EVALUATION AND PROFESSIONAL OPINIONS REGARDING GEOLOGIC AND HYDROGEOLOGIC ASPECTS OF THE 2016 DRAFT ENVIRONMENTAL IMPACT STATEMENT AS IT PERTAINS TO SCHEDULED FACILITY CLOSURE IN 2019 OR EXTENDING OPERATION UNTIL 2044

Navajo Generating Station – Kayenta Mine Complex Project Navajo Nation, Arizona, USA

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Executive Summary

This expert report evaluates a Draft Environmental Impact Statement (DEIS) and related documents prepared for the Navajo Generating Station (NGS) and the associated Kayenta Mine Complex (KMC) as part of the regulatory and permitting process required to extend the operational life of the NGS facility and the KMC mines through 2044. The NGS is a 2,250-megawatt, coal-fired electric power plant that began operation in 1974. The NGS is scheduled to stop producing electricity in late 2019 if operation is not extended through 2044. The KMC is the sole source of coal burned at the NGS, and the NGS is the sole user of KMC coal. The Navajo Nation leases 1,786 acres for the NGS facility. Most of the coal ash produced by NGS is disposed 1.5 miles east of the plant at a dedicated landfill totaling 765 acres. The landfill has a nominal capacity of 38 million cubic yards of coal combustion byproduct (CCR). Most of the remaining 1,021 acres are occupied by the NGS power plant.

Evaluation of the DEIS is focused on specific past, present, and future issues regarding water resources and contamination at the NGS. Pollution sources at the NGS plant include several landfills, lined and unlined industrial ponds, and numerous industrial wastewater treatment and storage basins, some of which remain potential contamination sources even though they are no longer in use. By 2014, there was reported to be approximately 18 million cubic yards already in the coal ash landfill, and the area covered by coal ash is approximately 400 acres. However, it is not clear how much CCR is actually disposed at the NGS landfill.

The NGS plant is located upon a geologic unit known as the Carmel Formation that did not contain groundwater prior to operation of the NGS plant. Unintentional leakage of industry-impacted water from this "zero liquid discharge" (ZLD) facility has formed a 'new' aquifer in the Carmel Formation, and groundwater is now located as little as five (5) feet below the NGS plant. Beneath the Carmel Formation is the Navajo Sandstone, and that unit is saturated with groundwater (the "N Aquifer") below the NGS at an average depth of 870 feet. The NGS is actively pumping wells tapping the Carmel Formation to remove contaminated groundwater that contains concentrations of heavy metals, sulfate, and total dissolved solids (TDS), and some of these concentrations exceed federal water-quality standards. For example, water pumped from one well in October of 2015 contained selenium, a toxic heavy metal, at a concentration almost four times (4x) the federal water-quality standard. Shallow groundwater is being pumped continuously from the Carmel Formation because it is a source of mobile contamination that can impact the quality of groundwater in the regionally-important N Aquifer. Some NGS monitoring wells have been abandoned to eliminate possible pathways for the contaminated groundwater to move downward. The full extents of the industry-produced groundwater in the Carmel Formation are not defined, despite the fact that this problem has existed since at least 1979.

Impacts to the N Aquifer at the NGS site include increasing concentrations of sulfate and TDS. Fractures present in the Carmel Formation and the underlying Page and Navajo Sandstones act as preferred pathways for downward migration of contaminated groundwater. Fractured-rock aquifers are notoriously difficult to characterize, monitor, and remediate once they become contaminated. The numerous and obvious fractures in the sandstone bedrock forming the eastern wall of NGS' unlined coal ash landfill represent preferred pathways for ash leachate to enter the groundwater system. It is important to recognize that it takes time for contamination to migrate from a source and cause a detectable impact.

Semi-annual groundwater monitoring occurring at the unlined coal ash landfill is inadequate. There is only one active N-Aquifer monitoring well (DW-3) located near the northwestern corner of the coal ash landfill, and that well may not be in a location suitable to monitor the impact of coal ash leachate. The DEIS claims that the risk of leachate impacting the N Aquifer is minimal because the coal ash is disposed in a "dry" form, the climate is arid, and the groundwater is approximately 900 feet below grade. However, NGS intentionally placed approximately 200 to 350 million gallons of "plant process water" on the coal ash within the first decade of operation, and at least 70 million gallons of water falls on the coal ash every year as rain and snow.

The current monitoring plan for the coal ash landfill and the Carmel Formation beneath the NGS does not provide adequate safeguards against long-term impacts to the groundwater resources. The list of groundwater contaminants being monitored at NGS do not include several constituents that are commonly produced by coal ash. The NGS plan to comply with federal coal ash landfill rules claims that a more complete monitoring-well network will be in place at the CCR landfill by October of 2017, but the DEIS provides no description of what that network might include. Furthermore, this 'expanded' groundwater-monitoring network excludes the area of known groundwater contamination at the NGS plant site, and the full extent of groundwater in the Carmel Formation is not fully defined.

The DEIS was produced to support extension of operations at NGS through 2044, but some aspects of decommissioning the facilities by late 2019 are also described. Landfills used for soil wastes, asbestos, and other potential contaminants are present at NGS, and plans to evaluate and close those non-ash contaminant sources are nonspecific and vague. At least one large release of fuel oil has occurred at the NGS plant, but that contamination is not described in any detail. The plan describing closure of the coal ash landfill is focused on placing a cover over the ash, and the post-closure maintenance and monitoring plan contains no details beyond stating that NGS will comply with the 2015 federal CCR landfill rules. It is impossible to forecast accurately what it might cost to close, monitor, and (possibly) remediate the coal ash landfill at the NGS site because there are too many unknowns. A planning value of $100,000 per acre of ash is indicated from the limited data available from other coal ash landfill closures occurring in the United States. That figure does not include the costs of closure and remediation at the NGS plant site, including where contaminated groundwater is documented and where historic waste disposal areas may continue to be a source of contaminants.

I. Introduction and Purpose

The Navajo Generating Station (NGS) is a 2,250-megawatt, coal-fired electric power plant that began operation in 1974 (Figure 1). The associated Kayenta Mine Complex (KMC) is the sole source of coal burned at the NGS, and the NGS is the sole user of KMC coal. The Navajo Nation leases 1,786 acres for the NGS facility. Most of the coal ash produced by NGS is disposed at a dedicated landfill totaling 765 acres that has a nominal capacity of 38 million cubic yards of coal ash (aka, coal combustion residuals, CCR). The coal ash landfill is located approximately 1.5 miles east of the NGS plant (Figure 1). Most of the remaining 1,021 acres are occupied by the NGS power plant. Most of the KMC is located on the Navajo Nation, although a small portion is owned by the Hopi Tribe (Figure 2).

The NGS' largest owner and operating agent, the Salt River Project Agricultural Improvement and Power District (SRP), prepared a Draft Environmental Impact Statement (DEIS) in September of 2016 for the NGS-KMC Project. The NGS is scheduled to close by the end of 2019, and the DEIS was produced to support the permitting process required to extend the operational life of the NGS facility and the KMC through 2044. Groundwater Management Associates, Inc. (GMA) was tasked with providing an independent evaluation of geologic and hydrogeologic aspects of the DEIS and related documents that bear on the scheduled closing of the NGS in 2019, in particular the adequacy of the assessment, monitoring, and remediation of water resources already impacted by, or at risk from, coal-related contamination. The NGS-KMC Project is also identified as the "Navajo Project" within portions of the DEIS, and GMA assumes that the Navajo Project name is used to simplify the complex, interwoven nature of the entities and relationships involved with the numerous components of the NGS, its fuel source at the KMC, and the distribution and sale of the electricity produced by the facility. The lead federal agency for the NGS-KMC Project is the Department of the Interior's Bureau of Reclamation, which states that the DEIS is required by the National Environmental Policy Act of 1969 because the SRP and other interested parties and affiliates are seeking to "*continue operating the NGS and Kayenta Mine for another 25 years after the current lease expires, from 2020 through the end of 2044* (and that) *continuation of both the NGS and Kayenta Mine (the coal source for NGS) may result in significant impacts*." (NGS-KMC Project website: https://ngskmc-eis.net/)

II. Qualifications

Dr. Steven K. Campbell is GMA's Director of Environmental Services, and he is the investigator for the evaluation described herein. His opinions provided in this report are based upon his education, professional training, and experience with environmental assessments involving soil, surface water, and groundwater conditions, both their natural characteristics and impacts from human activities. Dr. Campbell has evaluated environmental assessments of coal-fired power plants, open-pit and min-reclamation disposal of coal ash, and the associated impacts of coal ash on surface and subsurface geologic media (e.g., groundwater) in Maryland and North Carolina, India, and South Africa. His opinions of the DEIS and related plans produced for the NGS-KMC Project are based on widely-accepted principals of geology and hydrogeology, common industry practices, documents provided to him, and publically-available information. Dr. Campbell's resume is provided in Appendix I.

