Four Corners Power Plant

Groundwater Quality Data Submittal
March 25, 2013

Introduction

This submittal is intended to provide the available historic groundwater, surface water and impoundment samples collected at the Four Corners Power Plant from 1987 through September 2012. It includes both groundwater and surface water quality analyses. It supplements the February 13, 2013 Geohydrology Submittal provided to OSM and in some cases relies on the information provided in that submittal to provide the context for the attached water quality data. In some cases drawings and discussions of the local geology and hydrology from the February 13, 2013 submittal are included and attached for the convenience of the reader when evaluating the data.

The data is provided on the attached DVD as a set of Excel Files. The Excel files are formatted differently for each data set depending on the amount of data and background information available. Where available, PDF copies of the original laboratory reports are provided in Exhibit 2. Tables 1, 2 and 3 contain information on the location of all samples and information on the well construction.

Background

The Plant is located near the western margin of the San Juan Basin, a structural depression that lies at the eastern edge of the Colorado Plateau. To the east of the Plant is the Hogback Monocline that forms the eastern edge of the Basin (Stone, et. al. 1983). The monocline dips to the east at about 38º just east of the Chaco River. The dip of the sediments quickly changes to about 3º to 5º to the east beneath the Plant.

The Cliff House Sandstone caps the Hogback to the west of the Chaco River. The Cliff House Sandstone intertongues with the overlying Cretaceous Lewis Shale. The Plant ash ponds are built upon the Lewis Shale, which is a marine shale that contains substantial amounts of evaporite deposits, including gypsum. The Lewis Shale dips about 3º to 5º to the east beneath to the ash ponds. The monitor wells installed around the ash ponds are all completed in the Lewis Shale. Based on the results from the construction of these wells, the Lewis Shale has a weathered zone about 10 – 50 feet deep, normally overlain by a thin layer of soil 1 – 2 feet thick. The weathered zone slopes to the west towards the Chaco River at about 1.2 degrees. The weathered Lewis Shale varies from brown to gray-brown to light gray in color. Beneath the weathered shale the un-weathered Lewis Shale is gray-brown to blue-gray to dark gray in color. It is significantly less permeable than the weathered shale. The Picture Cliffs Sandstone is located above the Lewis Shale. It is seen in outcrops on top of the mesa where the Plant is located.

Groundwater beneath the ash ponds flows to the west, mainly in the weathered shale and in local alluvial channels that drain towards the Chaco River (Figure 12). There is some uncertainty regarding the contribution of Morgan Lake to the local groundwater. The current groundwater contours suggest that it is a source of water up-gradient of the ash ponds. However, there are three (3) wells that do not fit this interpretation. Wells MW-12R, MW-41 and MW-42 appear to monitor localized perched water zones (see Figure 12). The water quality at these wells does not correspond to the water quality in wells down gradient of the ash ponds or to the water quality in what we believe to be the up-gradient wells, LS-1 and LS-2. Installation of additional wells located within the ash pond area and between Morgan Lake and the Ash Ponds is planned for later in 2013 to help clarify this issue. The locations for the proposed new wells are shown on Figure 16.

The geophysical data along with geologic information derived from boreholes drilled for the installation of monitor wells showed that the groundwater flow in this area is confined primarily to the weathered shale and local alluvial channels. In some cases, water flow was identified in small joint systems within the shale. The most significant flow is within the alluvial channels.

Monitor Wells Construction and Location information

Tables 1 and 3 provide the location and construction information for the monitor wells and extraction wells constructed in the vicinity of the ash ponds. These wells were sampled in the two most recent water quality sampling events performed in December 2011 and September 2012.

Figure 12 shows the location of the existing monitor wells. Later in 2013, additional monitor wells are planned for construction to replace existing wells that must be abandoned due to activities related to closure of the old Evaporation Ponds 1-4 and the construction of the new South Intercept Trench discussed in the February Geohydrology Submittal. New wells are also planned to provide additional information related to the impact of Morgan Lake on the local groundwater. These wells will be drilled between Morgan Lake and the eastern edge of the ash disposal area and at locations within the ash disposal area between old ash ponds 3, 5 and 6. The data from these wells should better define the gradient and flow direction of the groundwater between Morgan Lake and the ash disposal area. Additional wells are also planned for locations to the south of the ash disposal area to better define the extent and quality of the groundwater in this area. Figure 16 shows the planned location of these new wells and their planned depth.

