated in accordance with Southern Nevada Board of Health Solid Waste Disposal Site Permit LF007-TMW-01, as amended May 10, 2002. In 2006 the site ceased electrical generation and the landfill was closed according to the closure plan. The landfill is now in post-closure monitoring.

Analytical testing of ash residue confirms a non-hazardous characteristic profile. Volatile and semi-volatile organic compounds are not present in the ash residue, and waste characterization for metals using the toxic characteristic leaching procedure (TCLP) indicates metal concentrations are below toxicity characteristic thresholds (40 CFR 261.24).

Geology

The Site containing the former Mohave Generating Station is located in the Sonoran Desert section of the Basin and Range physiographic province. The Site is bounded on the east by the Colorado River, at an elevation of approximately 500 feet, and on the west by the Newberry Mountains, which are composed of the oldest geologic units in the area with a crest elevation exceeding 5,000 feet. The majority of the plant facilities were located on an elevated, eroded alluvial terrace at an elevation of approximately 700 feet that drains south and east along precipitous washes toward the river. A naturally occurring canyon south of the plant facilities was selected to be the repository for all waste ash material from the plant. The facility was named Ash Canyon Disposal Facility.

The regional climate for the Site is arid and warm. Mean annual precipitation in the immediate area is approximately four inches. This value may double outside the western boundary of the Site in the higher elevations of the Newberry Mountains. Annual rainfall ranges from less than one inch to as high as eleven inches on the property. Precipitation occurs almost entirely as short duration, high intensity rain storms. The resultant rain water from these storms rapidly converges in existing washes leading to the Colorado River.

Site geology is characterized by thick unconsolidated deposits of complexly-interbedded sands, silts, clays, and gravels deposited by the Colorado River and alluvial fan deposits eroded from the adjacent Newberry Mountains. Of these deposits, there are three main stratigraphic units of interest: the Older Alluvium (QTaf), the Younger Alluvium (Qal), and the Alluvial Fan Deposits (Qaf).

Sediments of the Older Alluvium (QTaf) consist of poorly sorted, angular, granitic pebbles, with silt, cobbles, and boulders. The unit is interpreted as being derived from coalescing alluvial fans that are compacted and moderately- to well-cemented with calcium carbonate. The maximum thickness of the Older Alluvium beneath the Site has not been determined; however, drilling indicates that the unit is at least 700 feet thick. Geophysical data suggests that this unit may extend to bedrock ranging from depths of 1,000 to 2,500 feet below grade surface (bgs). According to various investigative reports, aquifer test data suggests the Older Alluvium exhibits a transmissivity ranging from 600 to 1,950 square feet per day (ft_2/day) (HLA1986).

Younger Alluvium (Qal) overlies the Older Alluvium and contains more permeable deposits of sand and gravel. These deposits are derived from deposition by the Colorado River as it meandered across the area and from overbank deposition during flood events. Sediments encountered within this stratigraphic unit consist of very course, well-rounded sand, gravel, and cobbles, with silt and clay deposited in deep paleochannels of the Colorado River. The unit is well sorted, generally uncemented, and exhibits relatively high permeability. The transmissivity of the Younger Alluvium ranges from 1,950 to over 400,000 ft_2/day (HLA 1986).

The Alluvial Fan Deposits (Qaf) are contemporary with Younger Alluvium deposits and the two units interfinger stratigraphically. These Alluvial Fan Deposits are composed of material similar to the Younger Alluvium, yet the silt and clay content is higher than that found in the Younger Alluvium. These deposits are locally derived sediments that have accumulated along the mountain front to form the stratigraphic unit above the water table that is not generally involved with the saturated portion of the flow system.

Depositional history of the sediments in the region of the Site includes major episodes of channel erosion caused by the ancestral Colorado River. When the river regime changed from erosion to deposition, causing backfilling, mobilized sediments tended to be the coarse sand, gravel, and cobbles of the Younger Alluvium displaced by turbulent, channelized flow. The accumulation of Younger Alluvium within channelized features created buried paleochannels at the Qal/QTaf unconformity below the water table in the area of the Site.

Hydrogeology

The contact between the Younger and Older Alluviums is an erosional surface that is highly irregular with a network of paleochannels of the Colorado River cutting several hundred feet into the Older Alluvium as illustrated on Figure 2. The position and depth of the paleochannels was interpreted from various site investigations involving multiple phases of drilling, aquifer tests, and geophysical surveys.

The stratigraphic configuration within the water table, in part, determines the hydraulic conductivity of the uppermost saturated unit. Where the Younger Alluvium is sufficiently saturated, the higher hydraulic conductivity exhibited by these sediments dictates predominant groundwater movement. Where the Younger Alluvium remains above the water table, groundwater flow is determined by the characteristics of the Older Alluvium.