Figure 1: Locations of the NGS Facility, Coal-Ash Disposal Site, and Area Infrastructure

(Source: Figure 1-3, SRP, 2016a)

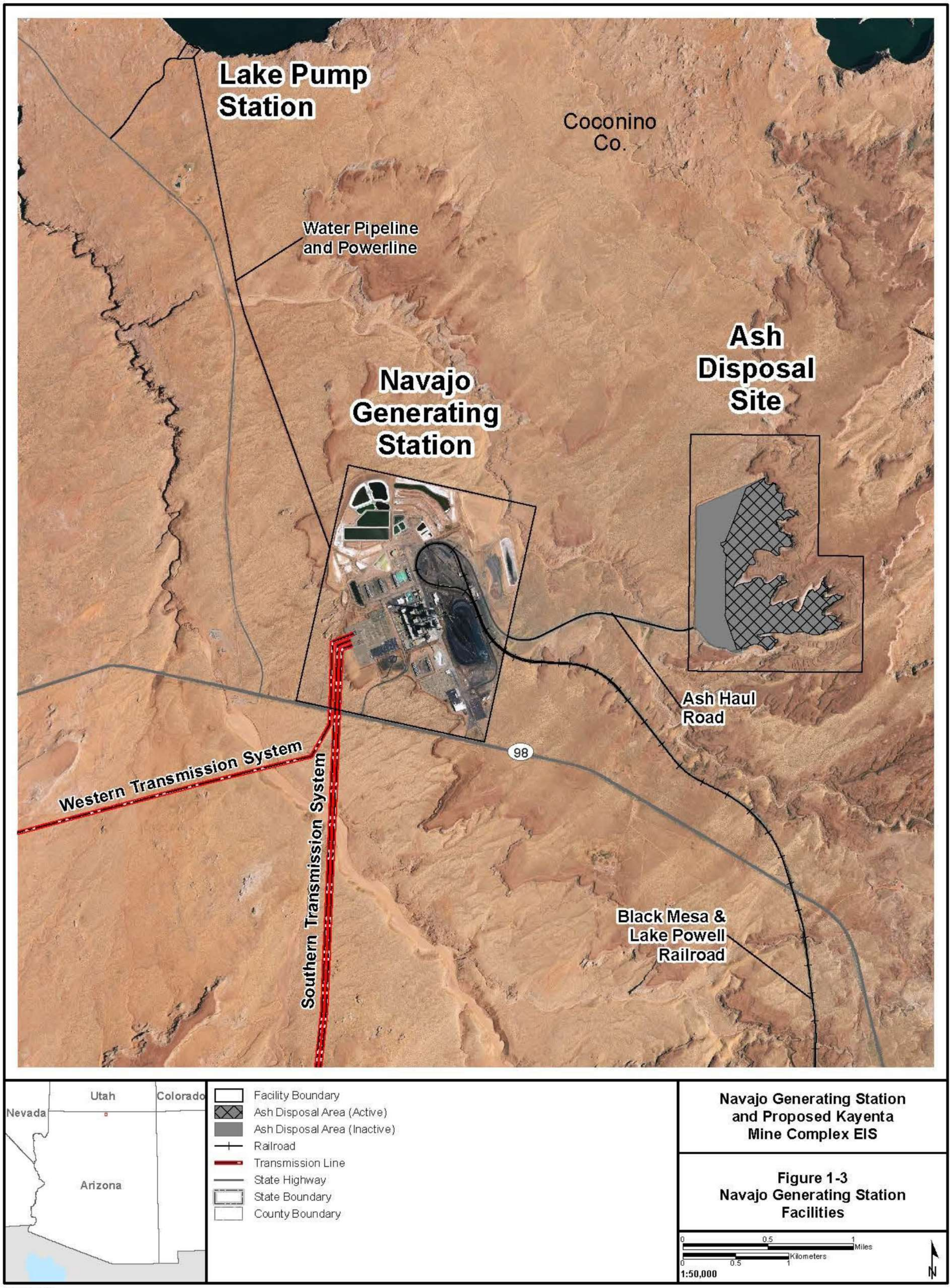

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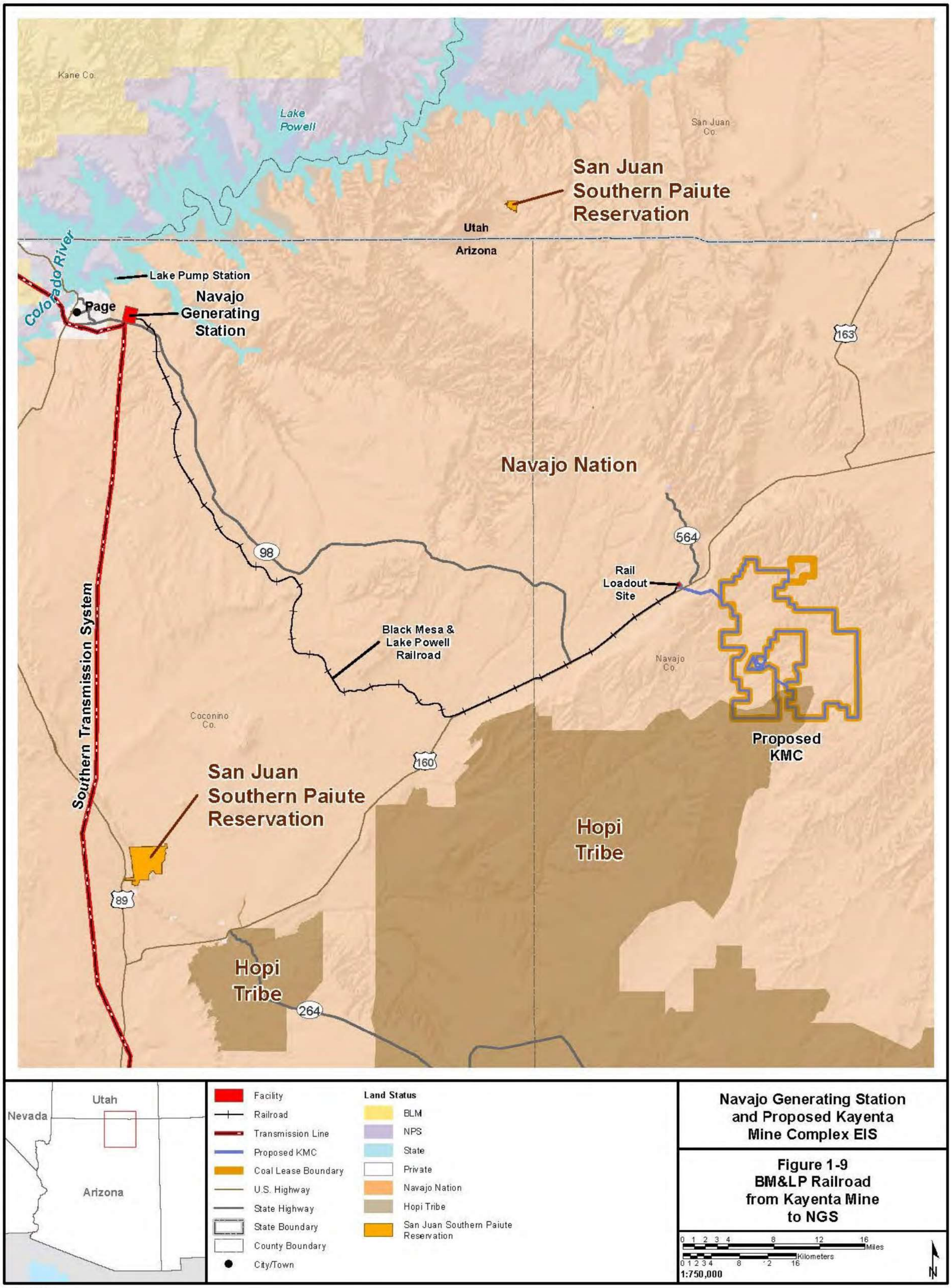
Figure 2: Locations of the NGS, the KMC, and Property Ownership in the Area
(Source: Figure 1-9, SRP, 2016a)



III. Information Reviewed

Dr. Campbell has reviewed the following documents and sources of information during his evaluation of the DEIS. This is not a comprehensive list of all information pertinent to his review and opinions.

Haley & Aldrich, Inc., 2016a, Written Closure Plan, Navajo Generating Station – CCR Landfill, 9 pages.

Haley & Aldrich, Inc., 2016b, Post-Closure Plan, Salt River Project, Navajo Generating Station – CCR Landfill, 4 pages.

Haley & Aldrich, Inc., 2016c, Initial Run-On and Run-Off Control Plan, Salt River Project, Navajo Generating Station – CCR Landfill, 267 pages

National Research Council of the National Academies, 2006, Managing Coal Combustion Residues in Mines, Washington, DC, The National Academies Press

NGS-KMC Project Website; https://ngskmc-eis.net/draft-eis-files/

Salt River Project Agricultural Improvement and Power District (SRP), 2016a, Draft Environmental Impact Statement, Navajo Generating Station-Kayenta Mine Complex Project, Text, 1652 pages

Salt River Project Agricultural Improvement and Power District (SRP), 2016b, Draft Environmental Impact Statement, Navajo Generating Station-Kayenta Mine Complex Project, Appendicies, 1094 pages

Salt River Project Website; https://environmental.srpnet.com/CCR

United States Department of the Interior, Bureau of Reclamation, 2016, Draft Environmental Impact Statement, Navajo Generating Station-Kayenta Mine Complex Project, Abstract (https://ngskmc-eis.net/wp-content/uploads/2016/09/draft-eis/Abstract.pdf) (retrieved on 5/25/2017)

United States Environmental Protection Agency (USEPA), 1998, Report to Congress Wastes from the Combustion of Fossil Fuels, Volume 2 Methods, Findings, and Recommendations

United States Environmental Protection Agency (USEPA), 2015, Hazardous and Solid Waste Management System, Disposal of Coal Combustion Residuals from Electric Utilities, Final Rule, 40 CFR Parts 257 and 261

https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations

https://en.wikipedia.org/wiki/Navajo_Generating_Station

IV. Observations and Opinions Regarding the DEIS in the Context of Water Resources

The DEIS and other pertinent documents were reviewed to identify some of the areas of concern regarding water resources and contamination that have resulted from historical operation of the NGS, the planned closure of the NGS by 2019, and anticipated issues that may result from extending the lifetime of the facility until 2044. The review summarized herein is not intended to be a complete assessment of the numerous known or potential environmental issues at the NGS, nor is it a comprehensive evaluation of issues that may result from extending the operation of the NGS for an additional 25 years. The KMC is not the focus of this evaluation, although some aspects of mining at the KMC were reviewed to the extent that time and documentation have allowed.

