UNITED STATES DEPARTMENT OF THE INTERIOR
OFFICE OF SURFACE MINING RECLAMATION AND ENFORCEMENT

Kayenta Mine
SMCRA Permit AZ-0001E Renewal
Environmental Assessment
Navajo County, Arizona

September 2017

U.S. Department of the Interior
Office of Surface Mining Reclamation and Enforcement
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°C	Degrees Celsius
µg/l	Micrograms Per Liter
µg/m^3	Micrograms Per Cubic Meter
A&WHbt	Aquatic and Wildlife Habitat
ADEQ	Arizona Department of Environmental Quality
af	Acre Feet
af/yr	Acre Feet Per Year
AGFD	Arizona Game and Fish Department
AgL	Agricultural Livestock Watering
amsl	Above Mean Sea Level
ANFO	Ammonium Nitrate/Fuel Oil
AQS	Air Quality System
AUM	Animal Unit Month
AVF	Alluvial Valley Floor
BA	Biological Assessment
BE	Biological Evaluation
BEA	United States Bureau of Economic Analysis
bgs	Below Ground Surface
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BMAP	Black Mesa Archaeological Project
BOR	Bureau of Reclamation
BTU	British Thermal Unit
C-Aquifer	Coconino Aquifer
CAA	Clean Air Act of 1970
CCR	Coal Combustion Residual
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulation
cfs	Cubic Feet Per Second
CHIA	Cumulative Hydrologic Impact Assessment
CIA	Cumulative Impact Area
CIAA	Cumulative Impacts Analysis Area
CO	Carbon Monoxide
CO_2e	Carbon Dioxide Equivalent
COPC	Chemicals of Potential Concern
CRA	Coal Resource Area
CWA	Clean Water Act of 1972
D-Aquifer	Dakota Aquifer
dB	Decibel
dBA	A-Weighted Decibels
DPM	Diesel Particulate Matter
EA	Environmental Assessment
EIS	Environmental Impact Statement
EMI	Ecosystem Management Inc.
EPA	United States Environmental Protection Agency

EPRI	Electric Power Research Institute
ERA	Ecological Risk Assessment
ESA	Endangered Species Act of 1973
ESCO	ESCO Associates
ESP	Electrostatic Precipitators
FDM	Fugitive Dust Model
FE	Federal Endangered
FEIS	Final Environmental Impact Statement
FONSI	Finding of No Significant Impact
fps	Feet Per Second
FT	Federal Threatened
FTA	Federal Transit Authority
GHG	Greenhouse Gas
GHGRP	Greenhouse Gas Reporting Program
GIS	Geographic Information System
gpd/ft	Gallons Per Day Per Foot
gpm	Gallons Per Minute
GWP	Global Warming Potential
HAP	Hazardous Air Pollutants
HHRA	Human Health Risk Assessment
HI	Hazard Index
HTWQS	Hopi Tribe Water Quality Standards
HQ	Hazard Quotient
IMPROVE	Interagency Monitoring of Protected Visual Environments
IPCC	Intergovernmental Panel on Climate Change
ISC	Industrial Source Complex
IWG	Interagency Working Group
km	Kilometer
kg	Kilograms
LOM	Life-of-Mine
lux	Lumens/mz
LW	Livestock Watering
MATS	Mercury and Air Toxics Standards
MBTA	Migratory Bird Treaty Act
MEI	Maximum Exposed Individual
mg/kg	Milligrams Per Kilogram
mg/L	Micrograms Per Liter
MMA	Minor, Michael & Associates
MMPA	Mining and Minerals Policy Act of 1970
mmt	Million Metric Tons
mph	Miles Per Hour
MSHA	Mine Safety and Health Administration
mt	Million Tons
mtpy	Million Tons Per Year
N-Aquifer	Navajo Aquifer
NAAQS	National Ambient Air Quality Standards

NAGPRA	Native American Graves Protection and Repatriation Act
NCNS	No Current Numeric Standard
NEI	National Emissions Inventory
NEPA	National Environmental Policy Act of 1969
NESHAP	National Emission Standards for Hazardous Air Pollutants
NGS	Navajo Generating Station
NGS-KMC	Navajo Generating Station – Kayenta Mine Complex
NHPA	National Historic Preservation Act of 1966
NNDFW	Navajo Nation Department of Fish and Wildlife
NNEPA	Navajo Nation Environmental Protection Agency
NNHP	Navajo Natural Heritage Program
NNS	No Numeric Standard
NNSWQS	Navajo Nation Surface Water Quality Standards
NO_2	Nitrogen Dioxide
NOx	Nitrogen Oxide
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NTUA	Navajo Tribal Utility Authority
O_3	Ozone
OB	Overburden
OSMRE	Office of Surface Mining Reclamation and Enforcement, Western Region
PAC	Protected Activity Center
PAH	Polyaromatic Hydrocarbons
PAP	Permit Application Package
Pb	Lead
PM	Particulate Matter
$PM_{2.5}$	Particulate Matter with an Aerodynamic Diameter of 2.5 Microns or Less
PM_{10}	Particulate Matter with an Aerodynamic Diameter of 10 Microns or Less
ppb	Parts Per Billion
ppm	Parts Per Million
PSD	Prevention Significant Deterioration
PWCC	Peabody Western Coal Company
RCRA	Resource Conservation and Recovery Act of 1976
Renewal	The Renewal of Surface Mining Control and Reclamation Act Permit AZ-000IE
SCC	Social Cost of Carbon
SIP	State Implementation Plan
SIR	Sampling Investigation Report
SMCRA	Surface Mining Control and Reclamation Act of 1977
SO_2	Sulfur Dioxide
SRP	Salt River Project
s.u.	Standard Unit
TCP	Traditional Cultural Property
TDS	Total Dissolved Solids
tpy	Tons Per Year

TRC	TRC Environmental Consultants
TSCA	Toxic Substances Control Act
TSP	Total Suspended Particles
TSS	Total Suspended Solids
UCL	Upper Confidence Limit
U.S.	United States
USC	United States Code
USGS	United States Geological Survey
USFWS	United States Fish and Wildlife Service
VMT	Vehicle Miles Traveled
VOC	Volatile Organic Compound
VRM	Visual Resource Management
WDEQ	Wyoming Department of Environmental Quality
WQS	Water Quality Standards

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1.0 PURPOSE AND NEED

1.1 INTRODUCTION

The Office of Surface Mining Reclamation and Enforcement, Western Region (OSMRE) has received an application from Peabody Western Coal Company (PWCC) for the renewal of Surface Mining Control and Reclamation Act (SMCRA) Permit AZ-0001E (the Renewal) for the Kayenta Mine located in Navajo County, Arizona (**Figure 1.1-1**). The Renewal application does not request or contain any changes to the permit or the Kayenta Mine Permit Application Package (PAP) (PWCC 2012). The Renewal application addresses mining and reclamation operations during the period of July 6, 2015 through July 5, 2020. This environmental assessment (EA) was prepared by OSMRE in compliance with the National Environmental Policy Act (NEPA) to analyze and disclose the effects of renewing the permit that authorizes mining operations for the Kayenta Mine during the Renewal period. The Council on Environmental Quality (CEQ) gives OSMRE discretion under 40 Code of Federal Regulations (CFR) 1501.3(b) to prepare an EA on any action to assist the agency in planning and decision making. OSMRE determined PWCC's application for renewal of the Kayenta Mine permit warranted preparation of an EA, and that the EA must include an assessment of the indirect environmental effects of the use (i.e., combustion) of the Kayenta Mine coal.

NEPA requires federal agencies to disclose to the public the potential environmental impacts of projects they authorize. NEPA also requires agencies to consider and analyze reasonable alternatives to projects that are proposed. Lastly, NEPA requires agencies to make a determination as to whether the analyzed actions would "significantly" impact the environment. "Significantly" is defined by NEPA and is found in 40 CFR 1508.27. If OSMRE determines that this Renewal would have significant effects following the analysis in the EA, then an Environmental Impact Statement (EIS) would be prepared for the Renewal. If the potential effects are determined not to be significant, a Finding of No Significant Impact (FONSI) statement would document the reason(s) why implementation of the selected alternative would not result in significant environmental effects. An EA provides evidence for determining whether to prepare an EIS or a FONSI statement.

This EA has been prepared in accordance with NEPA and the CEQ regulations for implementing NEPA (40 CFR 1500-1508); SMCRA of 1977 (as amended); OSMRE guidance on implementing NEPA, including the OSMRE *Handbook on Procedures for Implementing the National Environmental Policy Act* (OSMRE 1989); and other applicable regulations and federal guidance. Information gathered from federal, state, and local agencies, the Navajo Nation, Hopi Tribe, PWCC, Salt River Project (SRP), and publicly available literature, as well as in-house OSMRE sources such as PWCC's PAP, were used in the preparation of this EA.

1.2 BACKGROUND INFORMATION

The Kayenta Mine is located within 64,858 acres of land leased within the boundaries of the Navajo Nation and Hopi Indian Reservations in northern Arizona, near the town of Kayenta in Navajo County (about 125 miles northeast of Flagstaff, Arizona) (the Lease Area). PWCC holds leases

with the Navajo Nation and Hopi Tribe to mine up to 670 million tons (mt) of coal. Within that Lease Area, PWCC has an OSMRE approved SMCRA Permit Area of 44,073 acres for the Kayenta Mine (**Figure 1.1-2**). The Lease Area and Permit Area are located within the boundaries of the Navajo Nation and Hopi Indian Reservations, which the federal government holds in trust for the tribes. The surface and mineral interests on approximately 24,858 acres of the Lease Area are held exclusively by the Navajo Nation (Navajo Exclusive Lease Area, Lease 14-20-0603-8580), and approximately 40,000 acres of leased land are located in the Hopi and Navajo Joint Minerals Ownership Lease Area (Joint Lease Area, Leases 14-20-0603-9910 and 14-20-0450-5743). PWCC and its predecessor, Peabody Coal Company, have been conducting mining and reclamation activities within the Permit Area for the Kayenta Mine since 1973.

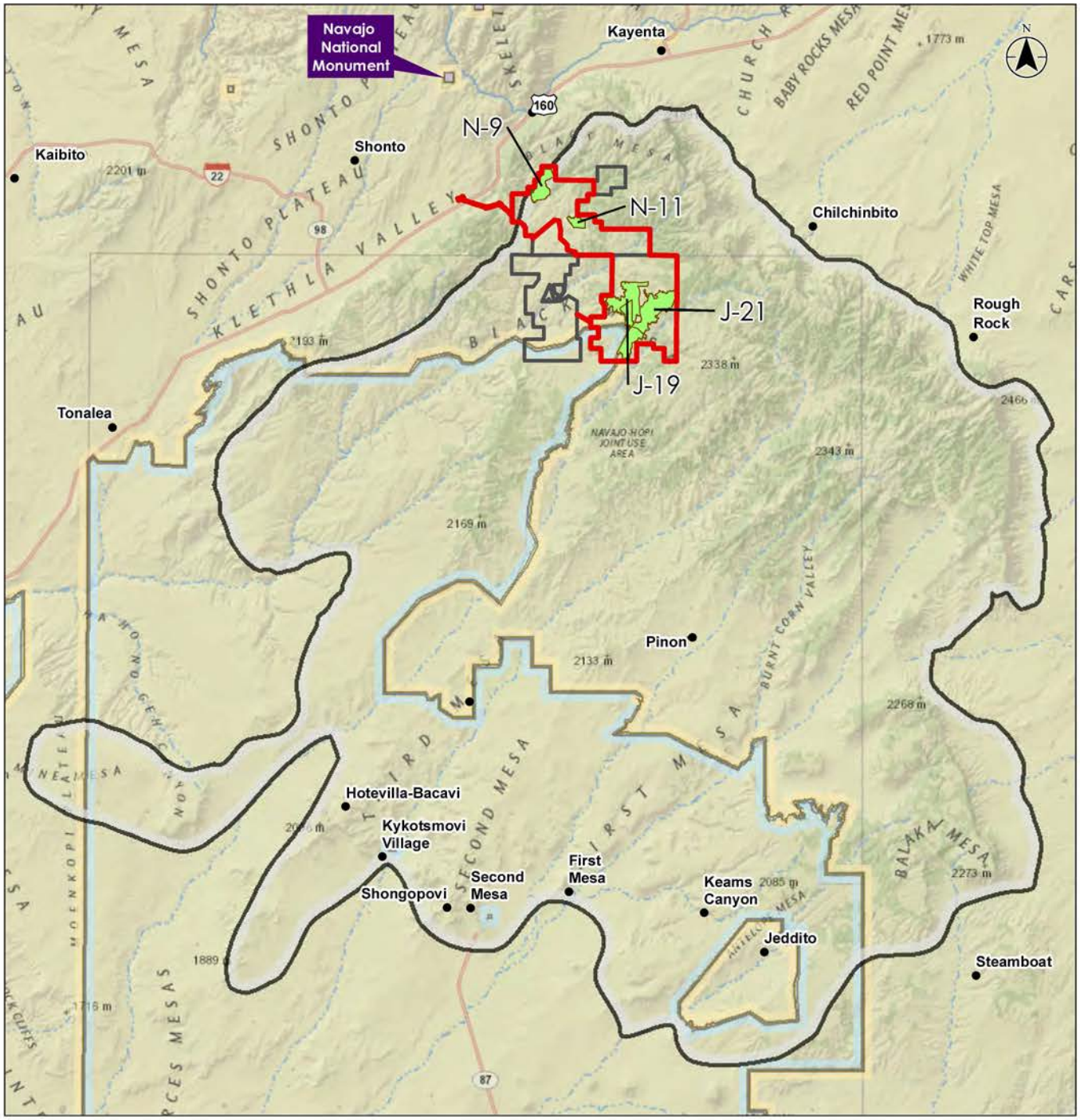
The mine operation produces about 8 mt of coal per year using typical surface mining techniques. The coal is delivered by electric railroad 78 miles northwest to the Navajo Generating Station (NGS), near Page in northern Coconino County, Arizona.

In 1990, OSMRE completed a Final Environmental Impact Statement (FEIS) (OSMRE 1990) and subsequently approved a life-of-mine (LOM) mining plan for the Kayenta Mine, and granted Permit AZ-0001C under the Permanent Indian Lands Program. Federal authority to mine the leased reserves according to a mining and reclamation plan approved by OSMRE is only granted for specific coal resource areas (CRAs) at five-year permit intervals. OSMRE has renewed Permit AZ-0001C every five years and converted the permit number to AZ-0001D in 1995 and to permit number AZ-0001E in 2012. In August 2011, OSMRE completed the Kayenta Mine Permit (AZ-0001D) Renewal EA, which evaluated ongoing mining in CRAs N-9, J-19, and J-21 and reclamation activities in CRA N-11. On January 6, 2012, OSMRE issued a FONSI determination and approved that permit renewal to authorize mining under Permit AZ-0001E during the period July 6, 2010 through July 5, 2015.

On February 26, 2015, PWCC filed a timely application with OSMRE to renew Federal Permit AZ-0001E for the renewal period July 6, 2015 to July 5, 2020. On April 2, 2015, OSMRE notified PWCC that the agency had determined the application to be administratively complete and was ready for public notice. PWCC published public notices in local newspapers announcing the availability of the permit renewal for public review and comment.

In accordance with federal regulations at 30 CFR 774.15(a), a valid permit issued pursuant to an approved regulatory program shall carry with it the right to successive renewal within the approved boundaries of an existing mining permit. Further, 30 CFR 774.15(c)(1) requires OSMRE to approve a complete and accurate application for a permit renewal unless it finds in writing that at least one of six enumerated criteria is met (**Section 1.5**).

On June 29, 2015, OSMRE issued an Administrative Delay in Decision determination until a thorough review is completed to ensure compliance with NEPA and other applicable laws. Under permit AZ-0001E, in accordance with the Administrative Delay, and consistent with the statutory right to renewal, PWCC has the right to continue mining under the prior existing permit in approved CRAs N-9, J-19, and J-21, as well as to perform reclamation activities in areas previously mined (i.e., CRA N-11 and other CRAs), pending a decision by OSMRE on the Renewal application.



Notes

1. Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 Feet
2. Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

Legend

- PWCC Lease Area
- Kayenta Mine Permit Area
- Coal Resource Area
- Black Mesa Coal Field

Land Status

- Navajo National Monument (National Park Service)
- Hopi Indian Res.
- Navajo Indian Res.

0 5 10 miles

1:700,000 (at original document size of 8.5x11)

Stantec

Project Location	203706045
T35N R18E, T36N R17E, T36N R19E	Prepared by CLG on 2016-10-11
Navajo County, AZ	Technical Review by SL on 2016-10-11
	Independent Review by DK on 2016-10-11

Client/Project
PWCC
Kayenta Mine SMCRA Permit
Environmental Assessment

Figure No.
1.1-1

Title
Vicinity Map

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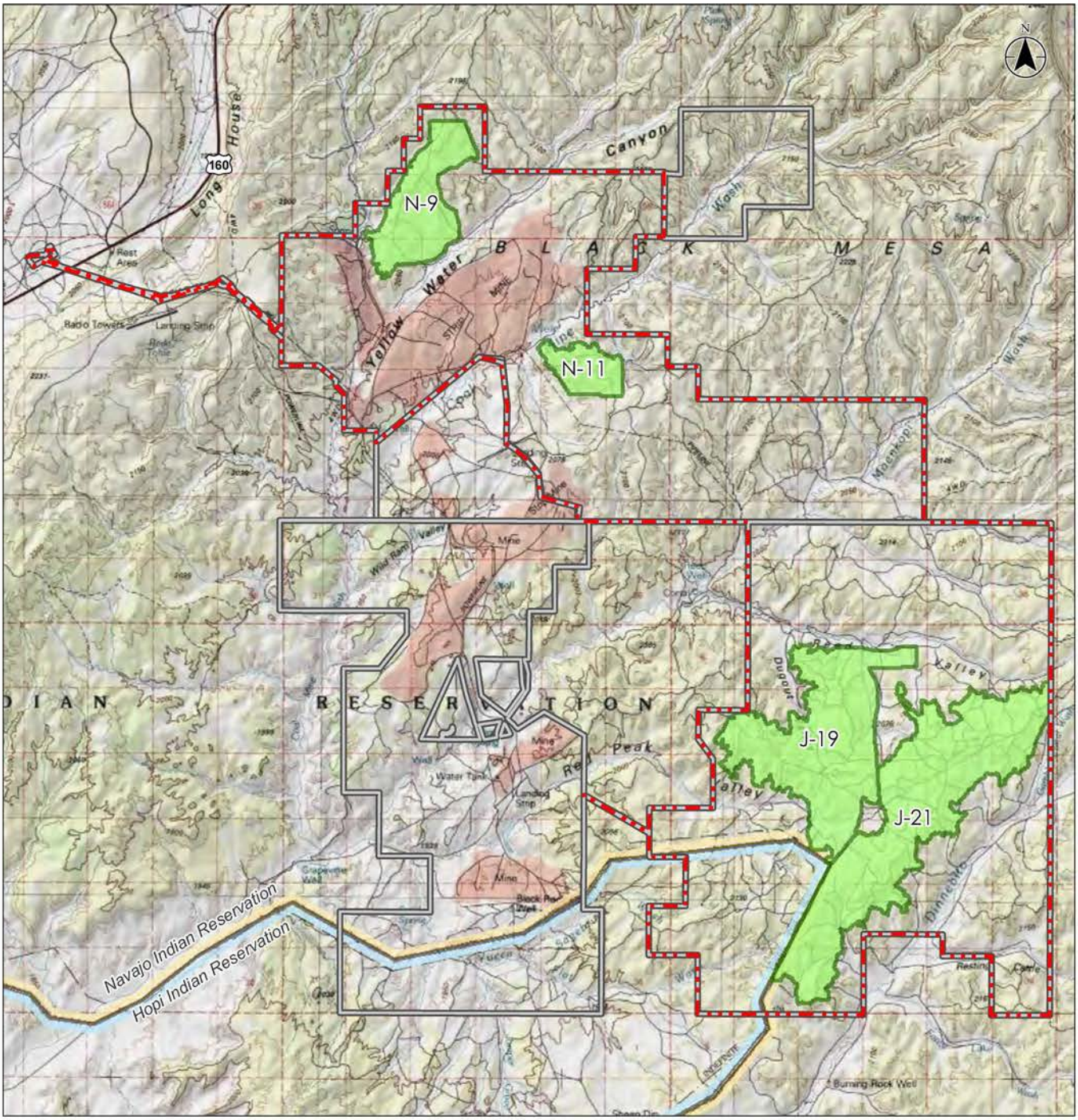
V:\2037\Active\203706045\03_data\gis_cad\gis\mxds\EA\Figure 1.1.1 Vicinity Map.mxd Revised: 2016-10-11 By: cgallegos



Legend

- Coal Resource Area
- Kayenta Mine Permit Area
- PWCC Lease Area
- Hopi Indian Res.
- Navajo Indian Res.