Historic Groundwater Level Data for 1987 – September 2012

An Excel file titled "FC-WL_Data_1987-Sept2012.xlsx" table is attached with the historic groundwater level data for the Four Corners Power Plant ash pond area. Tables 1 and 3 provide the information on the well locations and construction. Figure 12 shows the location of the wells and the interpreted water level contours for February 2012. Most of the monitor wells were installed in the 1987 timeframe. For perspective on the data, Ash Pond No. 6 had just been put into operation in late 1986. Of particular interest, you may note that well MW-7 had a recent significant rise in water level starting in the last quarter of 2011. The rise peaked at about 14 feet in September 2012. A measurement in February 2013 shows that the water level is now declining. This well is located just south of the Lined Decant Water Pond (LDWP) and Lined Ash Impoundment (LAI) (see Figure 12). A review of activities in the area revealed that the plant was applying Morgan Lake water to a nearby borrow area. The water was applied for both dust control and to condition the soil for excavation of the borrow. The water quality data collected from the well in December 2011 and September 2012 showed that there was a significant increase in TDS, Sulfates and Nitrates compared to historic levels. At the same time the boron levels in the well declined significantly compared to historic levels. Because boron levels are a marker for ash pond water and based on the fact that past data show increases in TDS, Sulfates and Nitrates associated with recent application of water to the Lewis shale, we believe that the cause of this water level rise is the borrow activity near the well. A similar situation occurred at well MW-11 in 2008. Borrow activities to the east and up gradient from this well caused a rise in water level and a similar change in water quality.

A review of the water level data also shows that many of the wells show a significant decrease in water level starting in 2004. We believe this is related to the fact that the LAI went into service at this same time. Since the LAI went into service in 2004, no Unit 1-3 ash has been disposed to an unlined ash impoundment. The positive impact of this operational change is evident in the data.

Water Quality Data from December 2011 and September 2012

The most recent and the best data is that collected in the two most recent sampling events. In December 2011, water quality samples were collected from the monitor wells located around the ash ponds and from the ash ponds, Morgan Lake and the southern seepage area. In September 2012, a second set of samples was collected from selected monitor wells that were sampled in December 2011 and from a set of new wells installed in March 2012. These sampling events were conducted to provide a comprehensive review of the existing groundwater conditions in the Plant ash pond area. A new method was used for analysis of metals that significantly reduces the matrix interference issues associated with the saline waters. We believe that these samples present the best data available to show the existing conditions at the Plant.

Table 4 lists the results from these two sampling periods. Exhibit 2a contains the laboratory reports for the data. An Excel file titled "2011Dec_vs_Sept2012_GW-WQData.xlsx" is also attached with the data.

As discussed in the Background Section, the Lewis Shale is a marine shale that contains considerable evaporite deposits. As a result, the groundwater within this unit is highly saline. Based on the December 2011 data, the total dissolved solids (TDS) content of the groundwater varies from 5,200 to 58,000 mg/L. This high salinity causes significant matrix interference when analyzing for metals using the typical analytical methodologies. To overcome this difficulty, we analyzed the metals using EPA method 200.8 with Collision Cell Technology (CCT), which avoids the matrix interference issues found with EPA method 200.8 without use of the technology. As a result, we were able to obtain lower detection levels and more accurate metal concentration data. Some samples were analyzed both with and without the CCT. The data shown in Table 4 demonstrate that the detection levels with the CCT are typically lower, sometimes an order of magnitude lower, and the detected results are typically lower for the collision cell analyses as opposed to the analyses without use of the CCT. This is due to the inability of the method without the CCT to accurately quantify the metal concentration. In particular, the collision cell method improves the results for arsenic, chromium, selenium, and other metals. Exhibit 1 contains a discussion of the EPA method with CCT by Dr. Richard Burrows, Director of Technical Services for TestAmerica Laboratories, Inc. Dr. Burrows describes what causes the interference and how the CCT removes this problem. He also discusses why this method is appropriate for analysis of the Four Corners groundwater.