Key questions evaluated in this expert report include:

1. Where is groundwater located and has it been impacted by activities at the NGS?
2. What is extent of existing groundwater contamination associated with the NGS? Has the physical distribution of the contamination been defined by the monitoring network and approach that is being used at the site?
3. Is the groundwater monitoring-well network and sampling and analysis plan adequate to address the NGS' waste disposal areas?
4. Is surface water contamination occurring or likely to occur as a result of NGS waste disposal?
5. Are the current remedial measures at NGS sufficient in light of the documented pollution and the likely closure of the plant? If not, what remedial measures must be taken?
6. Are the closure and post-closure plans for the NGS ash-disposal site and other landfills sufficient?
7. How long might it take to remediate and/or be confident that environmental contamination of soils, surface water, and groundwater at NGS are at safe concentrations?
8. Is it possible to estimate the cost to close, remediate, and monitor environmental conditions for the NGS' ash-disposal and landfill sites?

IV.1 Where is groundwater located, and has it been impacted by activities at the NGS?

- The DEIS described in adequate detail the geology at and near the NGS and KMC, the arid climate of the NGS and vicinity, surface water conditions, and the natural and man-induced recharge to the subsurface groundwater systems. The DEIS reports that groundwater occurs in shallow strata of the Carmel Formation directly beneath the NGS plant, and in the deeper Page and Navajo Sandstones. The DEIS acknowledges that groundwater distribution and quality have been impacted by historical activities at the NGS (e.g., industry-impacted groundwater accumulation in the previously-dry Carmel Formation).
- The NGS is located approximately 4,375 feet above mean sea level (AMSL). The surface of the coal combustion residuals (CCR) previously disposed in the CCR landfill are approximately 4,530 feet AMSL (Figure 3). The base of the retention dam (aka, dike or berm) holding the coal ash in place against the natural topography formed upon sandstone is approximately 1.15 miles in length and occurs at an elevation of 4,390 feet AMSL (Figure 4), so the retention dam is more than 140 feet high. In 2015, coal ash was being disposed at an elevation of approximately 4,510 feet AMSL in the northern third of the ash pit (Figure 4). Comparison of Figures 3 and 4 indicate that the ash-retention dam is constructed of ash covered with a veneer of soil that appears to lack stabilizing vegetation other than what has grown voluntarily.
- The NGS was designed to have "zero liquid discharge" (ZLD), meaning that all water used by the plant was recovered and treated for reuse, or was lost to evaporation. However, water has been, and is still being, lost to the subsurface at multiple places at the NGS facility, as described below.

Figure 3: Layout of NGS Coal-Ash Disposal Site and Groundwater Monitoring Wells
(Source: Modified from Figure 4, SRP, 2016b)

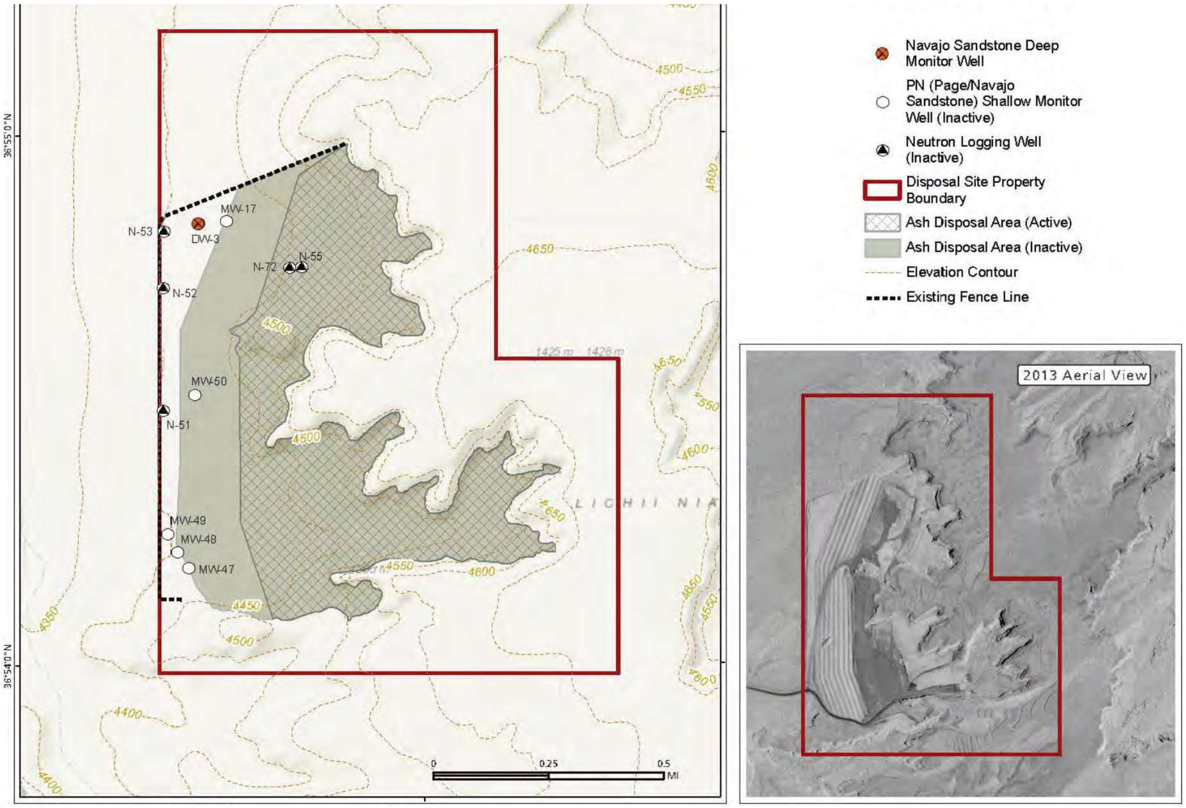
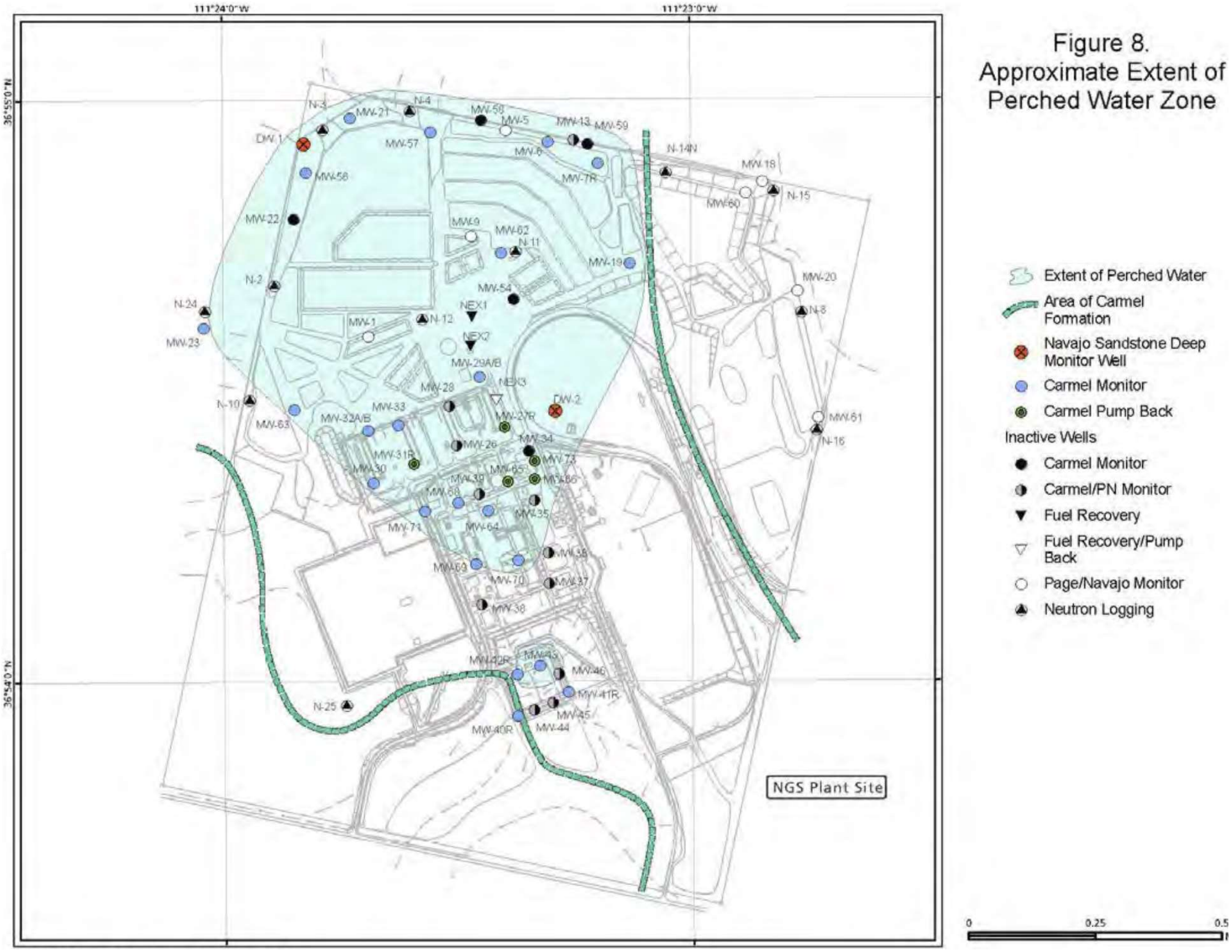


Figure 4: View of the NGS Coal-Ash Disposal Site in April of 2015
(Source: Google Earth)