0 1 2 miles

1:150,000 (at original document size of 8.5x11)

Stantec

Project Location 203706045

T35N R18E, T35N R19E, T36N R17E, T36N R18E, T36N R19E, T37N R18E
Navajo County, AZ

Prepared by CLG on 2016-12-23
Technical Review by NL on 2016-12-23
Independent Review by DK on 2016-12-23

Client/Project
PWCC
Kayenta Mine SMCRA Permit
Environmental Assessment

Figure No.
1.1-2

Title
Lease Area Map

Notes

1. Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 Feet
2. Service Layer Credits: Copyright:© 2013 National Geographic Society, i-cubed

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Under the authorization of the OSMRE Administrative Delay in Decision determination, mining and reclamation operations have continued from July 6, 2015 to the present. From July 6, 2015 to August 2016, approximately 232 acres have been disturbed (active mining), 857 acres are in active reclamation (either graded and/or topsoiled and reseeded), and 6.9 mt of coal have been mined. Approximately 610 additional acres would be disturbed (604 acres active mining plus 6 acres topsoil collection), 3,493 acres would be in active reclamation (grading and/or topsoiling/reseeding), and 27 mt of coal would be produced during the remainder of the Renewal period. If approved, the renewed permit would be Permit AZ-0001F.

Approval of the Renewal would authorize the continuation of ongoing mining operations in CRAs N-9, J-19, and J-21 and reclamation activities in CRA N-11 and previously mined areas (herein referred to as the Affected CRAs) within the Permit Area from July 6, 2015, through July 5, 2020. Active mining would cease on or before December 22, 2019, and reclamation activities would commence for the remainder of the five-year Renewal period. Approximately 842 acres would be disturbed in these CRAs during this five-year period. The proposed Renewal does not include any revisions to the mining and operations plan or the addition of any new mining areas. For the proposed Renewal period, coal-mining operations would be assumed to continue at the recent historical pace of approximately 8 million tons per year (mtpy) and existing facilities would be used for ongoing operations. A number of existing facilities such as temporary and approved permanent sediment- and water-control facilities, topsoil stockpiles, and some of the water wells are located throughout the Permit Area and are used for ongoing mining operations. The existing mine facilities are described in more detail in **Section 2.2**. The only new mine facilities that are proposed to be constructed as part of the mining in CRAs N-9, J-19, and J-21 and reclamation in CRA N-11 under the Renewal would be sediment ponds, roads, utilities, and topsoil stockpiles, as new but previously approved portions of these CRAs are mined or reclaimed.

Most of the facilities necessary for the mining operations are located within the Permit Area but some are located outside the boundaries of the Permit Area. These facilities include administrative offices and infrastructure, maintenance shops, warehouses, bath houses, empty silos and cap magazines, coal-processing facilities, equipment storage areas, water diversions and culverts, sheds, utilities, fuel-storage and tank farms, environmental monitoring sites, wells, and surface conveyor systems. The mine facilities outside the Permit Area have been separately authorized by OSMRE as part of the Initial Regulatory Program and are authorized for use in mining operations in accordance with SMCRA. This EA includes effects from the use of all mine facilities, within and outside the Permit Area, to the extent such facilities are necessary to the mining operations that would be authorized by the Renewal (**Section 2.3**).

A completely independent – but concurrent – NEPA process has been underway for the project area referred to as the Navajo Generating Station – Kayenta Mine Complex (NGS-KMC). That EIS will describe the potential environmental impacts from the proposed continued operations of the NGS-KMC for an additional 25 years, from December 23, 2019, through December 22, 2044. The project area for the EIS proposed action encompasses a large area of northern Arizona, with other portions falling within southern Nevada, southwestern Utah, and central Arizona (Bureau of Reclamation [BOR] 2016). The decisions associated with the NGS-KMC EIS would have no bearing on the decision for the Renewal that is the subject of this EA. However, the NGS-KMC EIS process is currently suspended pending a decision on closure and initiation of

retirement of the NGS in December 2019 (https://ngskmc-eis.net/). Therefore, the NGS-KMC project will not be discussed further in this EA.

1.3 PURPOSE AND NEED FOR THE PROPOSED ACTION

As described at §1502.13 (40 CFR 1500-1508), the purpose and need statement shall briefly specify the underlying purpose and need to which the agency is responding in proposing the alternatives including the proposed action.

The purpose of the action is for OSMRE to respond to the Renewal application for Permit AZ-0001E submitted to OSMRE in February 2015. OSMRE is the SMCRA regulatory authority for mining operations on Indian lands in Arizona. Pursuant to the Indian Lands Program (30 CFR VII, Subchapter E), OSMRE must decide whether to approve or disapprove renewal of the subject permit application (AZ-0001E) based only on the criteria listed at 30 CFR 774.15(c)(1) (**Section 1.5**). Federal authority to mine these reserves can only be granted in up to five-year increments, although the permit holder has a statutory right to successive renewals as long as certain regulatory criteria are met.

The need for the action is to provide PWCC the opportunity to exercise its right to successive permit renewals in accordance with 30 CFR 774.15 (a) so that it may continue extracting coal in accordance with its long-term mining plan and provide coal to its primary customer, the NGS. PWCC has applied for the renewal of permit AZ-0001E in order to continue ongoing mining operations in CRAs N-9, J-19, and J-21 through December 22, 2019; and reclamation in CRA N-11 and other reclamation activities on previously mined areas within the Permit Area through July 5, 2020.

1.4 RELATIONSHIP TO STATUTES AND REGULATIONS

The following key laws, as amended, establish the primary authorities, responsibilities, and requirements for developing Indian coal resources:

National Historic Preservation Act of 1966 (NHPA)

National Environmental Policy Act of 1969 (NEPA)

Mining and Minerals Policy Act of 1970 (MMPA)

Clean Air Act of 1970 (CAA)

Clean Water Act of 1972 (CWA)

Endangered Species Act of 1973 (ESA)

Surface Mining Control and Reclamation Act of 1977 (SMCRA)

Resource Conservation and Recovery Act (RCRA) of 1976

Toxic Substances Control Act (TSCA)

Mine Safety and Health Act (MSHA)

The MMPA declares that it is the continuing policy of the federal government to foster and encourage the orderly and economic development of domestic mineral resources. SMCRA provides the legal framework for the federal government to regulate coal mining by balancing the need for continued domestic coal production with protection of the environment and ensuring the mined land is returned to beneficial use when mining is finished. OSMRE was created in 1977 under SMCRA to carry out and oversee those federal responsibilities. OSMRE implements its SMCRA responsibilities under regulations at CFR Title 30 – Mineral Resources, Chapter VII - Office of Surface Mining Reclamation and Enforcement, Department of the Interior, Subchapters A-T, Parts 700-955.

1.5 AUTHORIZING ACTIONS

In accordance with SMCRA, federal regulations at 30 CFR 774.15 (a) grant a right of successive renewal within the approved boundaries of an existing mining permit. Surface coal mining and reclamation activities are authorized by OSMRE in up to five-year incremental periods to provide an opportunity for OSMRE to review the mine's compliance with applicable terms and conditions of permits. Based on 30 CFR 774.15(c)(1), OSMRE must approve a complete and accurate application for a permit renewal unless it finds, in writing, that at least one of the following criteria exists:

1. The terms and conditions of the existing permit are not being satisfactorily met;
2. The present surface coal mining and reclamation operations are not in compliance with the environmental protection standards of the Act and the regulatory program;
3. The requested renewal substantially jeopardizes the operator's continuing ability to comply with the Act and the regulatory program on existing permit areas;
4. The operator has not provided evidence of having liability insurance or self-insurance as required in 30 CFR 800.60;
5. The operator has not provided evidence that any performance bond required to be in effect for the operation will continue in full force and effect for the proposed period of renewal, as well as any additional bond the regulatory authority might require pursuant to subchapter J of [Title 30, Volume 3, Chapter VII of the Code of Federal Regulations]; or,
6. Additional revised or updated information required by the regulatory authority has not been provided by the applicant.

On April 2, 2015, OSMRE determined that PWCC had submitted a complete and accurate application for permit renewal. Consequently, OSMRE's authority to deny the Renewal request is limited to the criteria listed above. If review by OSMRE indicates that none of the six criteria have been met for denial, OSMRE would not have the authority to deny the Renewal.

In deciding whether to renew or deny renewal of the Kayenta Mine permit, OSMRE's authority to consider environmental factors is constrained by SMCRA and its implementing regulations. Criteria 2 above requires the surface coal mining and reclamation operations to be in compliance with SMCRA's environmental protection standards; however, the standards exclusively concern the surface coal mining operation and govern the conduct of the mining operation itself. Unless OSMRE finds that the mining operator is in violation of the standards, or another one of the statutory criteria is present, OSMRE must renew the permit. OSMRE only has regulatory authority over coal mining and reclamation operations and has no legal authority to prevent the

effects of the operations at the NGS. Nonetheless, OSMRE has determined that the scope of this EA should also include an analysis of the indirect effects of the use (i.e., combustion) of the Kayenta Mine coal at the NGS. Inclusion of these indirect coal combustion effects in the scope of this EA is based on recent court decisions (e.g., *WildEarth Guardians v. U.S. Office of Surface Mining et al.*, Case 1:13-cv-00518-RBJ (D. Colo. 2015)) that have directed OSMRE to include analysis of those indirect effects in other EAs pertaining to permit revision applications.

NEPA does not require an agency to engage in speculation. Moreover, where an agency has no statutory authority to prevent or reduce certain environmental effects, such effects are not a direct effect or an indirect effect of the proposed action for purposes of NEPA because the proposed action is not the legal cause of the effect (*Dept. of Transp. v Public Citizen* (2004) 541 US 752, 770). Neither SMCRA nor its implementing regulations permit OSMRE to consider the effects of or the use of coal on the environment, or impose measures to remedy those effects, in deciding whether to renew or deny renewal of the Kayenta Mine permit. OSMRE's action is not the legal cause of those effects.

1.6 OUTREACH AND ISSUES

Pursuant to CFR, Title 30, Chapter VII, Subchapter E, Part 750 and Subchapter G, Parts 773 and 774, PWCC published a public notice (**Appendix A**) in the Navajo Times and the Navajo Hopi

773.6(a)(1), the notices were published once a week for four consecutive weeks beginning on April 8, 2015 and ending on April 30, 2015. The public comment period continued for an

on the application and two requests for an informal conference.

Issues raised in the public comments included the following:

- Confusion as to the difference between the Renewal that is the subject of this EA and the NGS-KMC EIS (currently suspended) (**Section 1.2**);
- General concern over the mine operation;
- Concerns over the completeness and timeliness of the application;
- Concern that bond calculations were insufficient in the application; and
- Concern regarding PWCCs timeliness of reclamation and that it is creating erosion.

Additional information about the public involvement for the Renewal is provided in **Section 6.1.1**.

1.7 ORGANIZATION OF THIS EA

This EA is organized into the following chapters:

Chapter 1 – Purpose and Need: this chapter provides an overview of and background information for the Renewal; the purpose of and need for the Renewal; the roles, responsibilities, and authorizing actions of OSMRE; and a summary of OSMRE's outreach to date on the Renewal and concerns voiced by the public as part of that outreach.

Chapter 2 – Proposed Action and Alternatives: this chapter presents a detailed description of the action proposed by PWCC (Renewal of Permit AZ-0001E) and the No Action alternative (disapproval of the renewal of Permit AZ-0001E). Alternatives that were considered but dismissed from further analysis are summarized, as well as the reasons why they were not considered further.

Chapter 3 – Affected Environment: this chapter identifies the affected environment and describes the existing resources and uses that could be affected by the action and alternatives analyzed in the EA.

Chapter 4 – Environmental Consequences: This chapter describes possible environmental consequences of the Renewal. Direct and indirect impacts of the Renewal and No Action are assessed and described in order to allow for comparative impact evaluation. Impacts are compared to the socioeconomic and natural environment that would be expected to exist if no action were taken (Disapproval of Permit AZ-0001E).

Chapter 5 – Cumulative Effects: This chapter describes the possible environmental consequences of the Renewal or No Action (as appropriate) when added to all past, present, and reasonably foreseeable actions in the Cumulative Impacts Analysis Area (CIAA) for each environmental resource evaluated in the EA.

Chapter 6 – Coordination and Consultation: This chapter presents the agencies and persons contacted as part of the development of the EA, including the public, tribes, and the United States (U.S.) Fish and Wildlife Service (USFWS) pursuant to the ESA Section 7 process. It lists the individuals involved in the preparation of this EA.

Chapter 7 – References: this chapter provides a list of all documents, data, or communications cited in the EA.

2.0 PROPOSED ACTION AND ALTERNATIVES

2.1 INTRODUCTION

This chapter describes the alternatives evaluated in this EA. Factors considered in evaluating whether alternatives were technically feasible or economically practical, and whether these would meet the purpose and need for the Renewal, include legal requirements, environmental issues and concerns, design, and/or engineering feasibility. The two alternatives addressed in this EA are as follows:

Alternative 1: Proposed Action – Approve Renewal of Permit AZ-0001E

OSMRE would approve the renewal of permit AZ-0001E for continued mining in CRAs N-9, J-19, and J-21 and reclamation activities in accordance with the current approved mining and reclamation plans (**Appendix B**), as well as the continued use of current and proposed facilities necessary for mining and reclamation operations[1] for not more than five years (July 6, 2015 to July 5, 2020).

Alternative 2: No Action – Disapprove Renewal of Permit AZ-0001E

OSMRE would not renew permit AZ-0001E; however, required reclamation operations would continue, including initiation of final reclamation and mine closure.

This chapter also provides background information on PWCC's existing operations at the Kayenta Mine. The description of Alternative 1 is based on the currently approved PAP; readers desiring greater detail can review the additional descriptions, maps, and drawings contained in the PAP.

Section 4.1.1 provides a summary comparison of the direct and indirect environmental effects of the alternatives.

Other alternatives that would not achieve the purpose of and need for the project, would not be technically feasible for mining operations, or would not be economically feasible or practical were eliminated from detailed study. These are described in **Section 2.5**.

In accordance with OSMRE's Administrative Delay issued on June 29, 2015, PWCC is permitted to continue mining in approved CRAs N-9, J-19, and J-21, as well as to perform reclamation activities in areas previously mined, including CRA N-11, pending a thorough review to ensure compliance with NEPA and a decision by OSMRE on the Renewal application. The analysis in this EA assumes OSMRE will issue a decision on the Renewal Application on or about August 31, 2017 after completion of the NEPA process. As a result of the Administrative Delay in Decision determination, both Alternatives 1 and 2 consist of impacts to resources that have already and will have occurred between July 6, 2015, and August 31, 2017. For Alternative 1 (**Section 2.3**),

[1] The only new mine facilities that are proposed to be constructed as part of the mining and reclamation under the Renewal would be previously approved sediment ponds, roads, utilities, and topsoil stockpiles. Reclamation and collection of topsoil from 6 acres would also occur on CRA N-11.

there would be additional impacts from August 31, 2017, through July 5, 2020. Between July 6, 2015 and August 31, 2017, approximately 56 percent of the acres proposed to be disturbed under Alternative 1 during the Renewal period will have been disturbed. Similarly, for reclamation activities up to August 30, 2017, approximately 54 percent of the lands proposed to be graded and 60 percent of the lands proposed to be seeded (**Table 2.3-1**) will have been completed. Lastly, approximately 53 percent of the coal proposed to be mined during the entire Renewal period (**Section 2.3**) will be extracted by the projected date of OSMRE's decision on the Renewal.

2.2 EXISTING OPERATIONS

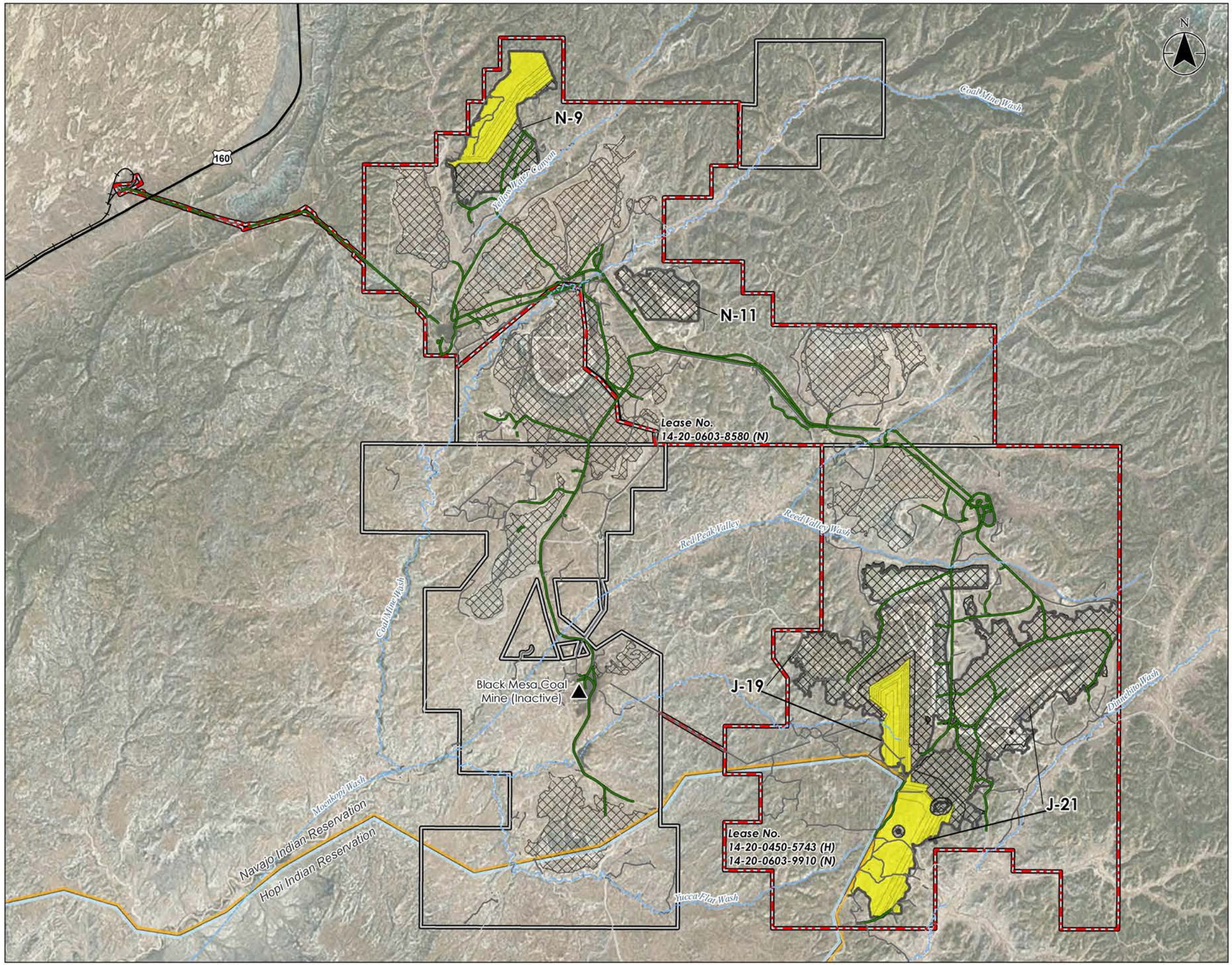
PWCC and its predecessor, Peabody Coal Company, have been conducting coal mining and reclamation activities at the Kayenta Mine since 1973. PWCC holds leases with the Navajo Nation and Hopi Tribe to mine up to 670 mt of coal. Most of the coal is sold to the NGS but a small amount is made available for use by tribal members. Historically, PWCC has produced about 8.1 mtpy of coal, but during the past few years production has decreased to an average of 7.5 mtpy due to reduced coal consumption at the NGS.