Figure 13 shows the TDS distribution in the groundwater indentified by the December 2011 sample data. Figure 14 provides stiff diagrams using the December 2011 data to show the general characteristics of the groundwater in the vicinity of the ash ponds.

A review of the data shows that boron is a marker for ash pond water. The levels of boron vary considerably over the site. Back ground levels are about 1 mg/L. The boron levels within the ash disposal area vary from <1 mg/L up to 130 mg/L. The median concentration is 9.5 mg/L.

The source of parameters is less clear. Many metals are associated with the Lewis Shale. For example, uranium is detected in most of the wells. However, the September 2012 sample from well MW-43 located just downstream (west of) Morgan Lake, contains uranium at a concentration of 0.084 mg/L. This is one of the highest levels of uranium detected in the area. However, this well is in a location that is not impacted by ash pond water. In fact, the uranium concentration in the LAI is 0.005 mg/L and <0.0020 in the LDWP.

In addition to the groundwater results, Table 4 also shows the water quality for Morgan Lake, the LAI, and the LDWP. The LDWP has generally higher concentrations of constituents than the LAI because of evaporation. Fly ash and scrubber materials are disposed into lined ash ponds. The LAI currently receives ash from Units 1-3. Excess ash transport water is drained from the LAI and sent to the LDWP where it is either pumped back to the plant for use in the air quality treatment systems or evaporated. Dry fly ash from Units 4-5 is disposed to the lined Dry Fly Ash Disposal Area (DFADA). Figure 12 shows the location of these disposal areas.

Chaco River Surface Water Quality Data collected in 2008 - 2009

An Excel file titled "FC-Chaco_SWQ-Data_2008-2009.xlsx" contains the water quality data collected from September 2008 through August 2009 at sample locations along the Chaco River upstream and downstream of the plant. Copies of the laboratory reports for this data are attached in Exhibit 2b. This data was not collected for the purposes of compliance but was intended to provide a picture of the conditions along the Chaco River and allow evaluation of changes in water quality. Samples analyses were performed for both total and dissolved metals. However, because the plant personnel did not have the equipment to filter the samples in the field and because the samples were not intended for compliance, the plant requested that the laboratory filter the samples for the dissolved analyses. This does not meet the method requirements of filtration immediately after sample collection but it was decided that this would still provide useful information. As a result, there are many instances where the dissolved metal concentration is greater than the total metal concentration. One would normally expect the dissolved concentration to be less than or equal to the total concentration depending on the amount of suspended solids. There is always some statistical variation due to the laboratory instrument and method accuracy.

A second issue with the data is the change in method used to analyze for metals. The metal analyses performed on the September 2008 through July 2009 samples used EPA method 200.7. The three samples collected in August 2009 were analyzed by a different laboratory using EPA method 200.8. The EPA method 200.8 has a much lower detection level than method 200.7.

The samples for this program were collected from an upstream location (Upstream), at two seep locations indentified as the Southseep and the Northseep and at two downstream locations identified as the Downstream and N36 Bridge locations. The Downstream location is just upstream of the unnamed tributary to the Chaco River that carries the Morgan Lake blowdown water to the Chaco River from Morgan Lake. The N36 Bridge location is at the bridged crossing of the Chaco River by local Highway 36. Figure 1 shows the location of these sample points. Table 2 lists the latitude and longitude of the locations.

Table 5 shows a selected portion of the Chaco River data for discussion. The table compares the data to the Navajo Nation Surface water standards for this reach of the Chaco River. Navajo Nation EPA sets the surface water quality standards for each reach of a water of the US within the Navajo Nation. The applicable standards depend on the uses for water within that reach. For the reach of the Chaco River near the Four Corners Power Plant, the assigned uses are, Aquatic & Wildlife Habitat (warm water) (A&WHbt), Fish Consumption (FC), Livestock Watering (LW), and Secondary Human Contact (ScHC). This reach of the Chaco River is not defined as a drinking water source so there are no drinking water surface water standards for this reach.