- Two distinct groundwater systems are at risk of contamination by NGS activities and waste disposal, including the coal ash landfill (Figures 3 and 4). There is a shallow zone of groundwater within the relatively-thin Carmel Formation (10 to 70 feet thick) that is exposed at or very near the land surface at the NGS plant. A major regional groundwater (aquifer) system (N Aquifer) occurs in the massive Navajo Sandstone located beneath the Carmel Formation.
- The Carmel Formation is predominantly siltstone, with some interbedded sandstone and mudstone. The DEIS states that "*the Carmel Formation is absent beneath the Solid Waste Landfill and Ash Disposal Area, which are underlain by the Page and Navajo sandstones*" (SRP, 2016a, page 3.7-15). SRP considers groundwater in the Carmel Formation to be "perched", meaning that the groundwater is disconnected from the N Aquifer by unsaturated portions of the Page and Navajo Sandstones. The N Aquifer is an important regional source of water supply, including in the vicinity of the KMC, although the proximity of Lake Powell negates use of the N Aquifer for industrial, irrigation, or domestic purposes at the NGS and the City of Page.
- In May of 2015, the depth to groundwater measured in 18 monitoring wells screened in the Carmel Formation averaged 13.4 feet below the land surface (BLS), and groundwater occurred less than five (5) feet BLS (SRP, Table 3, page 1B-230). SRP claims that Carmel groundwater has a limited extent directly beneath the NGS plant (Figure 5), yet much of this claimed distribution merely reflects the footprint of the monitoring-well network, and not necessarily the extents of groundwater. For example, the shallowest groundwater (4.7 feet BLS) was measured on the west side of the well network at MW-63, yet Figure 5 indicates that <u>no</u> groundwater is present immediately west of that well, which is extremely unlikely. In fact, it appears that most of the <u>horizontal</u> distribution of the groundwater in the Carmel Formation is undefined.
- Information in the DEIS does not indicate that the <u>vertical</u> extents of groundwater or the vertical hydraulic gradient within the Carmel Formation have been investigated, with the possible exception of what seems to be a well pair at MW-29A and MW-29B. Depth to water in those two wells in May of 2015 was approximately 66 and 12 feet BLS, respectively, suggesting a steep downward-directed hydraulic gradient. The measurements cannot be interpreted accurately because no well construction information is provided for MW-29A in the DEIS.
- The DEIS reports that "*groundwater was not encountered in the Carmel sediments during plant siting studies*" conducted prior to the NGS' construction, and "*perched water conditions occur as water infiltrates from the surface and is intercepted by the lower permeability sediments of the Carmel Formation*" (SRP, 2016b, page 1B-201). NGS-derived groundwater accumulations in the Carmel Formation have been known since 1979 (SRP, 2016b, Page 1B-243).
- In 2015, groundwater in the Carmel strata (Figure 5) was located an average of 13.4 feet below the surface at the NGS plant, and "*potential sources of the perched water include past seepage from the evaporation ponds, cooling towers, and previously unlined drainage ditches in the ash dewatering area*" (SRP, 2016b, page 1B-199). To combat this subsurface recharge by NGS industrial water containing "*elevated levels of TDS* (total dissolved solids) *and certain trace metals indicative of plant process water*", the SRP began pumping water from the Carmel Formation to "*capture and control possible migration of water*" (SRP, 2016b, page 1B-199). Ongoing pumping indicates that releases of industrial water persists at NGS.

Figure 5: Distribution of Groundwater in the Carmel Formation beneath the NGS
(Source: Figure 8, SRP, 2016b)



- The N Aquifer "*is the principal source of industrial (Kayenta Mine) and municipal water in the study area*" (SRP, 2016a, page 3.7-13). At the NGS plant, there is an average of approximately 870 feet of unsaturated Page Sandstone and Navajo Sandstone present between the bottom of the water-saturated Carmel strata and the top of the groundwater-saturated portion (water table) of the N Aquifer (Figure 6). In 2015, the depth to groundwater measured in the N Aquifer at monitoring well DW-1 located at the northwestern side of the NGS plant was 833 feet BLS (SRP, 2016b, Table 3, page 1B-231). Groundwater in the N Aquifer occurs in primary porosity located between individual sand grains and in fractures such as those readily visible at the coal ash disposal site where ash is in direct contact with the sandstone bedrock (Figure 7).
- Filling of Lake Powell behind the Glen Canyon Dam is reportedly causing the surface of the N Aquifer's water table at the NGS to rise at a rate of one to two feet per year, and the DEIS projects that the water table will stop rising when it reaches approximately 3,550 to 3,600 feet AMSL sometime "*in the next 50 to 100 years*" (SRP, 2016b, page 1B-209). Therefore, The DEIS projects roughly 100 feet of additional rise in the N Aquifer's water table over the next several decades without any additional groundwater recharge (or withdrawal) caused by NGS activities, changes in management or structure of the Glen Canyon Dam or Lake Powell, change in climate or weather patterns, new sources of aquifer withdrawal (pumping), etc.

Figure 6: Generalized Hydrogeologic Cross Section across the NGS
(Source: Modified from Figure 3.7-5, SRP, 2016a)

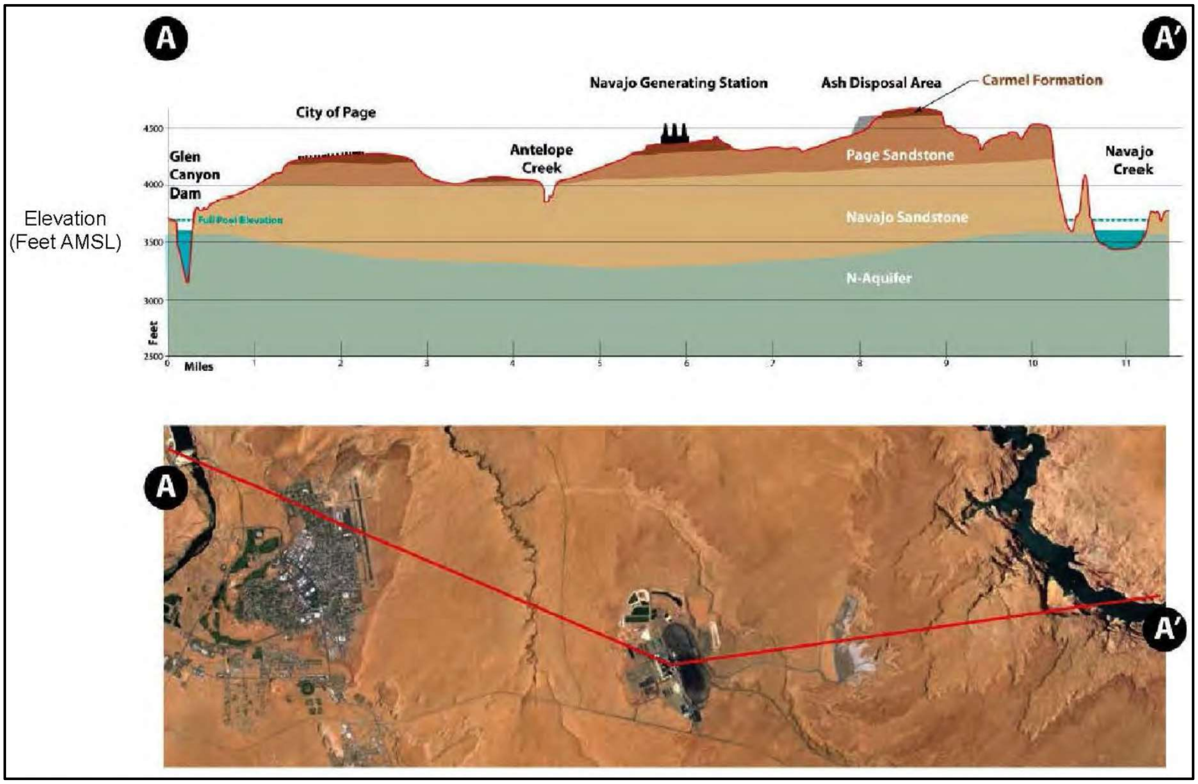
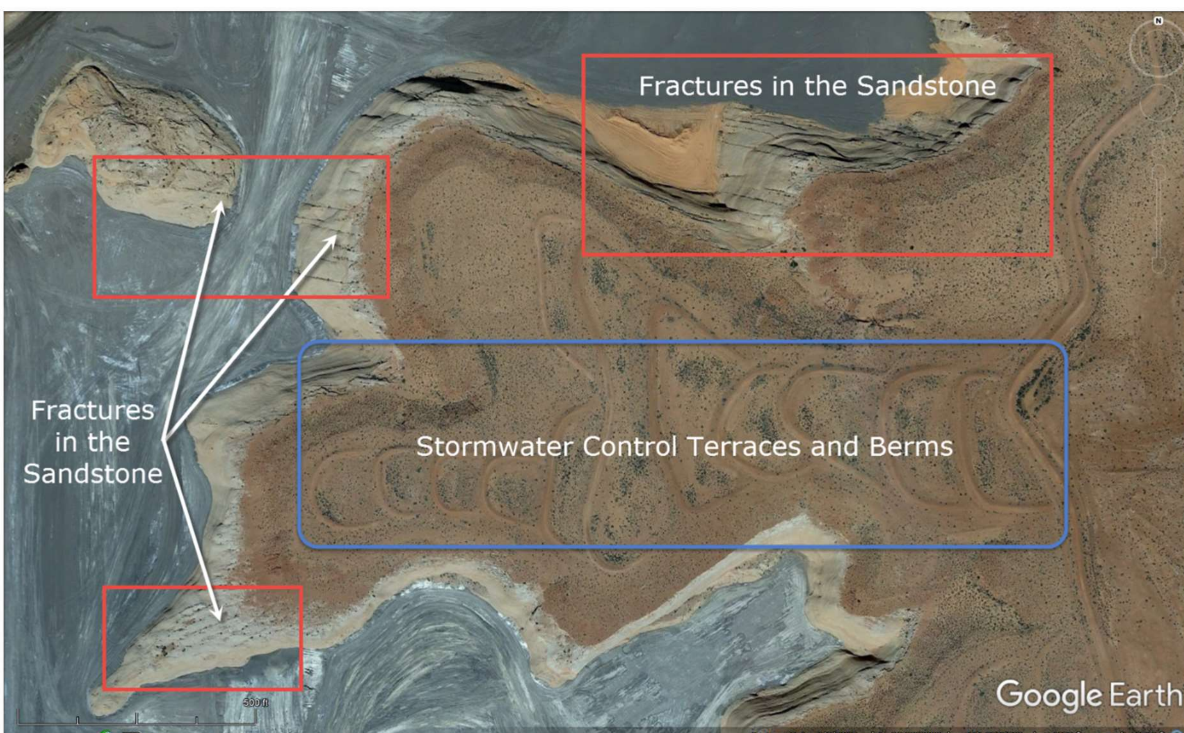


Figure 7: Fractured Sandstone at the NGS Coal-Ash Disposal Site in April of 2015
(Source: Modified from Google Earth)



- Between 1981 and 2015, groundwater flow within the N Aquifer beneath the NGS shifted from being directed toward the north-northwest and the Colorado River to southwestward and away from Navajo Creek. The amount and rate of groundwater rise during this 34-year period varied by monitoring well location (see table). The DEIS claims that this change in flow pattern reflects aquifer recharge from the filling of Lake Powell, but the amount of rise for each 17-year period varies considerably by well, and the DEIS does not appear to correlate a numerical relationship with lake filling, regional precipitation and recharge patterns (e.g., predominantly drought since 1994), etc. The smallest total rise in the N Aquifer's water table was measured directly beneath the NGS plant in well DW-2 (42 feet between 1981 and 2015), and only 5 feet of rise occurred in DW-2 during the first 17 years.