Coal is mined at the Kayenta Mine by conventional multi-seam surface mining methods. Active mining is currently occurring within CRAs N-9, J-19, and J-21 (**Figure 2.2-1**). Prior to any mining related disturbances, topsoil is removed from planned disturbance areas and redistributed or stockpiled as necessary to satisfy the needs of the OSMRE-approved reclamation plan and timetable. Topsoil is moved directly to areas undergoing reclamation or is stored in stockpiles for future use in reclamation.

Blasting is usually necessary to fragment and loosen the overburden (non-coal) materials covering the coal prior to removal. Closely spaced holes are drilled using rock or coal drills, loaded with ammonium nitrate/fuel oil (ANFO), and then detonated. Draglines remove the fragmented overburden using a method in which an elongated pit, or furrow, is excavated down to the shallowest coal seam. The overburden that is removed is placed in the mined-out pit alongside the current pit. The coal also is fragmented using explosives, or is ripped with bulldozers depending on seam thickness. Front-end loaders then remove the coal and load it into haul trucks, which take it to the coal preparation facilities. The material that is found between the coal seams is excavated by draglines, bulldozers, backhoes, loaders, trucks, and other similar equipment, and placed within the previous pit areas. If necessary, blasting is again used to fragment and loosen the non-coal material between the coal seams before removal by heavy equipment. When all the coal is mined from a pit, the overburden from the next pit is placed in the parallel mined-out pit, a process that is repeated until all the coal is mined from a CRA. Additional details related to Kayenta Mine mining practices are provided in **Appendix B**.

Once the coal arrives by haul truck at the preparation facilities, it is dumped into hoppers where it is stockpiled, crushed, screened, and blended. The coal is then transported by conveyor up to 16 miles to the northwest and placed in storage silos on the Black Mesa and Lake Powell Railroad[2].

[2] A private railroad not operated by PWCC or under the authority of OSMRE.



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Legend

- Black Mesa Coal Mine
- Intermittent Stream/Drainage
- Railroad
- Navajo-Hopi Partition Line
- Kayenta Mine Permit Area
- PWCC Lease Area

Mine Activities

- Proposed Mining & Associated Disturbance 2015-2019
- Mined Out - Reclamation Complete or Ongoing

PWCC Mine Road

- Primary
- Ancillary
- PWCC Mine Road

0 1 2 miles

1:100,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 Feet
2. Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Project Location
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Prepared by CLG on 2017-02-24
Technical Review by SL on 2017-02-24
Independent Review DK on 2017-02-24

Client/Project
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Kayenta Mine SMCRA Permit
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Figure No.
2.2-1

Title

Lease and Permit Area Map

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The coal is then loaded onto unit trains powered by electricity and transported approximately 78 miles to the NGS where the coal is combusted to produce electricity.

As soon as possible after mining starts and sufficient room is available for backfilling, reclamation begins. In general, rough backfilling is completed by backhoes, loaders, trucks, bulldozers, scrapers, and/or draglines. Final grading is performed to recreate a post-mining topographic expression that is similar to the pre-mining topography using bulldozers or scrapers. At the completion of the final grading, topsoil is redistributed over the regraded overburden, reseeded, and revegetated in accordance with PWCC's approved reclamation plan (**Appendix B**). As of December 31, 2015, approximately 19,330 acres have been disturbed at the mine; of that, approximately 14,546 acres have been reclaimed to some degree per the approved reclamation plan (PAP). Approximately 10,397 acres of that disturbance, and 7,225 acres of reclamation to some degree, have occurred in the Affected CRAs (**Figure 2.2-1**, **Table 2.2-1**).

Table 2.2-1 CRAs and Current Mining Status as of December 31, 2015

CRA	Total Acres Disturbed	Total Acres Graded	Total Acres Topsoiled and Seeded (after grading)
N-9	1,331	270	60
N-11	877	786	393
J-19	3,927	2,493	1,727
J-21	4,262	3,676	3,353
Total	**10,397**	**7,225**	**5,533**

2.3 ALTERNATIVE 1: PROPOSED ACTION - APPROVE RENEWAL OF PERMIT AZ-0001E

Under this alternative, the OSMRE Western Region would approve the renewal of permit AZ-0001E, which would authorize continued mining and/or reclamation in CRAs N-9, N-11, J-19, J-21, and reclamation in previously mined areas as currently approved in the PAP. The Renewal period would be from July 6, 2015 through July 5, 2020.

2.3.1 Proposed Operations

While the mine production rate has recently decreased and would likely vary over time due to changes in NGS coal demand, under this alternative and for the purposes of this analysis, the mine would produce coal at the historical average production rate of 8.1 mtpy. Approximately 317 employees would continue to be employed at the mine for mining and reclamation activities. The areas proposed for new mining within the Affected CRAs (**Figure 2.2-1**) would be mined during the Renewal period. Approximately 842 acres would be disturbed by mining operations in the Affected CRAs (**Table 2.3-1**). Annual groundwater use for mining and reclamation purposes from the Navajo aquifer (N-Aquifer) would average an estimated 1,236 acre-feet per year (af/yr) during the Renewal period.

Existing facilities that would be used for mining operations under Alternative 1 are summarized in the following sections, while **Appendix B** provides more details of the facilities, mining operations, and reclamation activities. The mine facilities outside the Permit Area have been separately authorized by OSMRE as part of the Initial Regulatory Program and are authorized for use in mining operations in accordance with SMCRA regulations. This EA includes analysis of the direct and indirect effects from the use of all mine facilities, within and outside the Permit Area, to the extent such facilities are necessary to support the mining operations that would be authorized by the proposed action. The analysis of cumulative effects includes all past and present mine facilities.

Mining in CRAs N-9, J-19, and J-21 would cease on or before December 22, 2019. On that date, the current authorization for the operation of the NGS would end. The NGS is the sole commercial customer for Kayenta Mine coal and upon shutdown of the NGS, there would be no reasonable market for Kayenta Mine coal given the remote and isolated location of the mine and lack of existing infrastructure to export coal. Therefore, mining at the Kayenta Mine would cease and final reclamation would begin. For the purposes of this analysis, it is assumed that mine production would remain constant at 8.1 mtpy until cessation of operations on or before December 22, 2019.

In addition to the continuation of mining operations up to December 22, 2019, reclamation operations would continue on lands that have been disturbed by mining activities. Approximately 1,600 acres would be graded and 1,893 acres would be topsoiled and reseeded during the Renewal period (**Table 2.3-1**). Upon cessation of mining operations on or before December 22, 2019, reclamation activities would commence for the just-completed mining areas and for areas previously mined, plus final reclamation of the Permit Area would be initiated as currently approved in the SMCRA permit. Reclamation activities would continue through July 5, 2020, in accordance with the reclamation plan in the approved PAP and continue until PWCC's reclamation obligations are completed.

Table 2.3-1 2015 to 2020 Proposed Disturbance and Reclamation

Coal Resource Area	Proposed Disturbed Acres	Proposed Graded Acres	Proposed Topsoiled and Reseeded Acres (after grading)
N-9	348	397	422
N-11[1]	6	17	408
J-19	177	589	622
J-21	311	597	441
Total	**842**	**1,600**	**1,893**

[1] N-11 would be affected by only reclamation activities and not from mining operations.

2.3.2 Support Facilities

Support facilities that would be used under Alternative 1 include water supply wells, transportation facilities, office and equipment facilities, utilities, coal handling facilities, explosive storage facilities, environmental monitoring sites, water control facilities, and topsoil stockpiles.

2.3.2.1 N-Aquifer Water Supply

From 1972 to 2005, PWCC withdrawal of water from the N-Aquifer averaged 3,980 af/yr (Macy et al. 2012). Seventy percent of the PWCC withdrawal amount was used for the operation of a coal slurry pipeline that extended from the mine to the Mohave Generating Station, but the operation of the pipeline was discontinued in 2005 (BLM 2011a). From 2006 to 2010, PWCC withdrawal from the N-Aquifer was at an average rate of 1,228 af/yr, reduced by approximately 70 percent from the previous time period. When the PWCC water use during this period was combined with the water withdrawn for municipal water use, which was at an average of 2,940 af/yr, total withdrawal from the N-Aquifer during this period averaged 4,168 af/yr. PWCC water use since 2006 has constituted approximately 30 percent of the total groundwater withdrawal from the aquifer (Macy et al. 2012). Under Alternative 1, PWCC would pump water from the N-Aquifer at a rate of 1,236 af/yr from July 6, 2015 to December 22, 2019, nearly comparable to its historic pumping rate since 2006. After mining has concluded on December 22, 2019, PWCC would require 500 af/yr from the N-Aquifer during reclamation.

The water is pumped from the aquifer via three active aquifer supply wells. This water is used for ongoing mining and reclamation operations, principally dust suppression as required by federal regulations. PWCC also pumps the N-Aquifer to provide approximately 100 af/yr of potable water for local residents. The projected amount of water use from the N-Aquifer from 2015 to 2020 would continue to be 1,236 af/yr under Alternative 1. The PAP specifies the N-Aquifer well monitoring program.

2.3.2.2 Roads

There are two types of transportation routes within the Permit Area: primary roads and ancillary roads. Primary and ancillary roads are designed, constructed, and maintained in accordance with regulations and performance standards set forth under 30 CFR 816.150 and 816.151. The existing primary roads on-site would be used for mining operations such as heavy-duty vehicles to haul coal and other mine-support vehicles (including moving the draglines). Lighter-duty vehicles would be used on ancillary roads to access environmental monitoring sites and remote mine facilities such as temporary or permanent water control facilities, water wells, and utility lines. Primary roads would be used for operations in CRAs N-9, J-19, and J-21 through the Renewal period to transport coal to storage and processing sites within the Permit Area.

2.3.2.3 Office and Equipment Facilities

Office and equipment facilities for the Kayenta Mine operations include mine buildings, offices, shops, bath houses, storage silos and cap magazines, coal storage and crushing areas, equipment storage areas, water diversions and culverts, sheds larger than 100 square feet constructed on permanent foundations, fuel storage areas, and environmental monitoring sites.

2.3.2.4 Water Control Facilities

Sedimentation ponds, temporary and permanent impoundments, and MSHA-sized impoundment structures are elements of the Kayenta Mine sediment and water control plan. Sediment ponds used to control runoff and sediment from disturbed areas would be constructed consistent with regulations and performance standards set forth under 30 CFR 816.46, 816.47, 816.56, and other applicable regulations. All surface drainage from most disturbed areas passes through either a

temporary sedimentation pond or a siltation structure before leaving the Permit Area. Surface drainage from areas that are small in aerial extent (e.g., diversion ditches, roads, or areas not disturbed by the operator) use sediment controls other than temporary sediment ponds.

Temporary sediment ponds would be reclaimed when no longer needed to treat surface runoff from disturbed areas. As of 2015, 155 sedimentation structures exist within the areas leased by PWCC. Under Alternative 1, an additional eight temporary sedimentation control ponds would be constructed during the five-year Renewal period.

Water sources from pre-SMCRA permit impoundments, post-SMCRA permit impoundments, and existing or proposed sediment control ponds would be used to provide water for wildlife and livestock. Within the Permit Area, there would be 19 permanent impoundments that would be available if approved for post-mining wildlife and livestock use.[3]

There are 11 existing impounding structures at the mine that meet the size criteria set forth under 30 CFR 77.216(a). The primary purpose of the nine proposed permanent and two temporary structures, except for the freshwater pond, is to control sediment from disturbed areas. The purpose of the freshwater pond is to hold groundwater pumped from the N-Aquifer wells for dust suppression.

2.3.2.5 Topsoil Stockpiles

Where direct replacement of topsoil recovered in advance of mining disturbances is not feasible, topsoil would be stockpiled throughout the mine areas in accordance with regulations and performance standards set forth under 30 CFR 780.12(b)5 and 816.22(c) until needed for reclamation and revegetation activities. The dimensions, slopes, and volumes of topsoil stockpiles would vary depending upon the total salvage volumes, configuration of the stockpile location, and proximity to primary and ancillary roads within the Permit Area. Topsoil would be collected from a 6-acre site in CRA N-11, transported, and directly placed on graded areas in CRA N-11.

2.3.2.6 Project Design Features and Permit Conditions

The eight standard permit conditions from 30 CFR 773.17, standard permit terms and specifications from previous renewed permits, and one existing Special Condition pertaining to the monitoring plan for the Mexican spotted owl (*Strix occidentalis lucida*) (contained in the PAP) would be incorporated into Alternative 1 and remain as part of the renewed permit.

In addition to the standard conditions and the Special Condition of the existing permit described above, two conservation measures have been proposed by PWCC that are not incorporated in the PAP[4] and would be implemented by the NGS owners in 2017 to aid in the protection of endangered fish species (**Section 3.9.6**), specifically the Colorado pikeminnow in the San Juan River, the razorback sucker in the San Juan River and the Colorado River below the Glen Canyon

[3] OSMRE must approve such structures; however, for the purposes of this analysis it is assumed they will be approved.

[4] The conservation measures do not need to be enforceable by OSMRE as part of this process because they were not a part of the adverse effects determination (USFWS 2017) or the FONSI. They are goodwill gestures by the NGS and would be implemented for the benefit of the resources. Further information is provided in **Section 4.9.3**.

Dam, and the humpback chub in the Colorado River below the Glen Canyon Dam. PWCC would coordinate with SRP, operator of the NGS, to ensure that funding assistance is conveyed annually (or as needed) to federal agencies or conservation organizations to implement the projects listed below. PWCC would provide documentation of implementation of projects to USFWS and OSMRE no later than February 15 of each year for the previous year. PWCC, in coordination with SRP, would initiate the planning and contractual arrangements to convey funding for the projects as soon as the ESA Section 7 consultation process is complete. Further details are provided in the biological assessment (BA) for the Renewal (USFWS 2017).

1. Support Non-native Fish Management (Emergency Rapid Response) in the Colorado River, Grand Canyon Area

The NGS would provide funding support to the National Park Service (NPS) or other state, federal, or tribal agencies to monitor for and eradicate, as necessary, predatory non-native fish in the mainstem Colorado River and tributaries below Glen Canyon Dam to the confluence of Lake Mead. The measure would protect and conserve razorback sucker and humpback chub.

The funding would support implementation of the Comprehensive Fisheries Management Plan developed by the NPS in 2013 to conserve and protect listed and other native fish in Grand Canyon National Park. Nonnative fish could negatively impact populations of endangered humpback chub and razorback sucker within the Grand Canyon due to predation and competition. The measure would ensure agencies have funding and supplies to implement an effective rapid emergency response to nonnative fish detections. Funds also could be used by agencies (e.g., Arizona Game and Fish Department [AGFD], USFWS, and NPS) to assist with monitoring the Colorado River and tributaries below Glen Canyon Dam and critical areas of the watershed (e.g., Little Colorado River) that act as a conduit or source for nonnative fish. Funds would be provided to agencies annually (or as needed for rapid responses) for labor, travel expenses, and the purchase of chemicals, nets, and other equipment to conduct monitoring, fish eradication projects, and post-project surveys.

2. Support Transport of Colorado Pikeminnow and Razorback Sucker above the Waterfall Barrier in the San Juan River

The NGS would provide funding to support agencies and organizations (e.g., BOR, Utah Division of Wildlife Resources, Navajo Nation Department of Fish and Wildlife [NNDFW]) to implement capture and transport of Colorado pikeminnow and razorback sucker upstream of a waterfall barrier in the San Juan River arm of Lake Powell, which allows the fish access to habitat in the San Juan River. Currently, BOR is managing the implementation of the project with assistance from other state and tribal agencies. Funding to support the capture and transportation of these fish around this barrier would increase the number of potentially spawning fish in the San Juan River and serve as a mechanism to connect the river and lake below the waterfall with fish and habitat in the river upstream of the barrier.

For over 20 years, a large waterfall (about 30 feet high) has existed in the San Juan River near Paiute Farms, Utah, where the river enters Lake Powell. The waterfall is present when Lake Powell reservoir elevations are below 3,660 feet above mean sea level (amsl), which has been

continuous since 2000, except for a one-month period in 2011. This waterfall serves as a barrier to movement for all fish species. While the waterfall effectively keeps nonnative fish from moving upriver, it also prevents native fish, especially Colorado pikeminnow and razorback sucker, from moving back upstream after they have drifted over the waterfall. Ryden and Ahlm (1996) identified this barrier as a major impediment to migrating fish. In the spring of 2016, a pilot program was conducted by BOR to relocate Colorado pikeminnow and razorback sucker over the waterfall using buckets to move tagged fish. Approximately 170 razorback sucker and four Colorado pikeminnow were translocated.

The collection and translocation would be implemented in approximately March, April, and June every year through 2020. The frequency, timing, or duration of field work would be adjusted in coordination with USFWS to maximize effectiveness of the translocation effort. The funding could be used to support staff time, travel cost, field equipment, tagging equipment, and holding and transportation of fish.

2.4 ALTERNATIVE 2: NO ACTION - DISAPPROVE RENEWAL OF PERMIT AZ-0001E

Under Alternative 2, OSMRE would not approve the renewal of permit AZ-0001E as of July 6, 2015, for the continuation of surface coal mining and/or reclamation in CRAs N-9, N-11, J-19, J-21, and other disturbed areas within Permit AZ-0001E as described above under Alternative 1. Due to the limited discretion under the statutory mandate for renewals, OSMRE cannot select this alternative unless a finding can be made that one or more of the six criteria in 30 CFR 774.15 (**Section 1.5**) is met.

Under Alternative 2, and for the purposes of this analysis, ongoing mining operations at the Kayenta Mine are assumed to have occurred between July 6, 2015, and August 31, 2017, because impacts would occur during this period due to OSMRE's Administrative Delay in Decision. Under Alternative 2, mining would cease on August 31, 2017. Facility removal and reclamation activities would proceed within the three CRAs being currently mined, plus N-11 and other disturbed areas within the Permit Area according to the provisions in the current approved reclamation plan, PAP, and SMCRA regulations. Reclamation activities would continue throughout the Kayenta Mine until December 2017 or until all reclamation obligations are met.

The number of employees at the Kayenta Mine would decrease from 317 employees to the approximately 175 employees required to conduct reclamation. Reclamation activities within the Permit Area would require approximately 500 af/yr from the N-Aquifer water supply wells. PWCC's existing leases with the tribes require N-Aquifer wells to be left properly cased for the tribes once PWCC successfully completes reclamation and relinquishes the leases (as described in the PAP).

2.5 ALTERNATIVES CONSIDERED BUT DISMISSED FROM FURTHER CONSIDERATION

Federal agencies are required by NEPA to explore and objectively evaluate reasonably feasible alternatives that meet the project's purpose and need, and to briefly discuss the reasons for

eliminating any alternatives that were not developed in detail (40 CFR 1502.14). The range of reasonable alternatives is typically limited to those that fall within the agency's statutory mandate and those that at least partially serve the agency's objective. During the development of this EA, several potential alternatives were considered by OSMRE. NEPA does not require agencies to analyze the environmental consequences of alternatives that it has in good faith rejected as too remote, speculative, impractical, or ineffective.