As discussed previously, boron is a marker for ash pond water. A review of the data in table 5 shows an increase in boron concentrations when comparing the Upstream data with the Downstream data. However, when comparing the Upstream data to the N36 Bridge data, there is little change. The Navajo Nation surface water standards for boron are 128 mg/L (ScHC), 5 mg/L (LW) and no standard for the FC and A&WHbt uses. A review of the data show that out of 15 samples collected at the Downstream site, only one exceeded the 5 mg/L LW standard. This was the June 4, 2008 dissolved boron analysis (5.1 mg/L). The total boron concentration for this same sample was 4.8 mg/L. The boron concentrations at the N36 Bridge site did not exceed 1.2 mg/L which is close to the background level for the groundwater. The boron levels at the seeps are higher. However, this data illustrates that the small seepage flow does not significantly impact the water quality downstream of the plant.

Other parameters appear to vary according to the sediment load in the river. Although no flow measurements were made during the sampling round, a review of the aluminum data gives a good indication of time when the Chaco River was carrying a high sediment load. The total aluminum concentrations for the Upstream station varied from 0.44 mg/L to 613 mg/L with a median concentration of 2.98 mg/L. The dissolved concentrations for that same location varied from 0.12 mg/L to 0.53 mg/L. The reason for this large difference is that the source of the aluminum is the natural clays in the area. As a result the aluminum is a good surrogate for sediment load. The dates with the highest aluminum concentrations were October 2008, May 26, 2008 and July 1, 2008. These dates also correspond to high concentration of other metals both upstream and downstream of the plant.

The data also show that there are some metals that are not present in the seeps but are present in the Chaco River upstream and downstream. Mercury is an example of this situation. It is detected upstream of the plant in October, May and July of 2008 (the same dates with high sediment load discussed above). Mercury was never detected at the seeps.

Selenium never exceeded a surface water standard either upstream or downstream of the plant. Arsenic and lead were detected upstream of the plant on October, May and July of 2008. The concentrations for arsenic and lead did not show significant change from upstream compared to downstream.

<u>2004 through 2009 Historic Groundwater Data from Upgradient Monitor Wells LS-1 and LS-2</u>

In October 2003 two wells were drilled as the up gradient wells for the ash disposal area. These are wells LS-1 and LS-2. These wells are completed in the Lewis Shale. They are very low production wells and as can be observed by reviewing the water level data, they did not completely equilibrate until 2010 or 2011. Sampling even with normal bailers caused significant drawdown and delayed the date of final water level equilibration. For that reason, since 2008, the water samples have been collected using a HYDRAsleeve sampling device that minimizes the amount of water withdrawn from the wells.

The data is attached as an Excel file titled "Wells_LS-1_and_LS-2_2004-2009WQData.xlsx." The laboratory reports associated with this data are attached in Exhibit 2c.

<u>1988 through 2009 APS Groundwater and Surface Water Data.</u>

Two Excel files are attached with this data. The file names are "FC_HistoricAPS_GW-QualityData_1988-2009.xls" and "FC_HistoricSW_QualityData.xls." Tables 1 and 2 show the locations for these samples.

This data was collected by Plant personnel and, at least for the major cation and anion data, the samples were analyzed at the plant chemistry laboratory. There are no laboratory reports available for this data.

Although the laboratory reports are not available, the data still provide a consistent story. A review of the data, like the December 2011 and September 2012 data show that boron is a marker for ash pond water. A review of water quality changes over time shows that in the past (1988) there was little groundwater movement in areas to the north of the old ash disposal areas. This is the area where Ash Pond No. 6 was constructed. The TDS of this groundwater was as high as 126,000 mg/L. Sulfates and nitrates were also high. Nitrate concentrations as high as 1,000 mg/L were recorded. Sulfates concentrations of 79,000 mg/L were also recorded. These parameters are considered background levels in the Lewis Shale. The boron levels were recorded at the background level of 1 mg/L. Over time, the TDS, sulfate and nitrate levels declined and the boron levels increased. This shows that as water moves through the shale, the evaporate deposits are dissolved and flushed from the system. The boron associated with the ash pond water increases over time. As discussed in the section on the groundwater level data, this same thing happens when water is applied to the Lewis Shale during construction activities (see the discussion about the water level rise at monitor well MW-7).