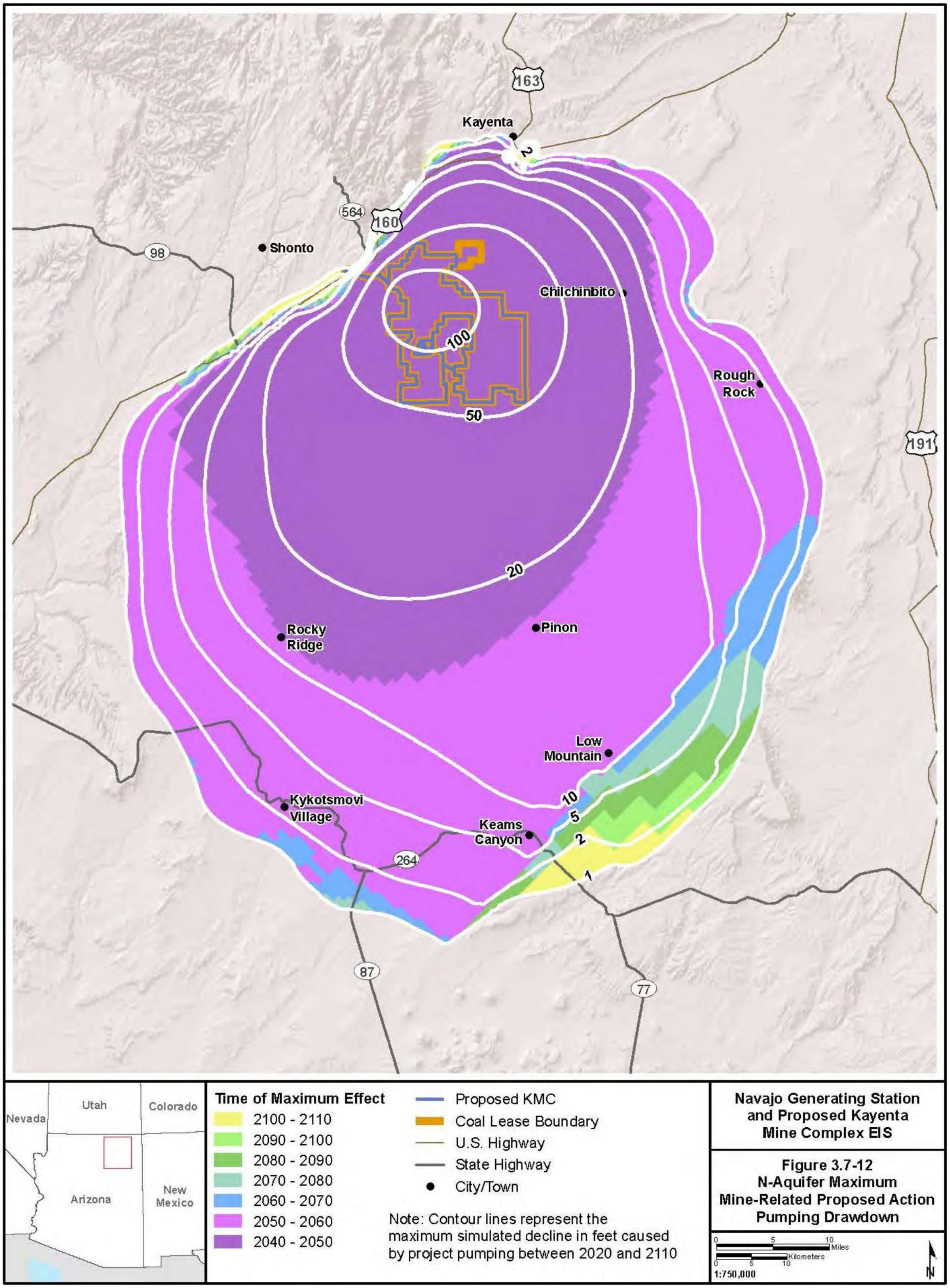
N Aquifer Monitoring Well Groundwater Elevations

Date	DW-1	DW-2	DW-3
Dec 1981	3378	3421	3444
Nov 1998	3413	3426	3472
May 2015	3465	3460	3516

Elevations in feet AMSL

- Variability in the rates of water-level rise recorded through time in the three N Aquifer wells is likely to reflect the heterogeneous distribution of water-bearing fractures in the sandstone aquifer, among other factors. The DEIS claims that "*Although some fracture flow was indicated at DW-2, there is no evidence of extensive fracture flow throughout the Navajo Sandstone below the site*" (SRP, 2016b, page 1B-199). This statement is inconsistent with "*fracture flow (roughly 1 to 2 gpm)*" detected in the only active CCR landfill monitoring well DW-3 "*at approximately 569 feet bgs in 1997 and again in 2015*" (SRP, 2016a, page 3.7-45). It is more likely than not that most of the groundwater extractable from the N Aquifer using a well and pump is in fact located in fractures, and all relatively rapid groundwater flow in the aquifer occurs exclusively through fractures.
- The DEIS projects that KMC groundwater withdrawals from the N Aquifer will cause the water table to drop from more than 100 feet to a few feet for up to 55 miles away from the KMC (Figure 8). The assumptions and methods used in computer modeling of KMC groundwater withdrawals (SRP, 2016b, Appendices WR-9 and WR-10) have not been evaluated in connection with this expert report.
- In summary, activities at the NGS have impacted the groundwater system that existed for millennia prior to construction and operation of the plant. A 'new' aquifer has been produced in the previously-dry Carmel Formation by unintentional water leakage from the surface at this supposedly ZLD facility, and that groundwater contains constituents from industrial activities. The regional N Aquifer has been impacted by NGS' activities, as described below. Existing and proposed mining at the KMC will impact groundwater resources in multiple aquifers, both in terms of availability and water quality.

Figure 8: Projected Water Level Declines in the N Aquifer by Mining at the KMC
(Source: Figure 3.7-12, SRP, 2016a)



IV.2 What is the extent of existing groundwater contamination associated with the NGS, and has it been defined by the monitoring approach that is being used?

- The DEIS identifies several sources of impact to surface water and groundwater resources that may occur or persist if operation of the NGS is extended to 2044, including: (1) additional volumes of coal ash production and disposal, (2) spills or leaks from NGS fluid storage, handling, or evaporation ponds, (3) water withdrawals from Lake Powell, and (4) stack releases of elements or acidic constituents that could impact water quality that may exceed applicable water-quality standards (SRP, 2016a, page 3.7-43).
- The DEIS specifically claims that "*no impacts to surface water or groundwater resources (i.e., N-Aquifer) have been identified at NGS from the use of water at NGS, including the existing solution and evaporation ponds*" (SRP, 2016a, page 3.7-46). However, the DEIS tacitly or explicitly acknowledges that groundwater quality has been impacted by activities conducted at the NGS since it began operation in 1974, as described below.
- Coal ash handling and disposal is an obvious and important source of contamination at coal-fired electricity generating facilities, although there are many other solid and liquid contaminant sources present. At the NGS, non-ash contaminant sources include petroleum product storage and use, solid and liquid organic wastes, more than twenty stormwater and water treatment impoundments (e.g., evaporation ponds; Figure 9), coal and bulk chemical delivery and storage, and onsite disposal of building materials and other solid wastes (Figure 10).
- A significant contamination pathway at the NGS is "*past seepage from the evaporation ponds, cooling towers, and previously unlined drainage ditches in the ash dewatering area*" that contains "*elevated levels of TDS and certain trace metals*" that has created "perched" groundwater in the Carmel Formation strata beneath the NGS plant (Figure 5). Water loss to the subsurface was known to be occurring from this ZLD facility by at least 1979 (SRP, 2016b, Figure 2, page 1B-243), but SRP apparently did not begin actively pumping from the Carmel Formation to control those impacts until 2008. Although six wells (Figure 11) have been pumping for many years to "*capture and control possible migration of water*", the persistent and local rise of the groundwater surface beneath the NGS indicates that contaminated water is still actively being released to the subsurface (SRP, 2016b, page WR-8-1) despite SRP's claim of "no impacts". Contaminated groundwater in the Carmel Formation contains high concentrations of heavy metals, sulfate, and total dissolved solids (TDS), and some concentrations exceed federal health-based water-quality standards. For example, a sample collected from pumping well NA-66 in October of 2015 contained 0.18 milligrams/liter (mg/l) of selenium, which is almost four times the federal Maximum Contaminant Level (MCL) of 0.05 mg/l (SRP, 2016b, Table 5b, page 1B-236).
- The DEIS states that "*plant seepage may be on-going in two areas of the plant site* (and) *assessment of the ash dewatering system and cooling towers is needed to identify the source of this water*" (SRP, 2016b, page 1B-220). Remarkably, SRP admits that "*no information is available regarding the rates, volumes, and frequency of seepage to the subsurface* (and) *an evaluation of potential groundwater impacts was not performed*" (SRP, 2016b, page 1B-220). Significantly, the DEIS mentions <u>no</u> intent or plan to conduct an assessment of this persistent problem.