An action alternative may be eliminated from detailed analysis if:

- It is ineffective (does not respond to the purpose of and need for the action);
- It is technically or economically infeasible or practical (considering whether implementation of the alternative is likely given past and current practice and technology);
- It is inconsistent with the basic policy objectives for the management of the area;
- Its implementation is remote or speculative;
- It is substantially similar in design to an alternative that is analyzed; or,
- It would have similar or substantially worse environmental effects to an alternative that is analyzed.

2.5.1 Renewal of Permit with Additional Special Conditions

In addition to the permit conditions described in **Section 2.3.2.6**, OSMRE considered incorporating additional conditions to the Renewal. OSMRE's authority for denying a request for renewal is limited under 30 CFR 774.15 (**Section 1.5**). OSMRE has determined that PWCC has submitted a complete application for renewal, and after agency review of the PAP and consideration of prior public comments, OSMRE has not identified any additional conditions that would be warranted under the six statutory criteria. Moreover, based on the analysis of the environmental effects of the proposed action in this EA, and taking into account the effect of the voluntary conservation measures committed to by PWCC to protect the Colorado River Fish (which are analyzed as part of the proposed action), OSMRE has not identified any mitigation measures that would be necessary to reduce or eliminate any significant effects of the proposed action. This alternative was dismissed from further consideration because OSMRE has not identified any necessary conditions to ensure compliance with the statutory renewal criteria or reducing significant impacts, and therefore is not reasonable.

2.5.2 Use of the Dakota Aquifer

PWCC evaluated the feasibility of using the Dakota Aquifer (D-Aquifer) (GeoTrans, Inc. 2001) and determined that the D-Aquifer is of insufficient quantity and quality to replace the total water required for mine and potable water use. In addition, the use of water from the D-Aquifer would require the construction of a separate water treatment and delivery system to provide water for potable uses in accordance with the lease and for mining operations. Also, construction of the separate water system and use of the D-Aquifer would require a revision to the mining permit, which is not within the statutory and regulatory criteria of OSMRE in considering a permit renewal application. Based on aspects of economic practicality related to the construction of a separate water system, this alternative is not economically practical and fails to meet OSMRE's purpose and need.

2.5.3 Alternative Mining Methods

OSMRE and PWCC evaluated using different methods to mine coal from CRAs N-9, J-19, and J-21. OSMRE and PWCC considered recovering coal reserves in the Permit Area by use of underground recovery methods. PWCC and OSMRE reviewed the technical feasibility and economic practicality aspects of this method and determined that regional geology and anticipated surface cover within the Permit Area would not facilitate this mining method. Four considerations preclude underground mining at the Kayenta Mine:

- The main coal seams in the Wepo Formation are variable in thickness and tend to split into discontinuous seams (Nations et al. 2000). Underground mining is not technically feasible in areas where coal resources are located in variable and discontinuous seams.
- Typically, underground mining operations occurring in areas with the coal resource in splitting seams requires operators to wash the coal if it is diluted with other materials such as partings and overburden. PWCC does not currently have a coal washing operation and has not proposed one for development as part of the Renewal, which results in this alternative not being economically feasible.
- PWCC would have to refit existing or proposed operations to facilitate underground mining. PWCC would not be able to recover the same maximum economic recovery of coal reserves identified in the Permit Area due to the nature of underground mining, where pillars would need to remain in place permanently. Furthermore, longwall mining is risky in shallow overburden situations due to the tendency to cave, crushing the support pillars surrounding the longwall panel. Collapse of overburden would create a very hazardous working situation for underground miners, and cause damage to, or even loss of, mining equipment. For these reasons, this alternative is not technically feasible or economically practical (43 CFR 46.420(b)).
- It would require PWCC to obtain lease modifications as the current leases are for "surface mineable coal."

3.0 AFFECTED ENVIRONMENT

This chapter identifies the affected environment and focuses on the existing resources and uses that could be affected by the alternatives described in **Sections 2.3** and **2.4**. This EA includes a comprehensive approach to describing the human environment, the natural and physical resources, and people's relationship to those resources. Study area boundaries were developed for each resource and are described in their respective resource sections. Study areas for each resource are based on the predicted extent of direct and indirect impacts associated with the alternatives. Relevant current environmental conditions and human uses within the study areas have been identified and described using geographic information system (GIS) data, literature searches, electronic information and data searches, and personal interviews. The information presented in this section is derived from past studies and site-specific field data collected by or for PWCC.

This EA assumes that the combustion of Kayenta Mine coal at the NGS that would occur under the Renewal period could result in potential indirect effects to geologic resources, air and climate, water resources, special status wildlife and fish, Indian trust assets, visual resources, and health and safety. Therefore, the affected environment related to combustion at the NGS is described for these resources.

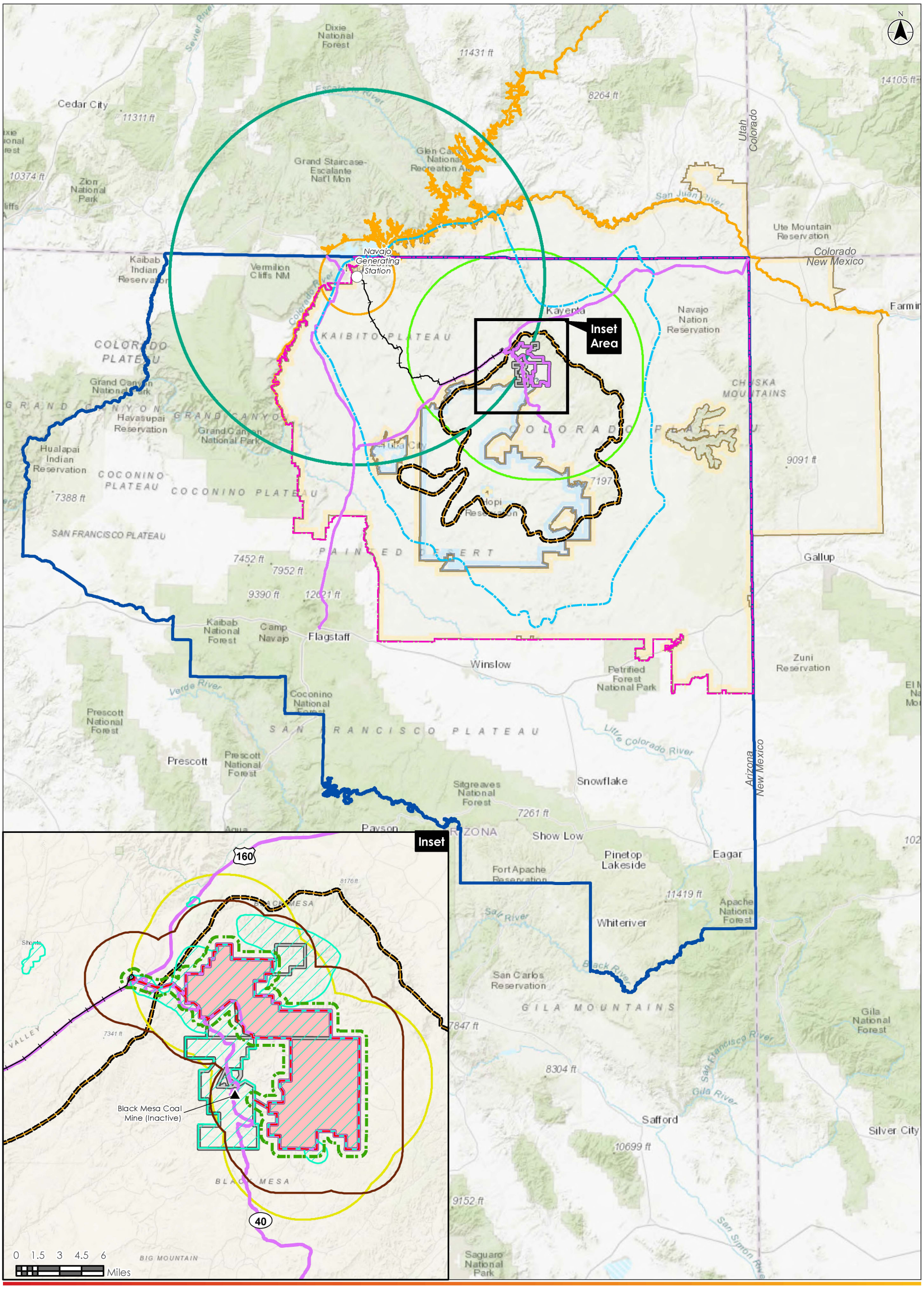
The following resources are not analyzed further in this EA because they are not present within the study area (i.e., not directly or indirectly affected): Wilderness, Wild and Scenic Rivers, and Wild Horses and Burros.

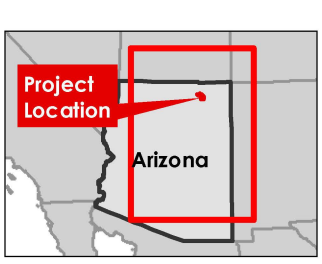
3.1 GENERAL SETTING

The 44,073-acre Permit Area is located within the boundaries of the Navajo Nation and Hopi Indian reservations near Kayenta in Navajo County, Arizona (**Figure 1.1-1**). The Permit Area is located on the geographic feature known as Black Mesa within the Colorado Plateau physiographic province. The specific study areas for each resource analyzed in this EA are described in the individual resource subsections; some resources have different study areas for direct versus indirect effects. The direct effects study areas are provided on **Figure 3.1-1**.

3.2 GEOLOGIC, MINERAL, AND PALEONTOLOGICAL RESOURCES

The study area for geology and paleontological resources is the Black Mesa coal field (**Figure 3.1-1**). The Colorado Plateau physiographic province is characterized by relatively flat-lying and laterally continuous Paleozoic and Mesozoic sedimentary formations. The Affected CRAs fall within the Black Mesa basin (**Section 3.4**), which contains coal-bearing rocks deposited within the basin that supply the mine operation.





Notes

1. Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 Feet
2. Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Legend

- Black Mesa Coal Mine (Inactive)
- Navajo Generating Station (NGS)
- Railroad
- Kayenta Mine Permit Area
- PWCC Lease Area
- Study Area for Soil Resources and Indian Trust Assets
- Study Area for Land Use and Recreation
- Study Area for Noise and Vibration
- Study Area for Vegetation
- Study Area for Visual Resources
- Study Area for Transportation and Access
- Study Area for Geologic, Mineral and Paleontological Resources, Landforms and Topography, and Special Status Plant Species
- Study Area for Climate Change
- Study Area for Air and Climate Resources and Human Health
- Study Area for Water Resources
- Study Area for Environmental Justice
- Study Area for Wildlife and Fish
- Study Area for Social and Economic Conditions

Land Status

- Hopi Indian Res.
- Navajo Indian Res.

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Project Location 203706045
T35N R18E, T35N R19E, T36N R17E, T36N R18E, T36N R19E, T37N R18E
Navajo County, AZ
Prepared by CLG on 2017-09-21
Technical Review by SL on 2017-09-21
Independent Review by DK on 2017-09-21

Client/Project
PWCC
Kayenta Mine SMCRA Permit
Environmental Assessment

Figure No.
3.1-1

Title
Resource Study Areas

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V:\2037\Active\203706045\09_data\gis_cad\gis\mxds\EA\Ch 3\Figure 3_1_1 Resource Study Areas.mxd Revised: 2017-09-21 By: cadlegis

3.2.1 Geologic Environment

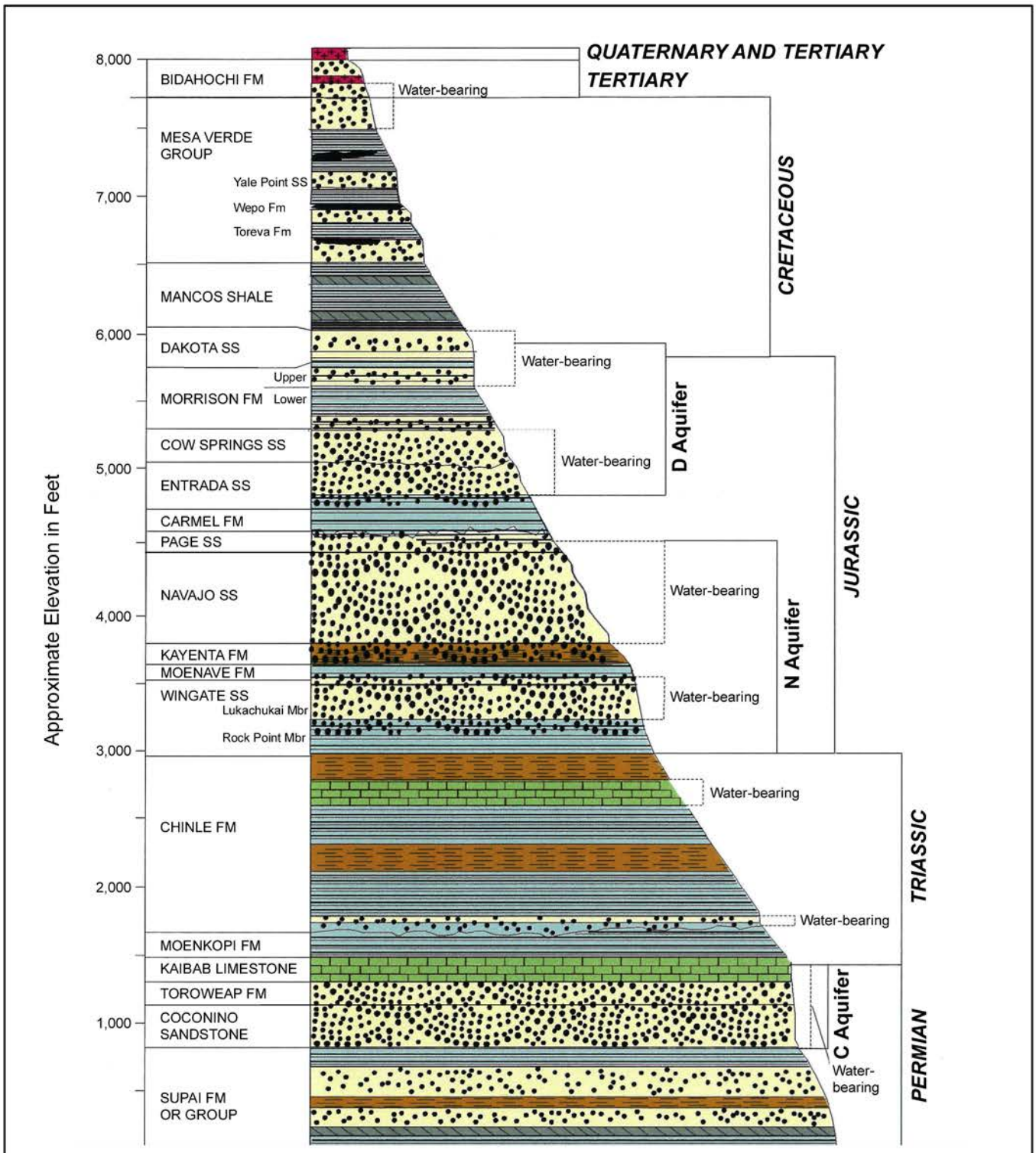
Relatively flat-lying, Precambrian to Holocene-aged sedimentary rocks dominate the geology of the study area with minor structural deformation by local folding and faulting. The Mesa Verde Group is the uppermost lithologic unit in the study area and includes the Yale Point Sandstone, the Wepo Formation, and the Toreva Formation in stratigraphic order from top to bottom (**Figure 3.2-1**). The Wepo Formation consists of coal, carbonaceous siltstone, mudstone, and sandstone and contains the coal mined at the Kayenta Mine. The Wepo Formation coal is the most economically viable to mine of the coals that occur in the study area because in general the seams are thicker, have the highest quality, and are the most mineable reserves (Nations et al. 2000). The Yale Point Sandstone is a medium- to coarse-grained quartz sandstone. It is interbedded with the underlying Wepo Formation and can be greater than 200 feet thick in the outcrop on the northeastern edge of Black Mesa. The Toreva Formation, which underlies the Wepo Formation, is a fossiliferous sandstone.

The Black Mesa physiographic feature is located on the northeastern limb of the broad syncline that forms the Black Mesa basin (**Section 3.4**). It is bounded by uplifts on the eastern, southeastern, western, and northern sides; folds define the southwestern and northeastern sides. These folds have very gentle dips and extend for miles. The folds along the north and northwest dip down to the southeast and create a hydrologic barrier within the N-Aquifer (**Section 3.7**). Faulting is less extensive than folding in the study area. Normal faulting associated with fold axes is the most common type. Most faults are oriented east-west and are displaced less than 40 feet. None of these faults are considered significantly active, and there is no indication that any recent volcanism ever extended to Black Mesa. Since 1973 there have not been any recorded earthquakes over 4.0 on the Richter scale in the study area or immediate vicinity (USGS 2016).

3.2.2 Mineral Resources

The primary mineral resource in the study area is coal. Of the mine-leased reserves of 670 mt of coal, approximately 455 mt have been mined through 2014. Mining in CRAs N-9, J-19, and J-21 is within the economically viable coal reserves of the Wepo Formation. The U.S. Geological Survey's (USGS) inferred total coal resource in the Wepo Formation exceeds 4.8 billion tons (Nations et al. 2000). Coal from the Kayenta Mine is transported from the mine to the NGS. Coal combustion residuals (CCRs) result from the combustion of coal at the NGS; CCRs that are not recycled are disposed of at NGS. The indirect effects study area for geological resources corresponds to the indirect effects on groundwater study area (**Figure 3.7-1**), and greater detail on the disposal of CCRs at NGS can be found in **Section 3.7.4**.

No other important mineral resources have been documented on the Black Mesa. Oil and gas test wells have been drilled sporadically, but no commercial resources have been found (Arizona Oil and Gas Conservation Commission 2015). The Mancos Shale, which underlies the Toreva Formation (**Figure 3.2-1**), has the potential to yield oil and gas. The potential for hydrocarbon production from the Mancos Shale at Black Mesa is unknown because there are no geochemical analyses for total organic carbon content or wells drilled to specifically test the shale (Rauzi 2015; Rauzi and Spencer 2013).



*Source: Macy and Unema 2013.

Coal, Carbonaceous Siltstone, Mudstone
Massive Sandstone
Cross-Bedded Sandstone
Interbedded Siltstone, Mudstone, and Claystone
Limestone
Siltstone

Figure 3.2-1
Regional Stratigraphic Column

12/7/2016

Minor amounts of scoria are formed when rocks adjacent to burning coal seams are baked and subjected to thermal metamorphism. The scoria is quarried for road maintenance aggregate and placement in portions of the mined and reclaimed areas to promote medicinal and traditional plant growth (OSMRE 2011).

Coal from the study area has been analyzed for rare earth minerals and germanium, but only trace amounts (less than 0.01%) are present. Such trace concentrations are currently not recoverable economically. Only secondary uranium mineralization occurs in the Toreva Formation on Black Mesa (Bureau of Indian Affairs [BIA] 1987).

3.2.3 Paleontological Resources

Paleontological resources (fossils) are the remains, imprints, and traces of once-living organisms preserved in rock layers. Examples of fossils include bones and teeth, shells, leaf impressions, footprints, and burrows. Fossils are nonrenewable resources with scientific, educational, commercial, and recreational (fossil hunting) values. The Cretaceous coal-bearing strata in the study area contains abundant plant and animal fossils and has high potential for yielding fossils. The fossils contained in these rocks are common throughout the study area.