This rather simple hydrogeologic relationship is complicated by the irregularly shaped erosional surface between the Younger and Older Alluviums and the presence of paleochannels across the Site. However, distinguishable and categorical differences in hydraulic conductivity observed across the Site can be used to discern where the aquifer is dominated by lower permeability materials of the Older Alluvium versus the higher permeability materials of the Younger Alluvium.

The defined paleochannels are important to Site characterization because they tend to exhibit hydraulic conductivity 10 to 100 times greater than surrounding materials, causing these distinct areas to serve as natural conduits for groundwater flow. Given the unique influences of Older versus Younger Alluvial deposits on hydraulic characteristics, the relative location and configuration of the two dominant paleochannels identified to cross beneath the Site are illustrated on Figure 2. Hydraulic conductivity is an important aquifer property that strongly affects the rate and direction of groundwater flow. Prior to this program, thirty nine hydraulic tests have been performed at wells over the entire Site to measure hydraulic conductivity. The resultant data demonstrate values ranging from 0.1 foot per day in the Older Alluvium to 553 feet per day in the younger Alluvium contained in the paleochannels.

Groundwater beneath the ash disposal area ranges in depth from approximately 58 feet below grade surface (bgs) in Ash Canyon (Well 69F) to approximately 211 feet bgs at the background Well 87A. The last gradient plot for the entire Site was measured in February 2011 at the close of the groundwater remediation project. The southeast flow direction has been consistent over the forty years of monitoring at the Site. The water level varied one to two feet over the years but the gradient pattern remained consistent. Hydraulic gradient across the Site tends to be relatively low, typically on the order of 0.0002 foot per foot.

Most of the ash disposal area is located over the eastern paleochannel. The five project sampling wells are located in the same paleochannel where the groundwater in the deeper zones flows from the northeast toward the southwest. Designated background wells 74B and 85B have been chosen to analyze the groundwater flowing from the Colorado River prior to passing beneath the disposal area. Three compliance wells, 59A, 69F, and 79C, are in a position to determine if any change occurred to the groundwater as it migrated beneath the disposal area.

Groundwater Gradient

The depth to groundwater and calculated groundwater elevation for the monitoring wells at each of the twelve sampling events for the 5-year monitoring period shows the change in the elevation between the sampling events and calculates the change between the events. The groundwater level declined an average of about 0.6 foot. The rise and decline of the groundwater levels are more related to the river levels than regional groundwater recharge. The river levels fluctuate daily with the amount of scheduled releases from Lake Mohave.

The calculated slope is 0.0004 foot per foot. The southeasterly gradient was consistent for the two monitoring events. This southeast flow direction for the groundwater has been consistent over the forty years of monitoring at the Site. These gradient plots display the flow direction of the groundwater surface. The gradient plots illustrate that most of the ash disposal area is located over a paleochannel. The five project sampling wells are located in this paleochannel where the groundwater in the deeper zones flows from the northeast toward the southwest.

Ash Characterization

Chemical characteristics and environmental testing of the ash material deposited in the landfill was presented in a WESTEC, Inc. report titled "Ash Canyon Ash Disposal Facility Closure and Postclosure Plan" dated February 1998. This report was submitted to SNHD and is the basis of the approved closure plan. The report presents chemical analyses of the ash material which demonstrates it is composed of predominantly silicon (56%) and aluminum (22%) with a minor amount of calcium (8%), iron (5%), magnesium (2%), and sulfur (1%). Laboratory reports for the chemical characteristics conducted on the bottom ash and fly ash materials are included in Appendix 4 of the SAP (2012).

The environmental compatibility of the ash material was determined by conducting Toxicity Characteristic Leach Procedure (TCLP) tests on samples of both fly ash and bottom ash. The fly ash and bottom ash samples did not contain detectable concentrations of soluble volatile or semi-volatile compounds. Barium was the only metal detected in the extract from the bottom ash TCLP test. The TCLP extract from the fly ash contained slight concentrations of arsenic, barium, chromium, and selenium. These concentrations were considerably less than the maximum regulatory levels. Based on the TCLP test results, both the fly ash and bottom ash materials would be designated as non-hazardous waste. Laboratory reports for the TCLP tests conducted on the two ash materials are included in Appendix 4 of the SAP (2012).

Ash Disposal

The ash materials were hauled into the Ash Canyon facility and placed in 12-inch layers over an area approximately 200- by 300-feet. The placed ash was compacted to a minimum of 80 percent of the laboratory maximum dry density. The compacted ash material is routinely tested to maintain quality control during the ash disposal operation. In-place density tests were conducted at various locations to check the relative compaction of the ash material. These tests indicate the required compaction of 80 percent was met or exceeded. Before diverting waste ash to a new area in the facility, the compacted ash material was placed to a maximum height of 30 feet with a slope of 3H:1V (horizontal to vertical). The compactive effort, added moisture, and warm ash yield a layer of material resembling concrete in hardness. The permeability of the compacted ash was tested and determined to be 5.3×10^{-4}.