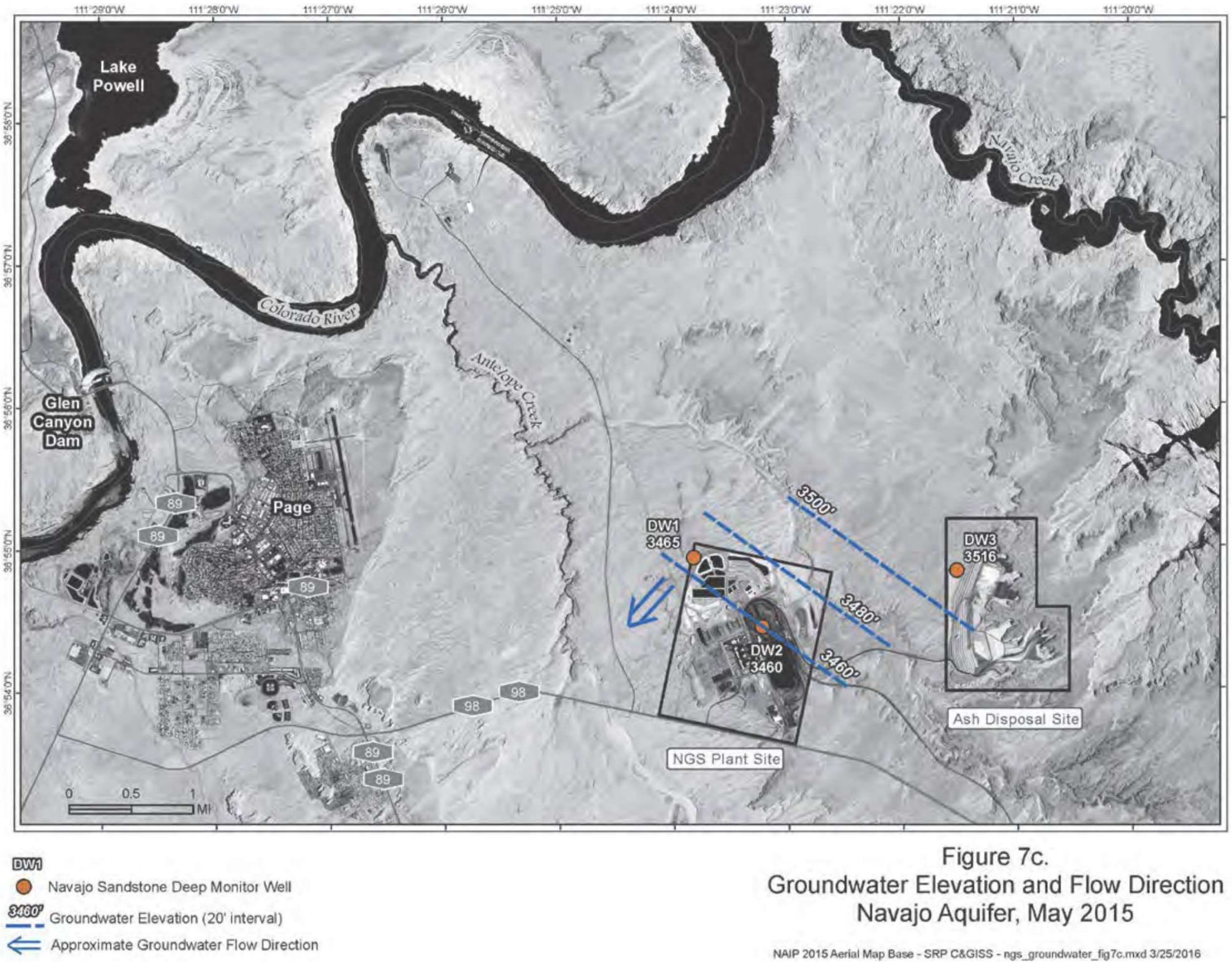
Figure 9: NGS Infrastructure and Potential Groundwater Contaminant Sources
(Source: Figure 4, SRP, 2016b)

Figure 10: NGS Solid Waste and Specialty Landfills
(Source: Modified from Figure 4, SRP, 2016b)

Figure 11: Carmel Formation Groundwater Recovery and Monitoring Wells
(Source: Modified from Figure 1, SRP, 2016b)

- Water quality in the N Aquifer is at risk from various surface contaminant sources, despite the roughly 870-foot separation between the 'perched' Carmel Formation groundwater and the top of the water table in the N Aquifer. Only three monitoring wells at the NGS penetrate the N Aquifer, wells DW-1 through DW-3 (Figure 12). These wells originally consisted of a pipe (casing) between the surface and 20 or 80 feet BLS, and an open borehole was drilled in the sandstone from the bottom of the pipe to 1,200 BLS (DW-1) or 1,500 feet BLS (DW-2 and DW-3). SRP attributed a "spike" in the concentrations of TDS and sulfate (SO_4) detected in well DW-2 beginning in about 1987 to be a result of the downward migration of NGS industrial-process water "perched" in the Carmel Formation via fractures in the underlying sandstone. Figure 7 shows large fractures in the sandstone that forms the sides of the unlined coal ash landfill. To try to eliminate further impacts to the N Aquifer, SRP installed a longer casing (liner) in well DW-2 to 660 feet BLS in 1989, followed by casing well DW-1 to 700 feet BLS in 2008, and casing well DW-3 to 750 feet BLS in 2015 (SRP, 20916b, page 1B-203). Time-concentration graphs for these three well (SRP, 2016b, Figures 10 through 12, pages 1B-256 to 1B-258) show trends in TDS and/or SO_4 that indicate impacts to N Aquifer water quality from NGS-leaked water and/or coal ash leachate migrating many hundreds of feet downward.

Figure 12: Groundwater-Flow Map for the N Aquifer at the NGS
(Source: Figure 7c, SRP, 2016b)



- The DEIS reports that 78 monitoring wells have been installed at the NGS since the mid-1970s, including; 3 wells completed in the N Aquifer; 58 shallow wells in the Carmel Formation, the upper Page/Navajo Sandstone, or in natural or manmade surficial deposits; and 17 'neutron' wells used historically to measure moisture content at depth. However, most of these wells have been "lost", abandoned, destroyed by subsequent onsite activities, or are simply not being used. Eleven wells in the upper Page/Navajo Sandstone were replaced or abandoned in 2013 because of concerns that the wells provided a vertical connection between the N Aquifer and surface contaminant sources and/or contaminated groundwater in the Carmel Formation (SRP, 2016b, page WR-8-1). Currently, groundwater monitoring appears to be restricted to three wells in the N Aquifer (Figure 3), and the DEIS lists 28 shallow wells in the Carmel Formation at the NGS plant (e.g., Figure 5) as "active", although that term does not mean that they are being monitored regularly.
- The CCR landfill area covered by disposed CCR is approximately 400 acres, but it is not clear how much coal ash is actually disposed at NGS. By 2014, there was reported to be approximately 18 million cubic yards of CCRs disposed in the coal ash landfill (SRP, 2016a, page 1B-63). The NGS produced more than 1.3 million tons of CCRs in 2014, of which 926,688 tons were put in the

landfill, and 380,739 tons were hauled offsite to other facilities (SRP, 2016a, page 1B-60). Assuming an average landfill accumulation rate of 750,000 tons per year, 40 years of plant operation would result in 30 million tons of CCR in the landfill. However, the 2014 estimate of 18 million cubic yards of disposed CCR would total only 11.7 million tons if each cubic yard of disposed CCR has a "dry" density of 0.65 tons per cubic yard. This calculation assumes that "dry" ash and scrubber byproduct (FGD-gypsum) weighs 0.54 tons and 0.77 tons per cubic yard, respectively, and that the 2014 ratio of coal ash to scrubber byproduct is typical for the NGS.

- Ongoing groundwater monitoring at the 400-acre coal ash landfill appears limited to the semi-annual sampling and testing of a single well in the N Aquifer (DW-3), and multiple shallow wells at the coal ash landfill are explicitly listed by SRP as "inactive" (Figure 3). Well DW-3 is located is located northwest of the ash retention dam, and the 2015 groundwater-flow (equipotential) map for the N Aquifer (Figure 12) indicates that well DW-3 is located hydraulically upgradient or side-gradient of the coal ash. Therefore, well DW-3 may not be located in a position that would allow impacts from the CCR landfill to be detected. The DEIS states that "*A deep well groundwater monitoring system is being installed and groundwater samples are collected from the uppermost aquifer. This system will monitor both upgradient and downgradient groundwater quality to comply with CCR regulations by October 17, 2017.*" (SPR, 2016b, page 1B-61). The DEIS does not include a more specific description of the planned coal ash monitoring-well network, or a revised sampling and analysis plan to address landfill monitoring (see Section IV.3 below).
- Another source of coal ash-contaminated water at the NGS facility is the "Power Block Drain" that "*collects drainage from the Unit 1, 2, and 3 bottom ash areas* (and) *includes: rainwater collected from concrete surfaces, bottom ash system washdown, bottom ash system leakage, and occasional upset-spillage from the bottom ash system and FGD slurry tanks*" (SRP, 2016b, page 1B-150). That ash-laden water is directed into the "Ash Ditch", which "*collects and transports a mixture of service water and process water with a high concentration of solids*" (SRP, 2016b, page 1B-150). It seems likely that leakage from the Power Block Drain and the Ash Ditch is responsible for at least some of the water accumulating as groundwater in the Carmel Formation.