3.3 SOIL RESOURCES

Soils are the result of processes on materials deposited or accumulated by geological processes. The development of diagnostic soil features is influenced over time by climate, parent material, biological activity, and topography (Natural Resources Conservation Service [NRCS] 2009). The study area for soil resources is the Permit Area (**Figure 3.1-1**). The soils on the plateaus, mesas, hillsides, and fan terraces of the study area range from a few inches to more than 5 feet deep and are generally well drained. Soils in many portions of the study area are subject to high wind and water erosion due to sparse vegetation cover, steep slopes, and soil type (AGFD 2006).

Soils in the study area are derived from the Cretaceous Mesaverde Group, a series of sedimentary sandstones, siltstones, and mudstones. In 1979, 1983, 1985, 2000, and 2003 SMCRA required that PWCC conduct site-specific soil surveys in the Permit Area and surrounding areas to provide detailed soil taxonomy and determine thickness of suitable topsoil, subsoil, and unconsolidated material for reclamation use. The surveys identified 14 soils in and surrounding the area. These soils are predominantly very fine to fine grained sandy loams with minor smectitic clayey soils. The smectite clays – also referred to as swelling clays - undergo as much as a 30 percent volume change due to wetting and drying. Soils in the study area are characterized generally as well drained with moderate shrink-swell potential (except for the smectitic clayey soils) and as slightly susceptible to wind erosion.

Topsoil is essential for re-establishing native vegetation and forage on reclaimed surface mines. Subsoil and weathered rock overburden beneath the topsoil supply additional nutrients and moisture for plant growth. By definition, topsoil means the A and E soil horizon layers of the four master soil horizons (30 CFR 701.5). The soils in the study area have A horizons that are between zero to four inches thick, depending on the soil. The topsoil is of insufficient quantity to salvage as a separate layer and must be salvaged together with suitable subsoil and suitable unconsolidated material below the subsoil to provide an average two-foot thick topsoil mixture

suitable for reclamation. Overall, a four-foot-thick suitable root zone is created per SMCRA requirements and the reclamation plan using a combination of this topsoil mixture underlain with suitable overburden. When a more rocky topsoil material is needed to support the reclamation plan, PWCC salvages the suitable residual soils unless their depth makes salvage impractical.

Certain shallow soils and rock outcrops derived from shale in the study area have the potential for higher than normal naturally-occurring selenium concentrations. Two native forb vegetation species (desert plume [*Stanleya pinnata*] and stinking milk-vetch [*Astragalus praelongus*]) that bioaccumulate selenium from these soils could create a level of toxicity in forage high enough to affect livestock. Although these selenium-accumulating plant populations are locally common, they comprise a very minor component of the vegetation communities. These selenium accumulators occur on the shallow shale soils associated with wooded ridges and disturbed areas, and are absent from the broad sagebrush valleys and wash terraces where the deeper soils occur (PAP). Topsoil for reclaimed areas is salvaged predominantly from these deeper soils.

Suspect concentrations of plant-available selenium were historically shown to occur in shale and coal overburden strata. Based upon the results of selenium analysis in plants and soils at a representative cross-section of sites where accumulator plants were found, the soils in which they were growing are not seleniferous (PAP, Ramboll Environ 2016a). These site-specific studies demonstrated that selenium would pose no harm to successful reclamation and therefore, in 2006, this parameter was removed from the list of suitability criteria used for evaluating topsoil and graded spoil. Baseline soil lead concentrations (less than 10 milligrams per kilogram [mg/kg]) were at the low end of the typical background range (Flatirons Toxicology 2016).

3.3.1 Prime Farmland Determination

The soils that occur in the study area are predominantly in the NRCS land capability Classes VI and VII. Soils in Classes VI and VII have severe to very severe limitations that make them unsuitable for cultivation and limit or restrict their use largely to pasture, range, woodland, or wildlife habitat. Soils in these groupings are used primarily for livestock grazing. The land in the study area has received a negative determination as prime or unique farmland from the NRCS (NRCS 2005).

3.4 LANDFORMS AND TOPOGRAPHY

The study area for landforms and topography is the physiographic feature Black Mesa (**Figure 3.1-1**). Black Mesa sits high in elevation relative to the surrounding areas of Arizona (Arizona Geologic Survey 1979), and is located within the Black Mesa Basin. The Black Mesa Basin is a broad synformal geologic structure defined by major uplifts (e.g., Defiance uplift) and regionally significant monoclines (e.g., Organ Rock Monocline). These large geologic structures control the regional attitudes of the rock formations and affect the types of landforms developed (Cooley et al. 1969).

Elevations within the study area generally range from 6,500 to 7,000 feet amsl. The topography of the study area is characterized by gently rolling hills on a relatively flat mesa. Restoration of mining sites to the approximate original contour is required by SMCRA and is detailed in the current reclamation plan. The reclamation vegetative mix and post-mining land uses are described

in **Sections 3.8** and **3.12**, respectively. Mined areas are backfilled and graded to approximate the original topographic relief. The approximate original contour restoration is designed to reestablish the drainage patterns to blend in with the surrounding undisturbed areas. Restored areas generally have smoother contours with less topographic relief than the original topography, and no pronounced landforms (e.g., no cliffs, steep buttes, or narrow canyons).

Cracks and sinkholes have been identified at several locations in the study area and likely are attributed to prolonged drought resulting in large desiccation cracks that have been further eroded during precipitation events. According to OSMRE (2011):

"In 2003 land subsidence features in the form of sinkholes, cracks, and slumps were reported near Forest Lake, about seven miles south of the [PWCC] lease area. After investigation by [OSMRE], Navajo Nation Minerals Department, Navajo Nation Water Resources Department, and [USGS], all of the subsidence features of concern were determined to be either in or adjacent to unconsolidated alluvial valley deposits and due to surface water entering and eroding desiccation features following an extended period of drought. These features are unrelated to the mining or water production facilities on the PWCC lease area…subsidence and formation of sinkholes in the [N-Aquifer] well field area is considered highly unlikely."

3.5 AIR AND CLIMATE RESOURCES

The study area for air and climate resources is the Permit Area plus a 50-kilometer (km) buffer around the Permit Area (**Figure 3.1-1**). In addition, the indirect effects on air and climate resources from combustion of Kayenta Mine coal at the NGS are evaluated. The study area for these indirect effects is the study area that was used for air quality photochemical modeling; the property boundary of the NGS plus a 300-km radius surrounding the facility (**Figure 3.5-2**). Air quality refers to the relative levels of air pollution in ambient air (i.e., outside air to which the general population may be exposed) in the study area. Air quality for a specific air pollutant is quantitatively expressed in terms of the concentration of that pollutant in ambient air (e.g., micrograms per cubic meter [$\mu g/m^3$] of air). In general, local air quality for a given pollutant is heavily influenced by emissions of that pollutant from stationary and mobile sources in the surrounding area. Once emitted into the atmosphere, the pollutant disperses into the ambient air.

The baseline air quality conditions in the study area are portrayed based on recent air quality monitoring data collected in the study area, including data on regional haze, mercury, and acid deposition. The CAA, (42 United States Code [USC] 7401 et seq.) and U.S. Environmental Protection Agency (EPA)-established CAA implementing regulations (40 CFR 50-99), create a comprehensive framework for the evaluation and regulation of both air quality and air quality impacts via National Ambient Air Quality Standards (NAAQS). NAAQS set the maximum allowable concentration of pollutants in ambient air. The overall approach of the CAA is based on the linkage between emission sources of air pollutants and the ambient concentrations of those pollutants.

Emission generating activities at the Kayenta Mine can be identified for both the pit areas and general mining operations, or with the coal preparation areas. Emission generating activities associated with the pit areas and general mining operations include:

- Topsoil removal and replacement by scrapers and road maintenance by graders;
- Overburden and coal drilling and blasting;
- Overburden removal by dragline, backhoe, and loader;
- Coal removal by front-end loader or backhoe;
- Dozer activity on overburden;
- Truck and scraper haulage of overburden;
- Truck haulage of coal from the pit area to the prep area; and
- Natural wind erosion of disturbed areas.

Emission generating activities in the coal preparation areas include:

- Haul truck dumping on coal piles;
- Hopper loading of coal;
- Coal conveyor transfer points;
- Primary crushing, screening, and secondary crushing;
- Coal sampling system crushing;
- Coal sampling system transfer points;
- Dozer maintenance of coal stockpiles;
- Coal pile wind erosion;
- Transfer points along the overland conveyor;
- Transfer to the silo; and
- Transfer from the silo to rail cars (rail loadout).

Emissions from these activities consist mainly of particulate matter (PM). The sources of other criteria pollutant emissions at the Kayenta Mine (i.e., nitrogen oxides, carbon monoxide [CO], and sulfur dioxide [SO_2]) are blasting and tailpipe exhaust from large mining equipment and haul trucks.

3.5.1 Ambient Air Quality Standards

The CAA requires establishment of NAAQS for seven criteria air pollutants across the U.S., including primary standards to protect the health of the citizens and secondary standards to protect other welfare-related values (**Table 3.5-1**). The CAA requires existing and proposed emission sources to demonstrate compliance with those standards. While some states adopt air quality standards that are more stringent than the NAAQS, the Kayenta Mine and the NGS are regulated by EPA and the federal statutes and regulations apply.

Table 3.5-1 National Ambient Air Quality Standards

Pollutant	Standard	Averaging Period	Concentration		Statistical Format
			ppb	µg/m³	
Ozone (O_3)	Primary & Secondary	8-hr	70	137	3-year average of the annual fourth-highest daily 8-hour concentrations
Nitrogen Dioxide (NO_2)	Primary	1-hr	100	188	3-year average of the annual 98th percentile highest daily 1-hour concentrations
	Primary & Secondary	Annual	53	100	Annual mean
SO_2	Primary	1-hr	75	196	3-year average of the annual 99th percentile highest daily 1-hour concentrations
	Secondary	3-hr	500	1,300	Not to be exceeded more than once per year
CO	Primary	1-hr	35,000	40,000	Not to be exceeded more than once per year
	Primary	8-hr	9,000	10,000	
PM with an aerodynamic diameter of 10 microns or less (PM_{10})	Primary & Secondary	24-hr	N/A	150	Not to be exceeded more than once per year on average over 3 years
PM with an aerodynamic diameter of 2.5 microns or less ($PM_{2.5}$)	Primary	Annual	N/A	12	Annual mean, averaged over 3 years
	Secondary	Annual	N/A	15	Annual mean, averaged over 3 years
	Primary & Secondary	24-hr	N/A	35	3-year average of the annual 98th percentile highest daily average concentrations
Lead (Pb)	Primary & Secondary	3-month rolling	N/A	0.15	Not to be exceeded

ppb: parts per billions by volume
ug/m³: micrograms per cubic meter; standard conditions
Source: 40 CFR part 50 NAAQS Table https://www.epa.gov/criteria-air-pollutants/naaqs-table

In ongoing review and regulatory actions, EPA and the state and tribal governments designate areas as:

- "Attainment," or "better than NAAQS" if monitored data demonstrate compliance with the standards;
- "Unclassifiable" or "cannot be classified" if monitored data are not available for such determinations; or
- "Non-attainment" for either primary or secondary standards if monitored values of the criteria air pollutants are above the NAAQS.

Non-attainment areas for ozone also may be sub-classified from "marginal" to "extreme," and non-attainment areas for PM_{10} and $PM_{2.5}$ may be sub-classified as "moderate" or "serious" depending on the air quality levels. Both the direct effects study area and the indirect effects study area are designated as in "attainment" or "unclassified" and are thereby in compliance with the NAAQS. None of the current non-attainment areas in Arizona include Navajo, Coconino, or Apache counties.

3.5.2 Hazardous Air Pollutants

Hazardous air pollutants (HAPs), or air toxics, are those pollutants that cause or may cause cancer or other serious health effects, such as reproductive effects, birth defects, or adverse environmental and ecological effects. Title III of the CAA Amendments of 1990 currently identifies 187 pollutants as HAPs, including certain metals that can be present in fugitive coal dust. In 2001, the EPA identified 21 HAPs as mobile source air toxics, six of which are designated priority pollutants (66 CFR 17235). Diesel particulate matter (DPM, as PM_{10}) is considered a carcinogenic air toxic. An EPA assessment examined the possible health hazards associated with exposure to DPM in diesel engine exhaust, which is a mixture of gases and particles. The assessment concluded that long-term (i.e., chronic) inhalation exposure is likely to pose a lung cancer hazard to humans, as well as damage the lung in other ways depending on exposure. Short-term (i.e., acute) exposures can cause irritation and inflammatory symptoms of a transient nature (EPA 2002). However, no EPA standard exists for DPM.

In addition to DPM from mining equipment and heavy trucks, coal combustion in power plant boilers emits a wide range of inorganic and organic HAPs from stacks (EPA 2011, 40 CFR 63 Subpart UUUUU).

3.5.3 Prevention of Significant Deterioration

The Prevention of Significant Deterioration (PSD) regulations (40 CFR 51.166 and 40 CFR 52.21) provide the overall air quality regulatory framework for the permitted operations of the Kayenta Mine and the NGS. The PSD program is designed to:

- Protect public health and welfare;
- Preserve, protect, and enhance the air quality in national parks, national wilderness areas, national monuments, national seashores, and other areas of special national or regional natural, recreational, scenic, or historic value;
- Ensure that economic growth will occur in a manner consistent with the preservation of existing clean air resources; and
- Ensure that any decision to permit increased air pollution in any area to which this section applies is made only after careful evaluation of all the consequences of such a decision and after adequate procedural opportunities for informed public participation in the decision-making process.

PSD does not prohibit new or existing stationary sources, such as oil refineries, factories, or power plants, from increasing emissions; rather, PSD is designed to ensure that emissions increases would have no significant effect on regional air quality (EPA 2013c).

EPA's PSD program defines when an emissions increase that results from certain types of changes at a stationary source is "significant," and thereby warrants investigation into the extent of the ambient air quality impact caused by that emissions increase. By definition, a PM_{10} emissions increase of 15 tons per year (tpy) or more is "significant," an emissions increase of 10 tpy or more of direct $PM_{2.5}$ is "significant," and a NO_x emissions increase of 40 tpy or more is "significant."

The NGS has not been required to obtain a permit under the PSD regulations; therefore, it is not an increment consuming facility. As a result, NGS impacts on ambient air quality in Class I areas were not evaluated for comparison to those Class I increments. The existing ambient air quality conditions at those locations already reflect the impacts from historic and ongoing operations at the NGS.

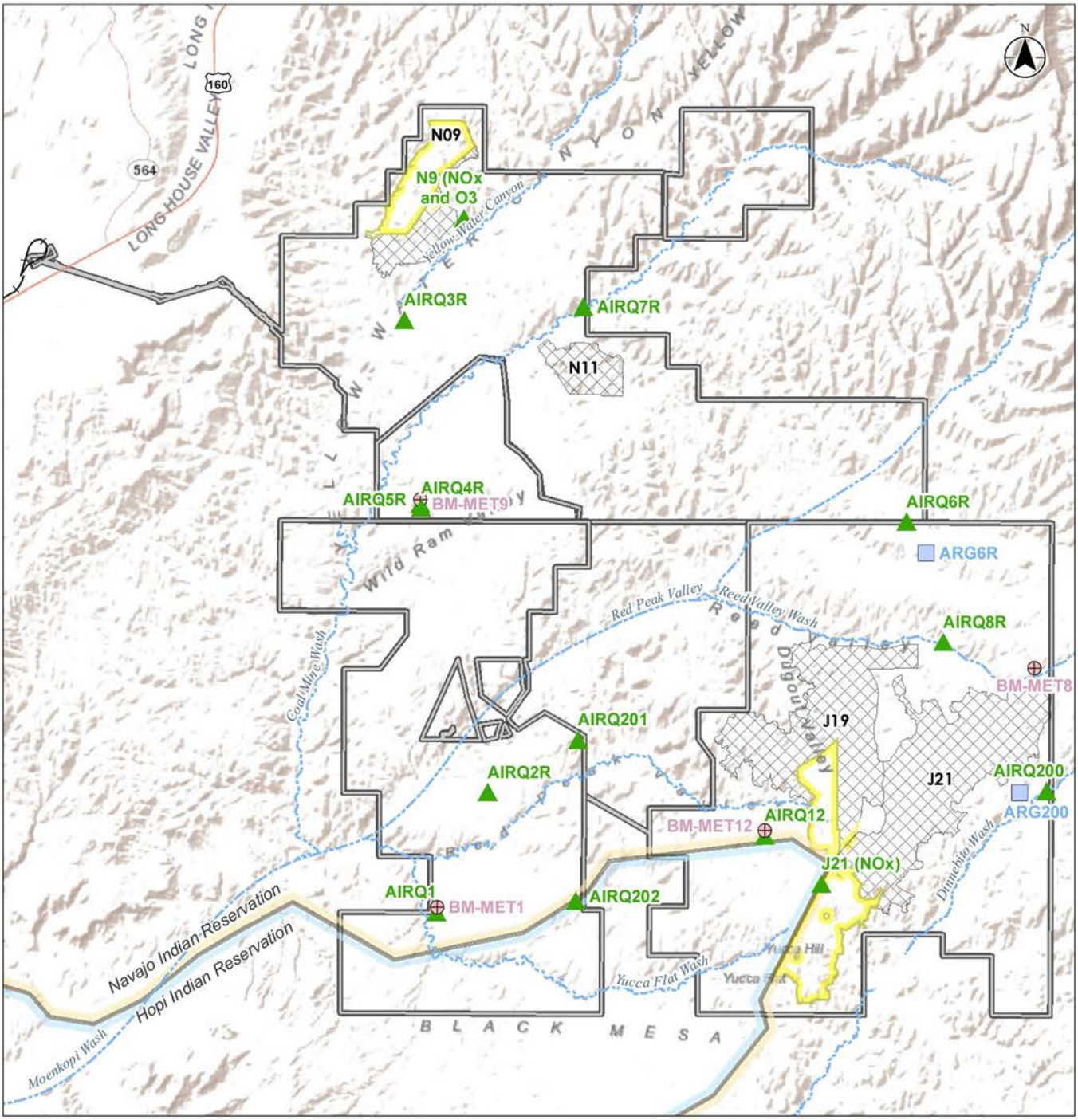
3.5.4 Title V Program

The CAA Amendments of 1990 introduced a new facility-wide Federal Operating Permit program. Federal Operating Permits, also known as Title V permits, are required for facilities with the potential to emit more than 100 tpy of a regulated pollutant, 10 tpy of any single HAP, or 25 tpy of any combination of HAPs and considered to be Title V major sources of air quality emissions. No NAAQS exist for HAPs; instead emissions of these pollutants are regulated by a variety of laws that target the specific source class and industrial sectors for stationary, mobile, and product use/formulations. However, Title V permitting is still required if HAP emissions rise above the defined thresholds.

The Kayenta Mine is operated by PWCC through lease agreements with the Navajo Nation and Hopi Tribe. The Navajo Nation Environmental Protection Agency (NNEPA) issued the mine an operating permit (NN-OP-08-010) on December 7, 2009. It expired five years later, but the mine is under a permit shield and is in the process of renewing their permit with the NNEPA.

3.5.5 Onsite and Regional Air Quality Monitoring

On-site monitoring has been performed at the mine for PM_{10}, $PM_{2.5}$, NO_2, and O_3. Multiple PM_{10} monitors have operated for approximately two decades (**Figure 3.5-1**); two NO_2 monitors have operated for three years; one O_3 monitor has recorded data for three years; and three $PM_{2.5}$ monitors have been in operation since October 2013. **Appendix C** provides on-site and regional data for all monitored criteria pollutants. All monitored concentrations are in compliance with the NAAQS.