The metal analyses included in this data suffer from the matrix interference issues described in the discussion of the December 2011 and September 2012 data. As stated above, we believe that the analyses performed using the Collision Cell Technology are more accurate.

The historic surface water data includes past analyses of the ash ponds, the evaporation ponds and the seeps.

1987 and 1992 Groundwater Data and 1987 Surface Water Quality Data

Attached are two Excel files titled "1987and1992_GW-QualityData.xlsx" and "1987_Surface-WQ-Data.xlsx." These files contain past analyses for the groundwater monitor wells and for surface water quality samples taken along the Chaco River, at the seepage areas and of the ash ponds and evaporation ponds. Tables 1 and 2 show the locations for these samples. The laboratory reports associated with these analyses are attached as Exhibit 2d.

This data constitutes the oldest data collected and available for the plant area. When reviewing the sample locations, it will be apparent in some cases that there have been changes since 1987. For example some of the sample locations plotted on Google Earth plot under the existing ash disposal areas. This simply shows that the ash disposal area has expanded since 1987. There are sample locations along the Chaco River. Some of them now plot in the middle of the river when in fact during 1987 they would have been located at the edge of the river. In some locations the eastern bank of the Chaco River has eroded back as much as 60 – 80 feet since 1987.

Conclusion

The data provided in this report represent our best efforts at preparing a complete listing of available data for the site. The data show that groundwater is flowing to the west towards the Chaco River. The data show that the groundwater is primarily moving in the weathered Lewis shale and in local alluvial channels that drain towards the Chaco River.

The data show that there are many parameters that are native to the Lewis Shale, for example sulfate, nitrates and uranium. The data show that boron is a marker for ash disposal waters. The data also show that boron concentrations downstream of the seeps are minimal due to the low flow associated with the seeps.

Operational changes at the Plant, closure and capping of old unlined ash disposal areas and construction of new intercept trench systems have reduced and once complete should prevent migration of groundwater towards the Chaco River. In 1993, extraction well systems were installed and began operation. Since 2004 all new fly ash from the Four Corners Units 1-3 has been placed in lined ash impoundments. Since 2007, all new fly ash from Units 4 and 5 has been placed in the Lined Dry Ash Disposal Area. Construction is in progress to close and cap the old unlined ash disposal areas.

Installation of the ET cap at Ash Ponds 1 and 2 is scheduled to be completed this summer. Construction is scheduled to begin in the summer of 2013 on the closure of Ash Pond No. 6. It is expected that installation of the ET cap on Ash Pond 6 will be completed by the summer of 2014. Capping these old ash disposal areas will prevent precipitation from collecting on top of the ash and prevent that water from seeping through the ash.

Finally, to provide a continuous barrier to the flow of groundwater towards the Chaco River, the Plant is constructing an intercept trench system located west of the ash impoundments along a north-south alignment. The northern portion of this trench system began operation in October 2011. Construction on South Intercept Trench has begun and is scheduled to begin operation in the fall of 2013.

Preliminary groundwater level data and water quality data demonstrate that the North Intercept Trench system is effective. Groundwater levels in monitor MW-30, MW-31 and MW-32 located down gradient of the trench system show significant water level declines after start of trench operation in October 2011. In addition, the boron concentration in well MW-32 has been reduced. The December 2011 boron concentration for this well was 130 mg/L. This was the highest level for all the wells sampled. The September 2012 analysis showed that the boron level has been reduced to 65 mg/L.

After the complete North and South Intercept trench system is complete and the old unlined ash impoundments are closed and capped, we are confident that any further migration of groundwater towards the Chaco River will be contained and prevented.

References

Stone, W. J.; Lyford, F.P.; Frenzel, P.F.; Mizell, H.H.; and Padgett, E.T., 1983. Hydrology and Water Resources of San Juan Basin, New Mexico. New Mexico Bureau of Mines and Mineral Resources, Hydrologic Report 6, 70p.

TABLES