Figure 13: NGS Power Block Drainage Ditch and Ash Ditch
(Source: Figure 3, SRP, 2016b)

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- Other potential sources of groundwater accumulating in the Carmel Formation include leakage from the many ponds and impoundments that are part of the NGS' water management and treatment system (Figure 9). The NGS has at least three non-ash landfills (Figure 10), but the DEIS does not appear to indicate that leachate emanating from these areas is being monitored.
- Analytical data for groundwater sampled from the Carmel Formation provided in the DEIS include exceedances of targeted contaminants, including heavy metals (e.g., SRP, 2016b, Table 5b, page 1b-236). It is likely that SRP possesses a large dataset of groundwater analyses for these (and other) monitoring wells, but those data and associated interpretations do not appear to be provided beyond the historical overview of groundwater monitoring provided in the "Navajo Generating Station Groundwater Monitoring Program Report 1978-Present" (SRP, 2016b, pages 1B-193-273) that is provided in in DEIS.
- No contaminant plume maps are provided in the DEIS to demonstrate that the horizontal and vertical extents of the known groundwater contamination has been defined or is being monitoring adequately. Other than pumping the Carmel Formation in an attempt to control the ongoing groundwater recharge from water leakage at the NGS, there appears to be no mention of groundwater remediation within the DEIS.
- A 5-Million-gallon aboveground storage tank is used to store bulk fuel oil at the NGS, and up to 1.8 Million gallons are burned each year at the NGS plant. Additional petroleum fuel storage and consumption occurs at the NGS facility. A substantial volume of fuel oil was released sometime in the mid-1990s when an underground fuel supply line leaked (SRP, 2016b, page WR-8-1). Three recovery wells were reportedly installed north of the Unit 1B Cooling Tower, and the DEIS claims that approximately 31,550 gallons of fuel oil were "recovered", presumably from the subsurface. The sparse information provided regarding the fuel oil release is inadequate to draw any conclusions about existing or potential groundwater contamination, although it is not uncommon for half or more of the original mass released to remain in the subsurface even after active recovery efforts have ended. Fuel recovery well NXE-3 is presently used to extract NGS-derived groundwater from the Carmel Formation (SRP, 2016b, page 1B-184).

IV.3 Is the existing groundwater monitoring-well network and sampling and analysis plan adequate to address the NGS' waste disposal areas?

- Some monitoring of groundwater distribution and quality in the Carmel Formation is occurring, even though there should be <u>no</u> such groundwater because the NGS is a ZLD facility and the DEIS reports that the Carmel Formation was "dry" prior to building the power plant. The DEIS contains some historic groundwater monitoring data, but there is no description of those data in the context of groundwater flow or contaminant plume distribution and migration. Ten monitoring wells at the NGS plant are reportedly being sampled and tested on a semi-annual basis for arsenic, barium, cadmium, chromium, fluoride, lead, selenium, sulfate, and TDS (SRP, 2016b, Tables 10d through 10m, pages 1B-166 through 1B-171). There is no explanation in the DEIS for why those are the only parameters being targeted for analysis.
- Although leachate is undoubtedly being produced at the coal ash disposal site, there is no evidence that it is being monitored at the present time, nor, apparently, in the past. The ash was

deposited directly upon fractured sandstone (Figure 7) or unconsolidated sand blanketing the sandstone, and no liner or low-permeability material such as compacted clay was installed prior to ash disposal. The DEIS reports that between 1978 and 1981, an estimated 127 to 293 Million gallons of "plant process water" was applied to the coal ash pile to "suppress dust" and to dispose of excess water, plus another 67 Million gallons of "plant process water" was applied to the coal ash pile in 1985 to facilitate water treatment repairs (SRP, 2016b, page 1B-213). A conservative annual average of approximately 70 Million gallons of precipitation falls directly on the 400 acres of coal ash each year. Collectively, it appears likely that more than 3 Billion gallons of water have been added to the surface of the disposed coal ash by natural or human actions since the NGS began producing and storing coal ash. Leachate and groundwater migration pathways through fractured rock are notoriously difficult to intercept or predict. SRP discovered this in 1987, six years after deep well DW-2 was installed, when "w*ater entering the open borehole below the surface casing via a fracture at 125 feet* (caused) *short-circuiting to the groundwater, causing a spike in TDS and sulfate levels.*" (SRP, 2016b, page 1B-203).

- There is only one active monitoring well at the coal ash landfill, deep well DW-3, which taps the N Aquifer (Figure 3). Data provided in the DEIS indicate that DW-3 is being sampled and analyzed on a semi-annual basis for the following parameters: arsenic, barium, cadmium, chromium, fluoride, lead, selenium, sulfate, and TDS (SRP, 2016b, Table 10c, page 1B-166). The DEIS does not describe why those are the only parameters being targeted for analysis. The 2015 federal rules for coal ash landfill closure and monitoring identify many other constituents that occur in groundwater impacted by coal-ash leachate.
- In summary, it is not possible to determine if the semi-annual monitoring activities at the NGS facility for the contaminated groundwater in the Carmel Formation are adequate until the full horizontal and vertical extents of the groundwater are delineated. The monitoring effort at the coal ash landfill appears to be wholly inadequate because it relies on a single monitoring well, poor placement of that well relative to 2015 groundwater-flow pattern, and the restricted list of targeted analytes. It does not appear that coal-ash leachate is being captured or monitored directly, and the plan to begin monitoring the CCR landfill using a more comprehensive network of wells by October of 2017 is not described in any detail within the DEIS.

IV.4 Is surface water contamination occurring or likely to occur as a result of waste disposal at NGS?

- The DEIS describes the arid to semi-arid nature of the NGS-KMC Project in great detail, including perennial and ephemeral (intermittent) surface water bodies. Perennial surface water in the vicinity of the NGS include Antelope Creek, Navajo Creek, the Colorado River, and Lake Powell (Figure 6). Impacts from NGS wastes appear to pose a minimal risk to those water bodies because of the distances involved. It is possible that airborne waste materials originating at NGS could impact surface water quality, including materials that escape capture or neutralization by the NGS' air-quality protection devices, fugitive coal-ash dust originating at the coal ash disposal site, and coal-ash dust escaping from trucks used to transport coal ash to other offsite facilities.
- Rainfall in the area of the NGS, especially during the summer 'monsoon' season, may occur as

intense, short-duration events that create considerable sheet flow that eventually becomes channelized in natural drainages. A number of ephemeral drainages are evident in aerial photographs of the NGS plant and the coal ash disposal site (Figures 1 through 3).

- The DEIS states that "*The use of dry disposal in conjunction with the dry climate and geology of the region reduces the mobility and leachability (downward movement) of any of the CCR constituents. Furthermore, retention of stormwater runoff, dust control, and groundwater monitoring procedures ensure the CCR constituents are contained on site.* (SRP, 206a, page 1-29). However, it does not appear that the DEIS describes specifically how precipitation upon, or directed onto, the coal ash disposal site is being managed other than by depositing the coal ash "*in horizontal terraces against the steep vertical walls of the sandstone outcrop in individual layers or lifts not exceeding 15 vertical feet* (and) *the final top layer is covered with a 2-foot-thick layer of native soils*" (SRP, 206a, page 1-29). A 2015 aerial view of the coal ash facility (Figures 4 and 7) reveals a series of terraces and berms built on the plateau east of the coal ash landfill that were installed to try to minimize surface water discharge onto the eastern side and surface of the disposed ash. To comply with the 2015 federal CCR disposal regulations, the DEIS includes a "CCR Landfill Compliance" work plan that states that the "*NGS will design, construct, operate, and maintain a run-on control system to prevent flow onto the active portion of the CCR unit during the peak discharge from a 24-hour, 25-year storm, and a run-off control system from the active portion of the CCR unit to collect and control at least the water volume resulting from a 24-hour, 25-year storm*" (SRP, 20-16b, page 1B-127). Design, construction, and operation of the CCR landfill surface water management system will reportedly occur "*by the proposed project start in 2019*" (SRP, 2016a, page 3.7-19). SRP's plans produced for the coal ash landfill closure, post-closure maintenance and monitoring, and stormwater run-on and run-off control are described below in Section IV.6.

IV.5 Are the current remedial measures sufficient in light of the documented pollution and the likely closure of the plant? If not, what remedial measures must be taken?

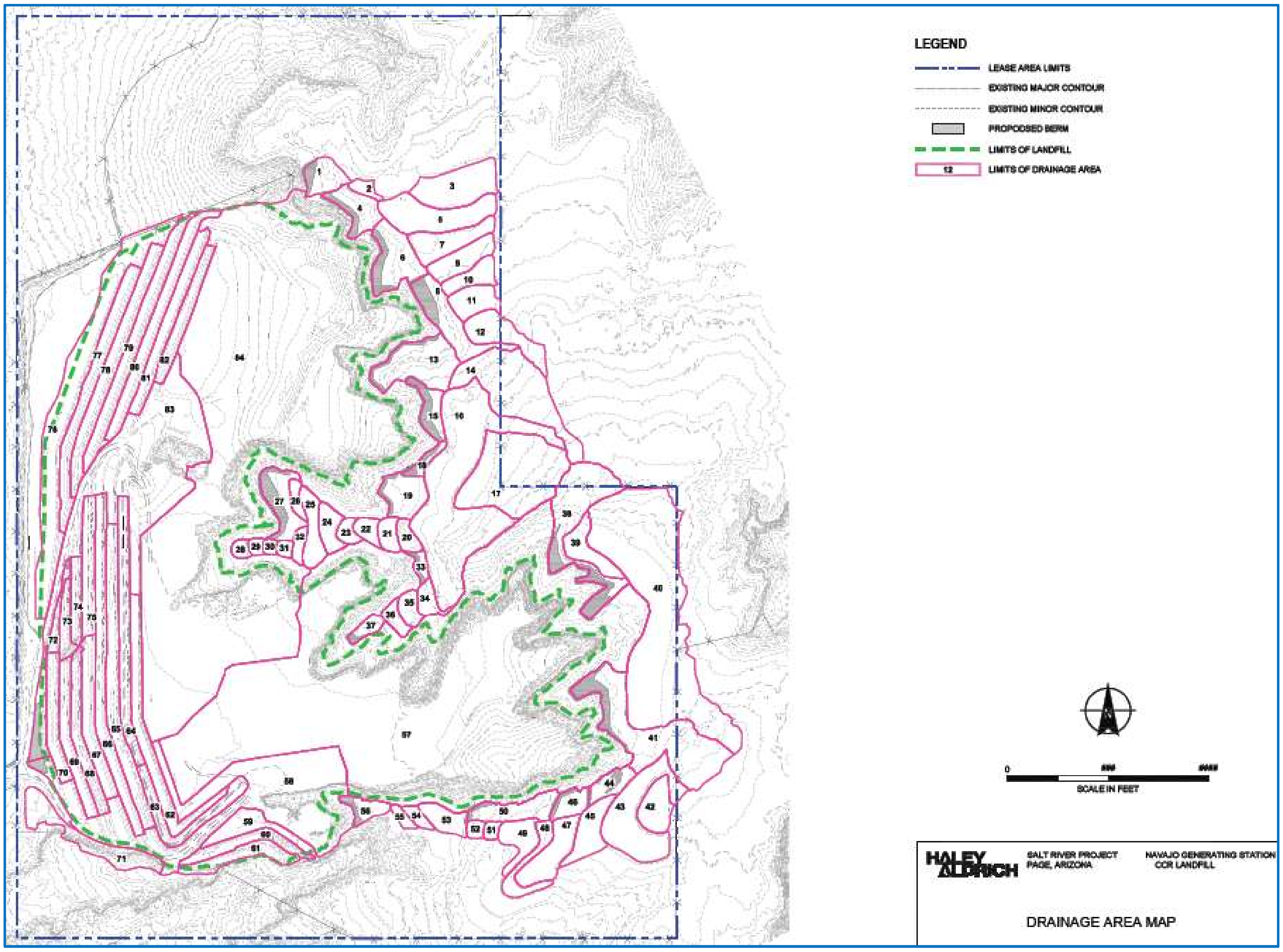
- The DEIS describes no active remediation or intentional (monitored) natural attenuation of groundwater contamination. It does not appear that SRP's "Groundwater Protection Plan" contains any of the standard components of an assessment or remediation plan, and the plan claims that "*there is no imminent risk of contaminating the aquifer*" (SRP, 2016b, page 1B-138).
- NGS industrial process water accumulating as "perched" groundwater in the Carmel Formation is being extracted by pumping to combat what appears to be decades of persistent releases of water from this supposedly ZLD facility. Groundwater pumped from the Carmel Formation is reportedly treated by the NGS' water-treatment facilities prior to reuse, but this is <u>not</u> a pump-and-treat remediation system, it is a "dewatering" system (e.g., SRP, 2016b, page 1B-180). SRP explicitly states that "*extraction wells will be pumped indefinitely for as long as perched water conditions remain at the Site*" (SRP, 29016b, page 1B-183).
- Effective remediation first requires identification of contamination sources, full delineation of the existing contamination, understanding migration pathways between the source and the groundwater system, and assessment of competing remedial strategies. It does not appear that