Notes

1. Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 Feet
2. Service Layer Credits: Sources: Esri, DeLorme, USGS, NPS
   Sources: Esri, USGS, NOAA

Legend

- Railroad
- Intermittent Stream/Drainage
- Navajo-Hopi Partition Line
- Proposed Mining & Associated Disturbance 2015-2019
- Mined Out - Reclamation Complete or Ongoing
- PWCC Lease Area

Monitoring Site Location

- PM 10 Site
- Meteorological Site
- Precipitation Gauge

0 1 2 miles
1:150,000 (at original document size of 8.5x11)

Stantec

Project Location 203706045
T35N R18E, T35N R19E, T36N R17E, T36N R18E, T36N R19E, T37N R18E
Navajo County, AZ
Prepared by CLG on 2017-05-31
Technical Review by EC on 2017-05-31
Independent Review by DK on 2017-005-31

Client/Project
PWCC
Kayenta Mine SMCRA Permit
Environmental Assessment

Figure No.
3.5-1

Title
Onsite Air Monitoring Stations

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V:\2037\Active\203706045\03_data\gis_cad\gis\mxds\EA\Ch 3\Figure 3_5_1 Onsite Air Monitoring Stations.mxd Revised: 2017-05-31 By: cgallegos

With respect to regional air quality at the Kayenta Mine, data from the Air Quality System (AQS) on EPA's AirData website (http://www.epa.gov/airdata/) were reviewed and evaluated to define background concentrations of SO_2, CO, and $PM_{2.5}$. The AQS database was searched using the interactive map for $PM_{2.5}$, SO_2, and CO monitors located in the general vicinity of the mine in Arizona, New Mexico, Colorado, and Utah. This process identified seven active $PM_{2.5}$ regional air quality stations, three active SO_2 stations, and one active CO station. The years 2011, 2012, and 2013 from identified stations were downloaded for further review and analysis.

A monitor was considered to be representative if the following requirements were met:

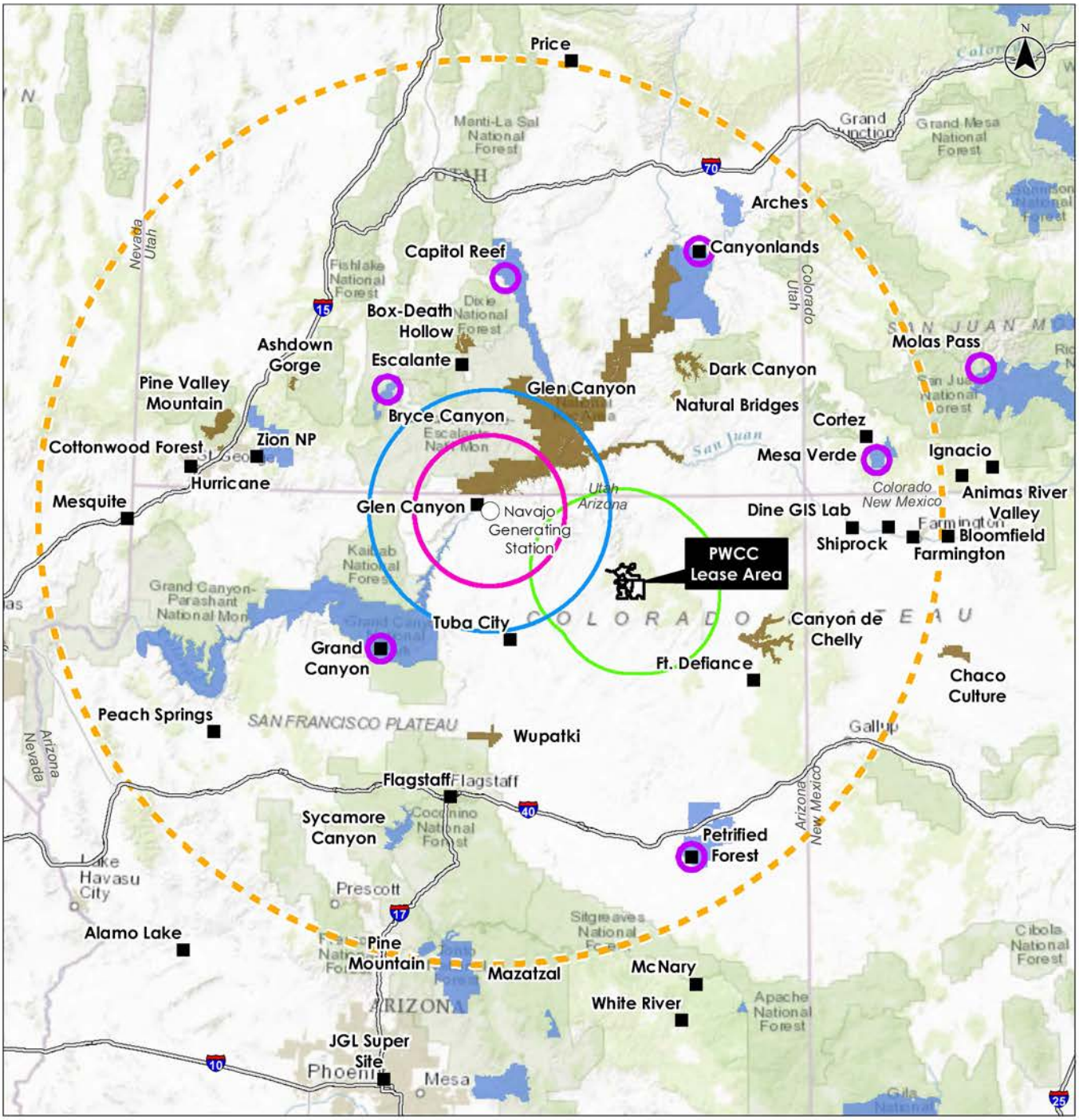
- The monitor was located in a rural-type setting and not in a city or population center;
- The monitor was not impacted by a nearby source;
- The available data covered years 2011 to 2013; and
- Data recovery was at least 75 percent for each year.

Based on the above criteria, the Farmington, New Mexico station was selected for characterization of background $PM_{2.5}$, the Bloomfield, New Mexico station was selected for characterization of background SO_2, and the Pine River Valley (Ignacio), Colorado station was selected for characterization of background CO. These data represent existing air quality in the region as well as background concentrations for use in projecting future air quality via modeling within the direct effects study area (50-km radius around the Kayenta Mine).

With respect to regional air quality at the NGS, the NGS operates the Glen Canyon ambient air monitoring station, 2.7 miles west of downtown Page, Arizona and approximately 6 miles west-northwest of the NGS. The Glen Canyon monitoring site collects particulate matter ($PM_{2.5}$ and PM_{10}) and SO_2 concentration data.[1] Following Arizona Department of Environmental Quality (ADEQ) Guidelines, eight regional air quality stations were identified for NO_2 and O_3 and one station was identified for CO and Pb. Based on ADEQ guidelines, the Hurricane/St. George, Utah station was selected for characterization of background NO_2, the Grand Canyon station was selected for characterization of background ozone, and the JGL Supersite station was selected for characterization of background CO and Pb. These data represent existing air quality in the region as well as background concentrations for use in projecting future air quality via modeling within the NGS near-field AERMOD modeling domain (80-km radius around the NGS) and within the indirect effects study area (300 km around the NGS).

The surrounding regional monitors (**Figure 3.5-2**) demonstrate compliance with the NAAQS (**Appendix C**), as well as identifying the area as "in attainment" (Minor, Michael & Associates [MMA] 2016). Further discussion regarding regional ozone can be found in **Section 4.5.1.4**.

[1] The Glen Canyon Monitoring site also collects ozone and NO_2 data. However, due to data quality issues identified with the ozone and NO_2 data, the ozone and NO_2 values recorded at Glen Canyon were not used for modeling or assessments.



Notes

1. Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 Feet
2. Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Legend

- Navajo Generating Station (NGS)
- PWCC Lease Area
- Air Modeling Study Area (300-km buffer of NGS)
- NGS Air Modeling Study Area for Indirect Effects (80-km buffer or NGS)
- Kayenta Mine Air Modeling Study Area for Indirect Effects (50-km buffer of Kayenta Mine Permit Area)
- Visibility and Human Health Indirect Study Area (50-km buffer of NGS)
- Class I Area
- Sensitive Class II Area

Monitoring Site Location

- Air Quality Monitoring Site
- CASTNET, NDN or IMPROVE

0 30 60 miles

1:4,000,000 (at original document size of 8.5x11)

Stantec

Project Location 203706045

T35N R18E, T35N R19E, T36N R17E, T36N R18E, T36N R19E, T37N R18E
Navajo County, AZ

Prepared by CLG on 2017-07-31
Technical Review by EC on 2017-07-31
Independent Review by DK on 2017-07-31

Client/Project
PWCC
Kayenta Mine SMCRA Permit
Environmental Assessment

Figure No.
3.5-2

Title
Regional Air Monitoring Stations

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V:\2037\Active\203706045\03_data\gis_cad\gis\maps\EA\Ch 3\Figure 3_5_2 Regional Air Monitoring Stations.mxd Revised: 2017-07-31 By: capalenga

3.5.6 Mercury and Air Toxics Standards

Coal-fired power plants are the largest source of mercury and acid gas emissions in the U.S.; they are responsible for about 50 percent of mercury emissions and about 77 percent of acid gas emissions. Most mercury deposited in the western U.S., however, originates in Asia (Strode et al. 2008). Peer-reviewed scientific literature shows that mercury emissions from electric generating units in the U.S. enhance mercury deposition and the response of ecosystems in the U.S. (77 Federal Register [FR] 9339). Other toxic metals emitted from power plants include arsenic, chromium, hexavalent chromium, nickel, and selenium (EPA 2013a). The deposition of mercury from the NGS could be an indirect impact related to the Renewal (**Sections 4.5**, **4.7**, **4.9**, and **4.17**); therefore, mercury and air toxics standards are discussed below.

When elemental mercury from the air reaches surface waters via direct and indirect deposition, microorganisms can convert it into methylmercury, a highly toxic form that can bioaccumulate in fish. Humans are primarily exposed to mercury by eating contaminated fish. Methylmercury exposure is a particular concern for women of childbearing age, fetuses, and young children because studies have linked high levels of methylmercury to damage to the developing nervous system, which can impair children's ability to think and learn. Mercury and other power plant emissions also can damage the ecological environment when present at sufficient concentrations and durations (EPA 2013a).

On December 16, 2011, the EPA issued the final Mercury and Air Toxics Standards (MATS) and Utility National Emission Standards for Hazardous Air Pollutants (NESHAP) rulemakings that were published in the Federal Register on February 16, 2012 (77 FR 9304). Promulgated as 40 CFR 63 Subpart UUUUU – National Emission Standards for Hazardous Air Pollutants (NESHAPS) for Coal- and Oil-Fired Electric Utility Steam Generating Units, the MATS establishes emission limitations and work practice standards for HAPs emitted from coal- and oil-fired electric utility steam generating units along with requirements to demonstrate initial and continuing compliance with the HAP emission limits.

As an existing coal-fired generating facility, the NGS must comply with specific HAP emissions limits for the following pollutants:

- Filterable PM, total non-mercury HAP metals, or individual HAP metals (antimony, arsenic, beryllium, cadmium, chromium, cobalt, copper, Pb, manganese, nickel, selenium);
- Hydrogen chloride or SO_2; and
- Mercury.

The NGS has implemented the monitoring, testing, recordkeeping, and reporting requirements, and performed the applicable work practice standards that are mandated to demonstrate compliance with the MATS.

3.5.7 Regional Haze

Regional haze is a result of aerosols in the atmosphere, which scatter and absorb light impacting visibility. Fossil fuel combustion is a major contributor to ammonium sulfate and ammonium

nitrate aerosols, while wildland fires are major contributors to organic carbon and elemental carbon. The majority of particulate emissions from surface coal mines are larger particles emitted at or near ground level with little or no buoyancy; therefore, surface coal mines are not the typical contributors to regional haze. The role of regional transport of fine particles and aerosols that contribute to elevated PM levels and regional haze impairment has been well-documented. There are no Class I areas or sensitive Class II areas within the direct effects study area for air quality. Class I areas and sensitive Class II areas within the indirect effects study area for air quality are shown on **Figure 3.5-2**.

Visibility and haze are regulated under the Regional Haze Rule of the CAA (40 CFR 51 Subpart P). Under the CAA, Class I areas are those in which visibility is protected more stringently than under NAAQS. Class I areas include national parks and monuments, wilderness areas, and other areas of special national and cultural significance. Section 169A (42 USC Part 7491) of the CAA sets forth a national goal for visibility which is the "prevention of any future, and the remedying of any existing, impairment of visibility in Class I areas which impairment results from manmade air pollution" (64 FR 35714). The Regional Haze Rule, enacted in 1999, requires states to establish goals and emission reduction strategies for improving visibility in all Class I areas as part of State Implementation Plans (SIPs) as geographically applicable. In addition, the EPA encourages states to work together in regional partnerships to develop and implement multistate strategies to reduce emissions of visibility-impairing fine particle ($PM_{2.5}$) pollution (64 FR 35714).

Reasonably attributable visibility impairment has been certified for six coal-fired electric generating facilities since 1986. In March 1986, the Department of the Interior certified that the NGS was causing visibility impairment in Grand Canyon National Park. After detailed technical analyses, public comment, and regulatory actions, emission controls to reduce SO_2 were installed on the three NGS units between 1997 and 1999. The Grand Canyon Visibility Transport Commission was created to recommend strategies to protect visual air quality at national parks and wilderness areas on the Colorado Plateau and made recommendations to EPA in 1996. In 2013 EPA implemented a federal plan for the NGS to meet the regional haze rule requirements to reduce visibility impacts of nitrogen oxides (EPA 2013).

The IMPROVE (Interagency Monitoring of Protected Visual Environments) program was initiated in 1985 to establish current visibility conditions and trends in national parks and wilderness areas. Average visual range in many Class I areas in the west is 60 to 90 miles (100 to 150 km) equivalent to 13.6 to 9.6 deciviews[2], or about 50 to 70 percent of the visual range that would exist without anthropogenic air pollution from stationary and mobile sources (64 FR 35714). Six regional IMPROVE stations (**Figure 3.5-2**) were used for characterization of the baseline regional haze level in the indirect effects study area using data for the period from 2010 to 2013 (**Appendix C**).

[2] One deciview represents the minimal perceptible change in visibility to the human eye and is proportional to the logarithm of the light extinction coefficient. As such, it is linear with respect to perceived visual changes over its entire range, analogous to the decibel scale for sound. A 1 dv change represents about a 10 percent change in the extinction coefficient. The higher the deciview value, the poorer the visibility.

3.5.8 Climate Change

The climate change study area is equivalent to the 100-km radius (**Figure 3.1-1**); the Renewal period would be short term and would not produce a significant amount of greenhouse gas (GHG) emissions. The study area for characterizing climate associated with the NGS (indirect effects) covers southern Utah and Northeastern Arizona. As climate changes in the region, the NGS may affect or be affected by the changing climate. Conditions and trends in a regional study area that includes the NGS would form a pattern relevant to the evaluation of the projected change and its environmental consequences. This study area includes the region that supplies water to Lake Powell because the Renewal would be affected by the availability of Colorado River water flow (BOR 2016). Long-term climate impact is not expected from the NGS as it will close by the end of 2019.

The primary natural and anthropogenic GHGs in the Earth's atmosphere are water vapor, carbon dioxide, methane, nitrous oxide, and fluorinated gases. GHGs allow heat from the sun to pass though the upper atmosphere and warm the earth and block some of the heat that is radiated from the earth back into space. As GHG concentrations increase in our atmosphere they impact the global climate by further decreasing the amount of heat that is allowed to escape back into space. Many GHGs are naturally occurring in the environment; however, human activity has contributed to increased concentrations of these gases in the atmosphere. CO_2 is emitted from the combustion of fossil fuels (i.e., oil, natural gas, and coal), solid waste, trees, and wood products, and also as a result of other chemical reactions (e.g., manufacture of cement). Methane results from livestock and other agricultural practices and by the decay of organic waste in municipal solid waste landfills. Methane also is emitted during the production and transport of coal, natural gas, and oil. Nitrous oxide is emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste. Fluorinated gases, while not abundant in the atmosphere, are powerful GHGs that are emitted from a variety of industrial processes and are often used as substitutes for ozone-depleting substances (e.g., chlorofluorocarbons, hydrochloroflourocarbons, and halons).

The EPA has taken action to regulate six key GHGs – CO_2, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. Because CO_2 is the most prevalent of the regulated GHGs, the EPA references the potential impact of GHG emissions in terms of their equivalence to carbon dioxide or CO_2e. The International Energy Agency estimated global emissions of CO_2e to be 32,190 million metric tons in 2013.

The EPA tracks GHG emissions in the U.S. by source sector (e.g., industrial, land use, electricity generation, etc.), fuel source (e.g., coal, natural gas, geothermal, petroleum, etc.), and economic sector (e.g., residential, transportation, commercial, agriculture, etc.) (**Table 3.5-2**). With so many GHG emission sources nationally, from cattle to vehicles to electric power generators, no single source is likely to represent a significant percentage of national emissions. **Table 3.5-2** shows GHG emissions (in CO_2e) by economic sectors for 2005, 2010, and 2014. **Table 3.5-3** shows total U.S. emissions in 2005, 2010, and 2014 by gas and source and by CO_2e; only the largest sources/sinks are shown for each gas.

Table 3.5-2 U.S. GHG Emissions Allocated to Economic Sectors

Implied Sectors	2005 (mmt[1] CO_2e)	2010 (mmt CO_2e)	2014 (mmt CO_2e)
Electric Power Industry	2,443.9	2,300.5	2,087.7
Transportation	1,999.6	1,827.4	1,810.3
Industry	1,486.2	1,394.5	1,461.7
Agriculture	600.2	631.1	625.4
Commercial	420.3	425.5	453.9
Residential	370.4	361.2	393.7
U.S. Territories	58.2	45.3	44.7
Total Emissions	7,378.8	6,985.5	6,870.5
Land Use, Land-Use Change, and Forestry (Sink)	(698.5)	(766.4)	(762.5)
Net Emissions (Sources and Sinks)	**6,680.3**	**6,219.0**	**6,108.0**

[1]Million metric tons

Table 3.5-3 U.S. GHG Emissions and Sinks

Gas/Source	2005 (mmt CO_2e)	2010 (mmt CO_2e)	2014 (mmt CO_2e)
Carbon Dioxide	6,122.7	5,688.8	5,556.0
Fossil Fuel Combustion	5,747.1	5,358.3	5,208.2
Non-Energy Use of Fuels	138.9	114.1	114.3
Metallurgical Production	66.5	55.7	55.4
Natural Gas Systems	30.1	32.4	42.4
Cement Production	45.9	31.3	38.8
Methane	717.4	722.4	730.8
Natural Gas Systems	177.3	166.2	176.1
Enteric Fermentation	168.9	171.3	164.3
Landfills	154.0	142.1	148.0
Coal Mining	64.1	82.3	67.6
Manure Management	56.3	60.9	61.2
Nitrous Oxide	397.6	410.3	403.5
Agricultural Soil Management	297.2	320.7	318.4
Mobile Combustion	34.4	23.6	16.3
Nitric Acid Production	11.3	11.5	10.9
Stationary Combustion	20.2	22.2	23.4
Manure Management	16.5	17.2	17.5
HFCs, PFCs, and SF6[1]	140.6	163.4	179.6
Substitution of Ozone Depleting Substances	99.7	141.2	161.2
HFC-22 Production	20.0	8.0	5.0
Electrical Transmission and Distribution	10.6	7.0	5.6
Total Emissions	7,378.8	6,985.5	6,870.5
Land Use, Land-Use Change, and Forestry (Sink)	*(698.5)*	*(766.4)*	*(762.5)*
Net Emissions (Sources and Sinks)	6,680.3	6,219.1	6,108.0

[1] hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride

Secondary GHGs do not have a direct atmospheric warming effect, but indirectly affect terrestrial radiation absorption by influencing the formation and destruction of tropospheric and stratospheric ozone, or in the case of SO_2, the absorptive characteristics of the atmosphere.

Additionally, some of these gases may react with other chemical compounds in the atmosphere to form compounds that are GHGs. **Table 3.5-4** provides national emissions of SO_2 for years 2005, 2010, and 2014. Levels of SO_2 emissions have decreased since 2005 somewhat due to reductions in electricity generation, but primarily due to increased consumption of low sulfur coal from surface mines in the western states and the installation of control equipment utilized by generators.

Table 3.5-4 U.S. Sulfur Dioxide (Indirect GHG) Emissions

Gas/Source	GHG 2005 (mmt)	GHG 2010 (mmt)	GHG 2014 (mmt)
Sulfur Dioxide	13.20	7.01	4.53
Energy (combustion, etc.)	11.72	6.24	3.82
Industrial Processes	0.83	0.62	0.60
Oil and Gas Activities	0.62	0.14	0.09

NAAQS do not exist for GHGs. In its Endangerment and Cause or Contribute Findings for Greenhouse Gases under Section 202(a) of the CAA (FR EPA-HQ-OAR-2009-0171), the EPA determined that GHGs are air pollutants subject to regulation under the CAA. GHGs' status as pollutants are due to the added long-term impacts they have on the climate because of their increased concentrations in the earth's atmosphere. Ongoing scientific research has identified that anthropogenic GHG emissions impact the global climate. Industrialization and the burning of fossil fuels have contributed to increased concentrations of GHGs in the atmosphere. GHGs are produced from both the direct process of coal mining as well as from the combustion of the mined coal. The amount of GHG emissions associated with these processes varies greatly based on mining techniques and combustion methodologies used.

The EPA has promulgated rules to regulate GHG emissions and the industries responsible under the Mandatory Reporting Rule (74 FR 56260, 40 CFR 98) and the Tailoring Rule (70 FR 31514, 40 CFR 51, 52, 70, 71). Under the EPA's GHG Mandatory Reporting Rule, coal mines subject to the rule are required to report emissions in accordance with the requirements of 40 CFR Subpart FF. Subpart FF is applicable only to underground coal mines and is not applicable to surface coal mines. Under the provisions of the Tailoring Rule (and a subsequent Supreme Court decision[3]), a facility would be subject to PSD permitting if it has the potential to emit GHGs in excess of 100,000 tpy of CO_2e and the facility exceeded the PSD major source threshold for a criteria pollutant. For existing facilities, this review would take place during any subsequent modifications to the facility.

The first EPA regulation to limit emissions of GHGs imposed carbon dioxide emission standards on light-duty vehicles, including passenger cars and light trucks. EPA is gathering detailed GHG emission data from thousands of facilities throughout the U.S. and will use the data to develop an improved national GHG inventory, as well as to establish future GHG emission control

[3] *Utility Air Regulatory Group v. EPA*, ___ U.S. ___, 134 S. Ct. 2427 (June 23, 2014).

regulations. The EPA finalized regulations for GHG emissions from new and existing fossil fuel fired electric utility generating units in August 2015. The Clean Power Plan would establish carbon emission performance limits for various state and tribal jurisdictions. The effect of the Clean Power Plan on future operations at the NGS is currently unknown, pending resolution of legal challenges to the rule, as well as a final determination regarding implementation of the Clean Power Plan on Navajo Nation lands. If or when the Clean Power Plan is implemented, it would provide a framework for evaluating future reductions in GHG at the NGS.

Global warming of approximately 2°C (above the pre-industrial baseline) is very likely to lead to more frequent extreme heat events and daily precipitation extremes over most areas of North America, more frequent low snow years, and shifts towards earlier snowmelt runoff over much of the western U.S. and Canada (Intergovernmental Panel on Climate Change [IPCC] 2013). Together with climate hazards such as higher sea levels and associated storm surges, more intense droughts, and increased precipitation variability, these changes are projected to lead to increased stresses to water, agriculture, economic activities, and urban and rural settlements. IPCC (2013) predicts an increase in temperature of 2°C or more for the U.S. Southwest by the middle of the 21st Century (**Figure 3.5-3**). Global warming of approximately 4°C is very likely to cause larger changes in extreme heat events, daily scale precipitation extremes and snow accumulation and runoff.

3.6 NOISE AND VIBRATION

Noise is defined as any sound that is undesired or interferes with a person's ability to hear. The basic measure of sound is the sound pressure level, commonly expressed as a logarithm in units called A-weighted decibels (dBA), which approximates the way the human ear hears. A-weighted sound measurements (dBA) are standardized at a reference value of 0 dBA, which corresponds to the average threshold of human hearing. The A-rated scale is logarithmic; that is, a sound that is 10 decibels (dB) louder is perceived by people as twice as loud (Federal Transit Authority [FTA] 2006). Vibration consists of rapidly fluctuating motions that can be described in terms of displacement, velocity, or acceleration.

The study area for noise and vibration include sensitive receptors at residences within and up to three miles from the Permit Area, including residences near the intersection of U.S. Highway 160 and Navajo Route 41, and along Moenkopi and Dinnebito washes (**Figure 3.1-1**). The three-mile distance was selected based on attenuation of a 100-dBA noise source to approximately 50 dBA. A sound level of 50 dBA is generally considered to be quiet (**Table 3.6-1**). The ambient conditions encountered in the study area consist of an assortment of sounds at varying frequencies (FTA 2006). The loudest single mining and excavation equipment noise source is the rock drill at 95 dBA (FTA 2006) (**Table 3.6-2**).

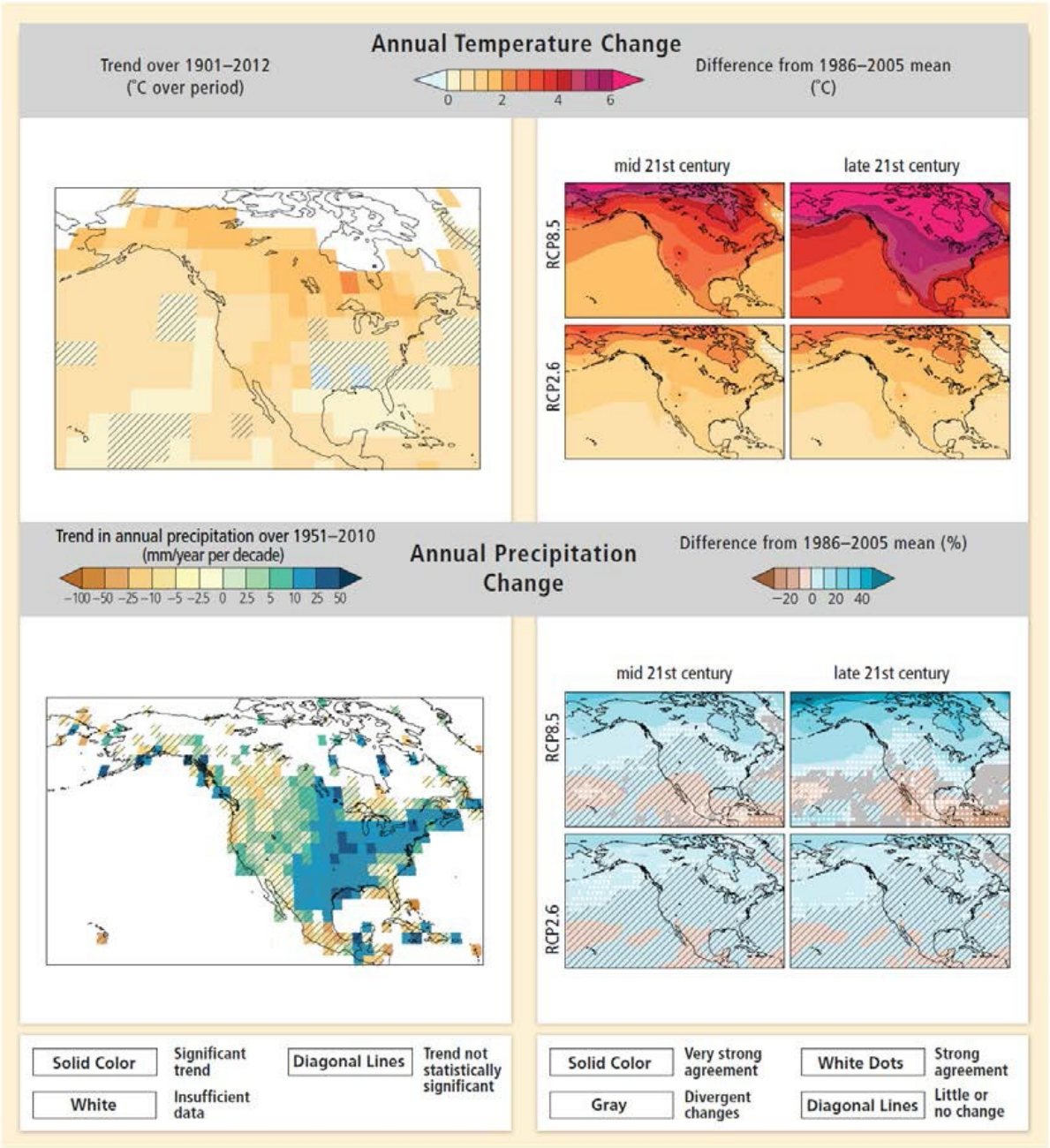


Figure 26-3 | Observed and projected changes in annual average temperature and precipitation. (Top panel, left) Map of observed annual average temperature change from 1901–2012, derived from a linear trend. [WGI AR5 Figures SPM.1 and 2.21] (Bottom panel, left) Map of observed annual precipitation change from 1951–2010, derived from a linear trend. [WGI AR5 Figures SPM.2 and 2.29] For observed temperature and precipitation, trends have been calculated where sufficient data permit a robust estimate (i.e., only for grid boxes with greater than 70% complete records and more than 20% data availability in the first and last 10% of the time period). Other areas are white. Solid colors indicate areas where trends are significant at the 10% level. Diagonal lines indicate areas where trends are not significant. (Top and bottom panel, right) CMIP5 multi-model mean projections of annual average temperature changes and average percent changes in annual mean precipitation for 2046–2065 and 2081–2100 under RCP2.6 and 8.5, relative to 1986–2005. Solid colors indicate areas with very strong agreement, where the multi-model mean change is greater than twice the baseline variability (natural internal variability in 20-yr means) and ≥90% of models agree on sign of change. Colors with white dots indicate areas with strong agreement, where ≥66% of models show change greater than the baseline variability and ≥66% of models agree on sign of change. Gray indicates areas with divergent changes, where ≥66% of models show change greater than the baseline variability, but <66% agree on sign of change. Colors with diagonal lines indicate areas with little or no change, where <66% of models show change greater than the baseline variability, although there may be significant change at shorter timescales such as seasons, months, or days. Analysis uses model data and methods building from WGI AR5 Figure SPM.8. See also Annex I of WGI AR5. [Boxes 21-2 and CC-RC]

Figure 3.5-3 Changes in Annual Average Temperature and Precipitation (IPCC 2013, Figure 26-3)

Table 3.6-1 Typical Noise Sources and Environments

Noise Source or Environment	dBA	Subjective Evaluation
Shotgun blast at close range Jackhammer at close range	130	Deafening
Commercial Jet take-off	120	Deafening
Motorcycle at 25 feet Propeller plane fly-over at 1,000 feet Diesel truck, 40 miles per hour (mph) at 50 feet	90	Very Loud
Passenger car, 65 mph at 25 feet Vacuum cleaner at 3 feet	70	Loud
Normal conversation at 5 feet	60	Moderate
Average office	50	Quiet
Average residence without radio	30	Faint
Soft whisper at 5 feet	20	Faint
Normal breathing Rustle of leaves in wind	10	Very Faint
Average threshold of human hearing	0	None

Source: FTA (2006)

Table 3.6-2 Source Noise and Noise Exposure Estimates

Noise Source		Source to Receiver Distance (feet)	Noise Exposure Estimates[1] (dBA)	Source-to-Receiver Distance (feet)	Noise Exposure Estimates[1] (dBA)
Mining and excavation	Bucket loader	50	89	200	65
	Haul trucks (100 tons)	50	88	200	64
	Ore trucks (tractor-trailer)	50	88	200	64
	Water truck	50	91	200	67
	Front end loader	50	80	300	70
	Fork lift	50	73	200	49
	Dozer	50	92	300	77
	Rock drill	50	95	300	79
	Dragline crane	50	88	300	73
	Scraper	50	92	300	77
	Pumps	50	71	200	47
	Generators	50	83	200	59
	Compressors	50	86	200	62
Traffic	Roadways[2]	50	70	200	60
	Electric railroad[3]	50	70	240	60

Source: Minor, Michael & Associates (2000); FTA (2006)

[1]All noise exposure estimates are based upon typical highway or vehicle operation. Railroad noise levels are described in day-night average sound level; all others are in equivalent noise level daytime.

[2] Roads with traffic at 55 miles per hour, but without trucks.

[3] Typical for Black Mesa and Lake Powell electric-railroad operations.

The existing noise environment in the study area is dominated by noise associated with mining operations, including coal processing, blasting, and hauling. Noise levels in the study area were estimated from typical mining equipment noise levels (**Table 3.6-2**). Existing sound levels at 50 feet from equipment are likely to range from 50 dBA to 95 dBA for typical daytime noise levels, depending on the level of intensity of mining activities, and decreasing with distance from the noise source.

Blasting is used as part of the mining operations to fragment material for excavation and transport. Surface blasting is conducted during daylight hours an average of twice daily during weekdays and is conducted at least 0.5 mile from any residence or occupied dwelling. Warning and all-clear signals audible for at least 0.5 mile are sounded before and after blasting. Except for emergencies, blasting occurs according to a schedule that is published annually in a newspaper with general circulation in the area. Additionally, blasting schedules are delivered to all individuals living in and within a 0.5 mile of the Permit Area.

Low-frequency vibrations are normally felt rather than heard. Existing sources of vibrations within the study area may occur as heavy equipment or truck travel through the study area or from blasting. Energy liberated from the blast is converted into vibrations as either ground motion or air overpressure (air blast). Ground motion is the principal vibration that could result from blasting, though air blast may be more noticeable because of the accompanying noise effects. Like other noises, air blast is measured in dBA; however, the overpressure is normally at low frequencies, and an air blast may be felt more than heard. Ground motion is a wave motion spreading outwards from the blast, like ripples spreading outwards after a stone is dropped into water. This ground motion is measured as peak particle velocity and is used as an indicator of possible blast damage.

Monitoring levels for ground movement and air overpressure from the mining operation have not exceeded established OSMRE limits since 2010.

3.7 WATER RESOURCES

The study area for water resources (direct effects) encompasses the Permit Area and adjacent areas underlain by the N-Aquifer and the D-Aquifer and where these aquifers discharge to the surface as springs (**Figure 3.1-1**). Drainage is controlled by the perennial Colorado River flowing from the northeast to the west across the plateau, and by the intermittent Little Colorado River, which runs from the south near the White Mountains and Holbrook, Arizona, to its junction with the Colorado River downstream from Page, Arizona (**Figure 3.7-1**). The study areas for indirect effects to surface and groundwater resources that could result from the combustion of Kayenta Mine coal at the NGS are shown on **Figure 3.7-1**. The study area for indirect effects to the surface water resource area includes part of the Colorado and San Juan River Basins because of the potential effects of coal combustion on aquatic biota and is discussed further in **Section 3.9**.

Water resources in the study area have been studied and monitored for decades (McGavock et al. 1966; Macy 2010). PWCC has conducted surface and groundwater studies and monitoring in support of its permit applications and associated regulatory requirements (GeoTrans Inc. 2006, 2005; PWCC 2010a). These studies include surface water quality, streamflow measurements, stream sedimentation studies, groundwater levels and quality, and groundwater modeling of the

N- and D-Aquifers. Discharges from PWCC sediment ponds are monitored in accordance with PWCC National Pollutant Discharge Elimination System (NPDES) Permit No. NN0022179. Discharges of stormwater from limited areas along the conveyor beltline and haul road crossings that have no sediment control structure downstream are authorized under the EPA's 2015 Multi-Sector General Permit (MSGP) for Stormwater Discharges Associated with Industrial Activity. PWCC also collects water quality samples from the water-distribution system to comply with Navajo Nation's Safe Drinking Water Act requirements. Water resources data that are relevant for the Renewal are the data in OSMRE (2011; 2011b) and PWCC (2010b).

3.7.1 Surface Water

Drainages in the study area are considered ephemeral and intermittent based on OSMRE definitions in 30 CFR 701.5. An ephemeral stream is one that flows only in direct response to precipitation or in response to melting of snow and ice and which has a channel bottom above the water table. An intermittent stream is a stream with a stream bottom that is below the groundwater table for at least part of the year and thus obtains flow from groundwater as well as surface water runoff. OSMRE further defines an intermittent stream in 30 CFR 701.5 as a stream or stream reach that drains a watershed of at least one square mile.

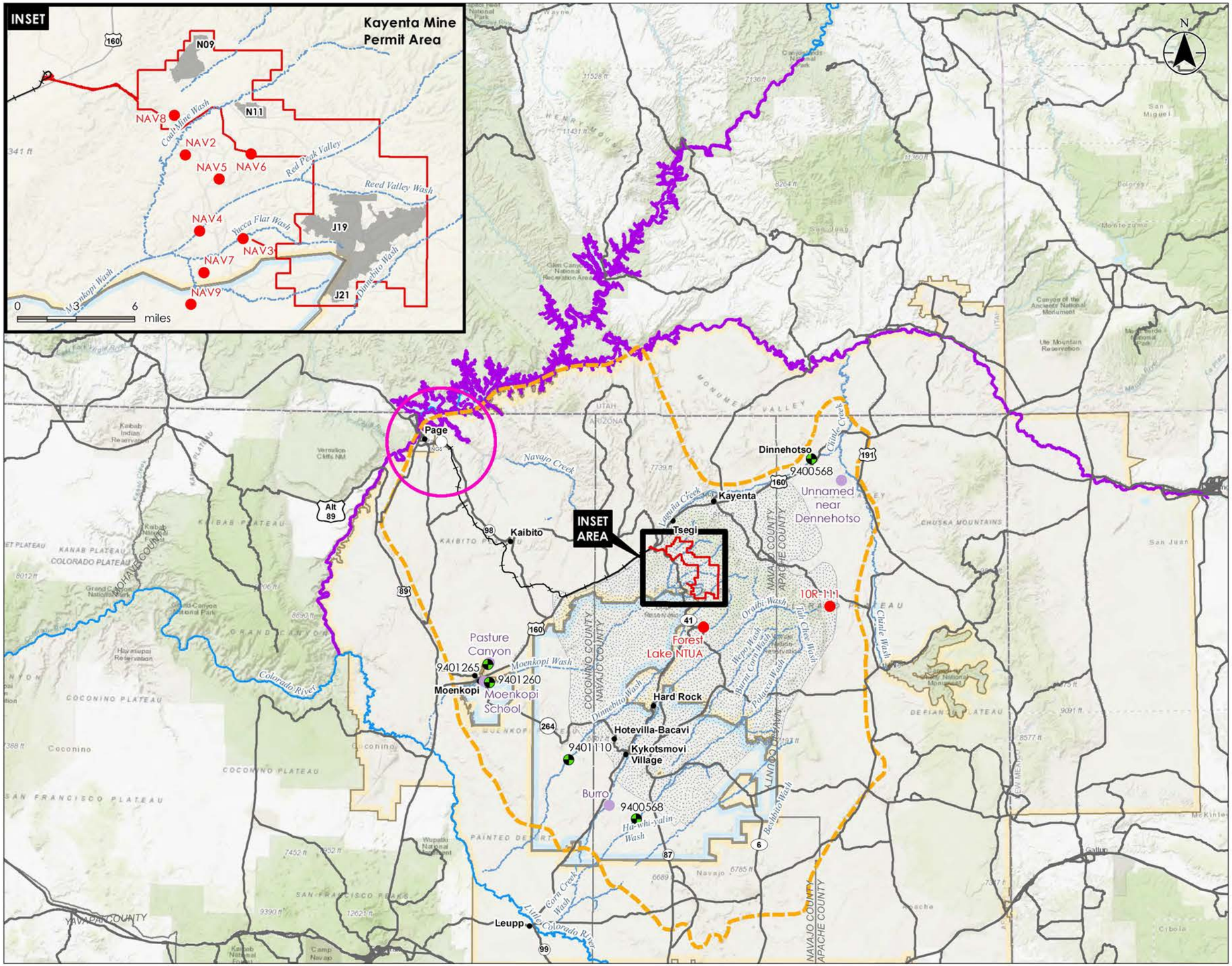
3.7.1.1 Surface Water Regulatory Requirements

Water Quality

Surface water runoff from areas disturbed by mining is required to be managed in a manner that prevents additional contribution of suspended solids to stream flow outside the Permit Area to the extent possible with best available technology and otherwise prevents surface water pollution (30CFR 816.41(d)). PWCC complies with this requirement by designing, constructing, and maintaining siltation structures, impoundments, diversions, and designating stream buffer zones within the Permit Area. PWCC also monitors in-stream water quality and submits quarterly reports to the EPA in accordance with their NPDES permits. OSMRE requires monitoring and reporting of surface water quality under 30 CFR Parts 780.21(i and j) and 30 CFR Part 816.41. Sediment control dams constructed under Section 404 permits are covered by Nationwide Permit 21 (NPW21) which authorizes dredge and fill activities. Water resource uses on Black Mesa and water quality standards for the Navajo Nation and the Hopi Tribe are discussed in Section 3.7.1.3 and summarized in BOR (2016), Appendix WR-1.