these basic elements are addressed in the DEIS, and in fact SRP admits that "*no information is available regarding the rates, volumes, and frequency of seepage to the subsurface* (and) *an evaluation of potential groundwater impacts was not performed*" (SRP, 2016b, page 1B-220).

IV.6 Are the closure and post-closure plans for the NGS coal ash disposal site and other landfills sufficient?

- The DEIS describes no NGS-specific closure or post-closure plans for the coal ash landfill or other non-ash landfills if the NGS facility closes as scheduled by 2019, and only the closure of the facility after the proposed 2044 closure date is mentioned. However, SRP has produced generic closure and post-closure plans for the coal ash disposal site (Haley & Aldrich, 2016a and 2016b) to comply with the 2015 federal "CCR Rule" for closure and maintenance of coal ash landfills, as described in 80 FR 21301-21501 and 40 CFR §257. The CCR landfill closure plan primarily describes the possible construction of a cap on the coal ash landfill, and there is no discussion of remediation in the closure or post-closure plans.
- The closure and post-closure maintenance plans for the coal ash disposal site would apply if the NGS stops operating in 2019 or if operation is extended to 2044. The DEIS states that "*the duration of CCR groundwater monitoring is for thirty years post landfill closure*" (SRP, 2016b, page 1B-72), but there are no details regarding components of the groundwater monitoring network that will reportedly be operational by October of 2017.
- Section §257.81 of the 2015 CCR Rule requires production of a stormwater "Run-on and Run-off Control Plan" to "*prevent flow onto the active portion of the CCR unit during the peak discharge from a 24-hour, 25-year storm*" (USEPA, 2015, §257.81(a)(1)). However, the current design (Haley & Aldrich, 2016c) falls short of the run-on control requirements for coal ash landfills.
- SRP claims that "*the combination of existing and berms under construction limit as much run-on flow as is reasonable under site conditions*" (Haley & Aldrich, 2016c, page 1), but they do not state how or why less than full <u>prevention</u> of run-on flow is necessary or acceptable. Inspection of Figure 7 and Figure 14 appears to show numerous locations where stormwater run-on is likely to occur from the plateau forming the eastern side of the CCR landfill without intercepting any barrier or berm.
- Regarding non-CCR landfills, the DEIS states that at the end of the lease term in 2044, "*a comprehensive environmental site assessment would be conducted to determine if there are any sources of contamination, look for paths of contamination, identify environmental receptors, and develop remedial alternatives, if applicable*" (SRP, 2016b, page 1B-110). There appears to be no such 'plan' stated for the closure of NGS in 2019.

Figure 14: Designated Run-on/Run-off Drainage Areas at the NGS CCR Landfill
(Source: Modified from Figure 1, Haley & Aldrich, 2016c)



IV.6 How long might it take to remediate and/or be confident that environmental contamination of soils, surface water, and groundwater at NGS are at safe concentrations?

- It is impossible to answer these questions at the present time because (1) known contamination at NGS may not be fully defined, (2) some at-risk geologic materials (e.g., groundwater the N Aquifer) may become contaminated in the future due to the potentially slow migration of contaminants and/or complex migration pathways (e.g., fractured rock aquifers), (3) existing monitoring efforts appear lacking in several cases (e.g., at and near the coal ash landfill), and (4) there are varying degrees of 'acceptable' risk that could be considered 'safe', the nature of contamination exposure to various sensitive receptors (e.g., people drinking contaminated water versus animals consuming plants growing in contaminated soil), and the fact that regulatory or other standards for contaminant concentrations vary by the type of media (e.g., groundwater ingestion versus dermal contact), exposure time, and other risk factors.

IV.6 Is it possible to estimate the cost to close, remediate, and monitor environmental conditions for the NGS' ash-disposal and landfill sites?

- It is not possible to answer this question with any accuracy at the present time. A planning estimate based on other coal ash closure plans occurring in the United States would be roughly $100,000 per acre of coal ash landfill, which would translate to $40 Million for the 400 acres at NGS. Closure, remediation, and required monitoring of the other landfill sites and impoundments at NGS could total a few million dollars.

V. Opinions Regarding the DEIS Review

The opinions provided herein reflect a reasonable degree of scientific validity, recognizing that (i) professional and industrial practices can vary, (ii) Dr. Campbell has not physically observed the NGS facility, and (iii) his opinions are based on evaluating documents provided to him, publically-available information, and his education, training, and real-world experience. Dr. Campbell reserves the right to modify or amend any opinion described herein upon consideration of additional information and data that may become available. Dr. Campbell's resume is provided in Appendix I.

Appendix I: Resume for Steven K. Campbell, Ph.D, PG

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STEVEN K. CAMPBELL, Ph.D, PG

Senior Hydrogeologist

EXPERIENCE SUMMARY

Dr. Campbell joined Groundwater Management Associates, Inc. (GMA) in 1994 after working at the Florida Geological Survey and teaching field geology, physical geology, environmental geology, oceanography, and earth science at two universities and a community college. Dr. Campbell is GMA's Director of Environmental Services and he manages the firm's Greenville office. He is responsible for ensuring the timeliness and quality of GMA's environmental projects, providing hydrogeology support and project management for environmental and water-supply projects, and supervising hydrogeology staff members, staff and project geologists. His clients include government agencies, industry, municipalities, developers, and commercial interests.

Dr. Campbell is GMA's project manager for the first Aquifer Storage and Recovery (ASR) system permitted and constructed in North Carolina. He has provided expert witness services in support of environmental litigation involving petroleum, coal ash, and other contaminants in Maryland, North Carolina, and India. Between 2001 and 2008, Dr. Campbell was the lead hydrogeologist for coastal plain and piedmont sites administered by NCDENR's Federal Trust Fund (FTF) program. He managed the assessment and remediation of over 100 FTF sites with petroleum-contaminated soil and groundwater. He has assessed soil and water contaminated with chlorinated solvents and metals.

Dr. Campbell is an Adjunct Teaching Assistant Professor in the Department of Geological Sciences at East Carolina University, where he has taught field geology, physical geology, and advanced igneous petrology. Since 1999, he has taught field geology at the North Carolina Geology Field Course held each summer in New Mexico and Colorado. Dr. Campbell has taught at 23 geology field courses since 1982.

Dr. Campbell is a member of several professional organizations, including the Geological Society of America, the National Ground Water Association, the American Geophysical Union, the Colorado Scientific Society, and the New Mexico Geological Society (lifetime member).

PROFESSIONAL EMPLOYMENT

Senior Hydrogeologist – 1994 to present
Groundwater Management Associates, Inc.

Adjunct Teaching Assistant Professor – 2013 to present
East Carolina University, Department of Geological Sciences

Visiting Assistant Professor – 1999 to 2013
East Carolina University, Department of Geological Sciences

Geologist – 1991 to 1994
Florida Geological Survey, Florida DEP

Visiting Assistant Professor – 1990
East Carolina University, Department of Geological Sciences

Instructor – 1986 to 1993
Florida State University, Department of Geology

Adjunct Instructor – 1989 to 1994
Tallahassee Community College, Division of Mathematics and Science

EDUCATION

Ph.D Geology, 1994, Florida State University
MS Geology, 1985, East Carolina University
BS Geology, 1981, East Carolina University

LICENSES

North Carolina Licensed Professional Geologist # 1414
Virginia Certified Professional Geologist # 2801 001800
North Carolina Certified Well Contractor # 2815-A

TRAINING AND CERTIFICATIONS

OSHA HAZWOPER Certified (40 hours)
OSHA HAZWOPER Annual Refreshers (8 hours)
MSHA Part 48 Surface Miner Training (24 hours)