Water Quantity

PWCC is required to reclaim lands disturbed by mining to a condition compatible with approved post-mining land uses (PAP). The approved post-mining land uses are livestock grazing, wildlife habitat, and cultural plants. In order to support these three land uses, the PWCC reclamation plan includes the construction of 51 permanent surface water structures to ensure an adequate distribution of post-mining water resources. This reclamation plan has been reviewed and approved by the BIA, the Navajo Nation, the Hopi Tribe, and OSMRE.



Stantec

Legend

- Navajo Generating Station (NGS)
- City/Place
- Railroad
- Major Road
- County
- Hopi Indian Res.
- Navajo Indian Res.
- Kayenta Mine Permit Area (Note 3)
- Coal Resource Area

Selected Hydrologic Features

- Well
- Spring
- Stream Gauge
- River
- Intermittent Stream/Drainage
- N-Aquifer Boundary and Indirect Effects Study Area for Groundwater Resources
- Confined Area of N-Aquifer (Note 4)
- Indirect Effects on Surface Water, Fish and Wildlife
- Indirect Effects on Groundwater, Indian Trust Assets and Vegetation

0 10 20 miles

1:1,460,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 Feet
2. Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community
3. Water Resources Direct Effect Study Area
4. Water Resources Indirect Effect Study Area for the Mine

Project Location
T35N R18E, T35N R19E, T36N R17E, T36N R18E, T36N R19E, T37N R18E
Navajo County, AZ

203706045
Prepared by CLG on 2017-07-31
Technical Review by SL on 2017-07-31
Independent Review DK on 2017-07-31

Client/Project
PWCC
Kayenta Mine SMCRA Permit
Environmental Assessment

Figure No.
3.7-1

Title
Water Resources Study Areas for Direct and Indirect Effects and Selected Hydrologic Features

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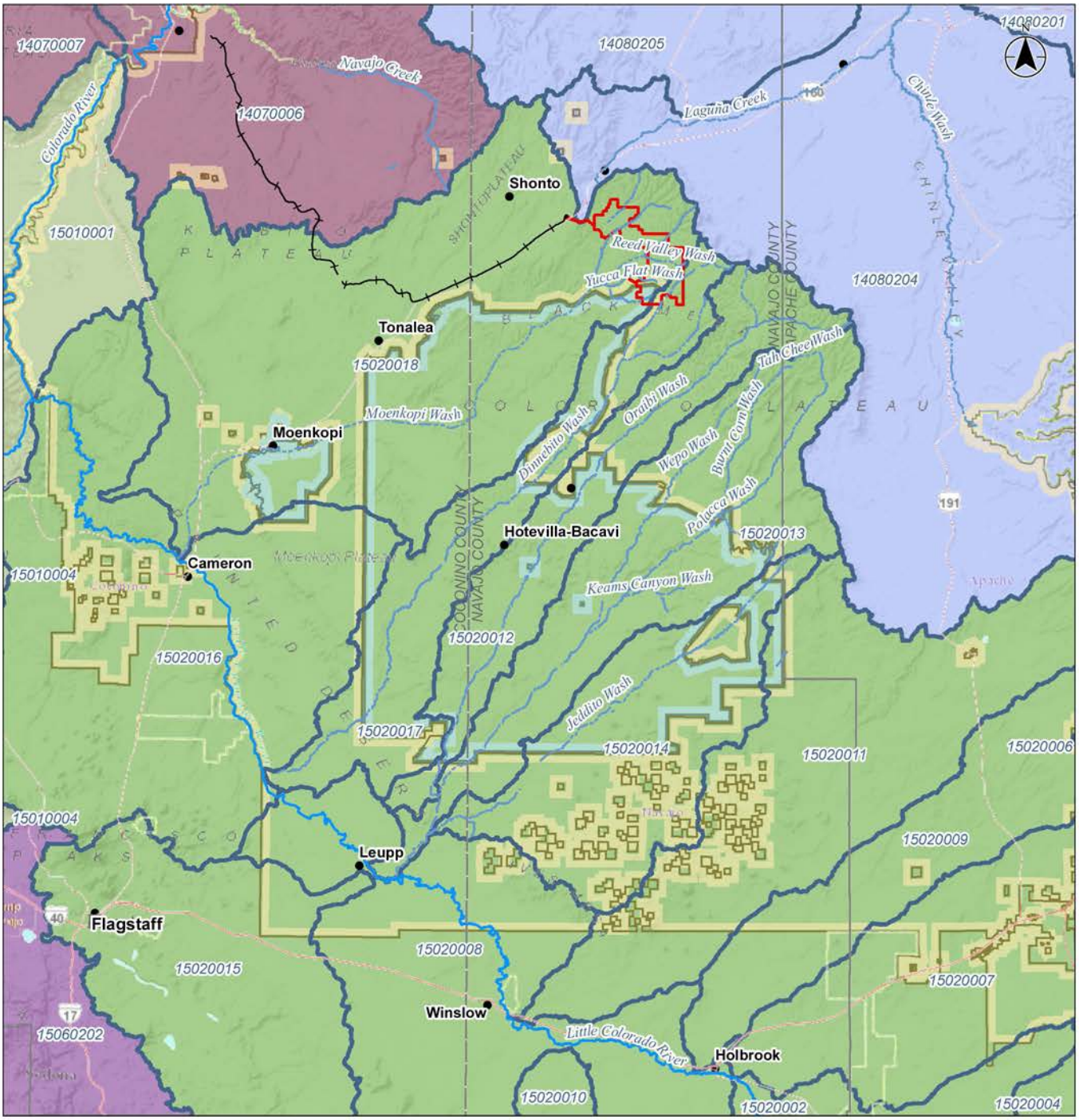
3.7.1.2 Surface Water Baseline Quantity

Major surface water features in the study area, including the Moenkopi, Dinnebito, Oraibi, Wepo, Polacca, and Jeddito washes, drain the study area to the southwest and join the Little Colorado River (**Figure 3.7-2**). Other important drainages associated with the Little Colorado river basin include Pasture Canyon, Shonto Wash, Begashibito Wash, Coal Mine Wash, and Red Peak Valley Wash. Laguna Creek and Chinle Wash drain Black Mesa to the north and join the San Juan River. All of the washes draining the study area are ephemeral with local discontinuous and relatively short intermittent reaches. Springs and seeps (**Section 3.7.2.6**) also discharge into the washes and limited stream segments in the lower portions of these washes may be perennial due to groundwater discharge. Dinnebito Wash and Moenkopi Wash and its five main tributaries convey runoff and spring discharges from the Permit Area. Segments of these washes and their tributaries including Moenkopi, Dinnebito, Wepo, Oraibi, and Laguna Creek are fed by springs. Coal Mine and Yellow Canyon washes are tributary to Moenkopi Wash (**Figure 3.7-1**). None of the tributaries or washes in or near the study area provides a reliable source of water for irrigation, livestock, or potable use. No irrigation diversions or historical use of surface water for irrigation or livestock use have been documented in the Permit Area.

The stream washes within the study area exhibit a parallel drainage pattern suggestive of topographic slope and structural control on drainage development. Within the study area and in the upper reaches of the washes, channel gradients are higher and channel meandering is less compared to downstream reaches. Watersheds associated with the upper reaches typically feature narrow valley profiles and deeply entrenched drainage channels. In the lower reaches, channel gradients lessen and meandering is more pronounced with wider valley bottoms and development of floodplains. Drainage densities range from around four to 16 miles of stream channel per square mile. High drainage densities, such as those developed in the study area, are common in semi-arid watersheds and reflect sandier, less developed soils, high basin elevation differences, lower vegetative cover, and the erosive power of flash floods that are common during high-intensity storm events (PWCC 2005b).

As of 2015, approximately 4.9 percent of the Dinnebito drainage area and 2.8 percent of the Moenkopi drainage area were controlled by sediment control structures. The structures have the potential to impound 40.5 acre-feet (af) of runoff, or about 1.3 percent of the total runoff in the entire Dinnebito Wash Basin (3,034 af). Sediment control structures in Moenkopi Wash have the potential to impound 605.1 af of runoff, or about 6.2 percent of the total runoff in the entire Moenkopi basin (9,727 af).

Surface flows within the study area are highly variable and primarily consist of storm runoff. Forty-six percent of annual precipitation in the study area is received from July through September and 64 percent falls in the period from April through September (PWCC 2001). Storm runoff events range from a few cubic feet per second (cfs) to more than 10,000 cfs depending on the location, intensity, and duration of a storm (OSMRE 2011). Intermittent reaches in many drainages are created by storm saturation of rock units at the surface and discharge of alluvial aquifers holding storm water bank storage. This flow is referred to as base flow and is generally what constitutes the low flow of the stream. Not all stream reaches within the study area exhibit periods of base flow. Based on data collected in 1985 and in 2009, base flow is generally low at stream sites



Notes

1. Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 Feet
2. Service Layer Credits: Sources: Esri, DeLorme, USGS, NPS Sources: Esri, USGS, NOAA
3. This is a classification system developed by the U.S. Geological Survey for identifying sub-basins within a watershed by a unique number.

Legend

- Railroad
- Intermittent Stream/Drainage
- River
- Kayenta Mine Permit Area
- County
- Hopi Indian Res.
- Navajo Indian Res.
- Sub-watershed Boundary and Hydrologic Unit Code (See Note 3.)

Watershed

- Little Colorado
- Lower Colorado-Lake Mead
- Lower San Juan
- Upper Colorado-Dirty Devil
- Verde

0 10 20 miles

1:1,300,000 (at original document size of 8.5x11)

Stantec

Project Location
T35N R18E, T35N R19E, T36N R17E, T36N R18E, T36N R19E, T37N R18E
Navajo County, AZ

203706045
Prepared by NL on 2017-01-05
Technical Review by DK on 2017-01-05
Independent Review by DK on 2017-01-05

Client/Project
PWCC
Kayenta Mine SMCRA Permit
Environmental Assessment

Figure No.
3.7-2

Title
Major Watersheds

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located along the major washes and tributaries (PWCC 2010b, PWCC 2005b). Base flow in Coal Mine Wash, Moenkopi Wash, and Lower Red Peak Valley Wash measured during 1985 and 2009 ranges from low values of 0.09 to 0.13 cfs to higher values ranging up to 1.12 cfs (**Table 3.7-1**).

Table 3.7-1 Base Flows in Major Washes and Tributaries

Wash	Low Base Flow (cfs)	High Base Flow (cfs)
Lower Coal Mine Wash	0.13	1.12
Middle Coal Mine Wash	0.09	0.12
Middle Moenkopi Wash	0.12	0.30
Lower Red Peak Valley Wash	0.11	0.18

Source: PWCC (2010b)

The average channel gradient in the Permit Area is approximately one percent, which induces high flow velocities during storm events (PWCC 2011). Velocities measured by PWCC using current meters commonly exceed five feet per second (fps) and have ranged up to 10 fps. A thunderstorm cell may produce intense rainfall in a small upper tributary, move to other tributaries within the same watershed, and may change intensity as the thunderstorm cell migrates over the area, producing multiple runoff surges at downstream monitoring stations (PWCC 2011).

PWCC established 14 monitoring stations to characterize the surface water regime and surface water quantity on Black Mesa within and near the Permit Area (**Appendix D**, Figure 11). Above-mining (upstream) and below-mining (downstream) monitoring stations were selected on Yellow Water Wash, Coal Mine Wash, Moenkopi Wash, Red Peak Valley Wash, and Dinnebito Wash. During 2001, PWCC submitted a request to OSMRE for cessation of monitoring at the upstream monitoring stations because data collected at these sites fulfilled the monitoring objectives (e.g., characterization of background flow regimes). Accordingly, OSMRE approved a reduction in the number of upstream monitoring stations in 2002.

PWCC currently monitors surface water at downstream monitoring stations 155 (Red Peak Valley Wash), 25 (Coal Mine Wash), 26 (Moenkopi Wash), and 34 (Dinnebito Wash) (**Appendix D**, Figure 11). Stations 155, 26, and 25 collect continuous flow stage levels using ultrasonic gages. Station 34 was originally a crest gage. In 2011, PWCC replaced station 34 with a new station designated SW34, located about one mile upstream, and installed a continuous monitoring gage similar to those at stations 25, 26, and 155 to provide surface water quantity data for monitoring outside of the Permit Area.

Monitoring stations 25, 26, 34, and 155 measure surface water runoff that is not impounded by PWCC dams, ponds, or impoundments, with the exception of relatively small quantities that occur from time to time as discharges from NPDES-permitted sediment control structures. These small flows are reported quarterly to the regulatory agencies (EPA, OSMRE, Navajo Nation, and Hopi Tribe) as required by the NPDES permit. From 2005 to 2009, discharges from NPDES-permitted outfalls (e.g., sediment control structures) due to precipitation events ranged from zero af in 2009 to a maximum of 57.81 af in 2007 with an overall average of 21.28 af for the five-year period. Combined measured surface runoff measured at stream monitoring stations 25, 26, and 155 varied annually for the period from 1987 to 2008, and was generally several orders

of magnitude higher than NPDES discharges during any given year. Total combined annual runoff for these three stations was low in 1994 (124.1 af), reached a maximum value in 2006 (4,105.8 af), and averaged 1,488.5 af for the 22-year time period from 1987 to 2008 (PWCC 2011). Based on the combined drainage area for the three stations (253 square miles), less the PWCC impounded area during each calendar year, an average annual runoff of 0.15 inches was calculated for the Moenkopi Wash drainage area (PWCC 2011).

3.7.1.3 Surface Water Baseline Quality

Navajo Nation surface water quality standards (NNSWQS) (Navajo Nation 2008) and Hopi Tribe water quality standards (HTWQS) (Hopi Tribe 2010) have been used to assess the historical and potential uses of various surface water sources near the Kayenta Mine (BOR 2016, Appendix WR-1). In addition, recommended livestock standards for both total dissolved solids (TDS) (National Academy of Sciences 1972) and sulfate (Botz and Pederson 1976) also have been used (PWCC 2005b). Comparisons with water quality standards established by the Hopi Tribe are limited to sources within the boundary of the Hopi Reservation on PWCC's lease. Water quality standards associated with livestock drinking water and aquatic and wildlife habitat apply to surface waters that support livestock grazing and wildlife habitat, both of which are approved post-mining land uses. Comparisons of shallow groundwater quality are limited to livestock drinking water standards established by the Navajo Nation (2008, 2010) and Hopi Tribe (2010) where applicable. Comparisons of base flow water quality monitored in 2009 with Navajo Nation and Hopi Tribe livestock standards and aquatic and wildlife habitat standards indicate most base flow meets these standards (PWCC 2010b). Because of the potential indirect effects of coal combustion at the NGS on aquatic biota, see **Section 3.9.6** for a discussion of overall baseline water quality information in the Colorado and San Juan River Basins.

Surface water quality varies based on the type of runoff (storm water runoff, snowmelt runoff, or base flow) to stream channels (PWCC 2011; Truini et al. 2005; USGS 2010). Data collected from surface water monitoring stations from 1980 to 2014 indicate that the dominant dissolved ions are calcium, magnesium, sodium (at times), bicarbonate, and sulfate. Dominant water types are calcium-magnesium sulfate and calcium-magnesium bicarbonate. Total suspended solids (TSS) varies depending on the nature of the storm and runoff and can range up to 994,000 milligrams per liter (mg/L). TDS can range up to 6,100 mg/L (BOR 2016, Appendix WR-1).

Exceedances of either the most protective water quality standard or the livestock watering standard are mainly for aluminum, cadmium, selenium, Pb, mercury, TSS, TDS, sulfate, vanadium, arsenic, copper, and iron. Streams with notable exceedances are Dinnebito Wash and Moenkopi Wash (BOR 2016, Appendix WR-1).

Stream water quality data presented in BOR (2016), Appendix WR-1 for years 2010 to 2014 indicate that open-channel flows on the Lease Area have mixed major cation chemistry (calcium, magnesium, sodium) with sulfate being the dominant anion for most streams. TDS ranges from 2,500 to 5,000 mg/L and was generally greater during low flow and baseflow conditions. TDS can decline during rainfall events, depending on the quality of the storm water runoff, and TDS generally increases downstream. Mixed source flows, where baseflow and runoff-affected flows mix, can have water quality intermediate between storm water runoff and baseflow. For Coal Mine Wash, the TDS of the mixed source flow is around 3,000 mg/L while the TDS of baseflow

is about 5,400 mg/L. This same mixing to yield intermediate water quality applies to other constituents as well.

Baseflow water quality generally declines downstream with an increase in TDS and other constituents. For Coal Mine Wash, TDS increases along with sodium and sulfate from Station SWQ80R (TDS = 4,820 mg/L) to Station SW 25 (TDS = 5,370 mg/L). For this stretch of Coal Mine Wash, most trace metals do not change appreciably and chloride shows a slight decrease downstream. However, for Moenkopi Wash between Stations SW2A (upstream) and SW26 (downstream), baseflow concentrations of TDS, sulfate, sodium, and other constituents do not change appreciably. Selenium decreases downstream. Thus, baseflow water quality changes along a major stream depend on the sources of water entering the stream and the variation in baseflow water quality that often reflects the lithology of units supplying baseflow. Mixed baseflow and runoff-affected flows also can show variations from drainage to drainage depending on seasonal water quality variations in runoff and variations in baseflow water quality along a drainage (BOR 2016, Appendix WR-1).

3.7.1.4 Storm Water Quality

PWCC categorizes surface water quality data based on sources of surface water monitored for permit requirements, including rainfall (storm water). Storm water generally has less contact time with salt-containing materials and TDS concentrations tend to decrease as runoff increases. Water quality analyses indicate a variety of water types, mostly calcium/magnesium sulfate and calcium/magnesium bicarbonate water. Mean concentrations of select chemical parameters in storm water on streams with monitoring stations are shown in **Table 3.7-2** along with the most protective water quality standard from the NNSWQS and the HTWQS and the livestock watering criterion for the chemical parameter.

These chemical parameters are indicators of water quality. Comparisons of storm water runoff water quality monitored in 2009 with NNSWQS and HTWQS for livestock and aquatic and wildlife habitat indicate 88 percent of the analytical results met livestock standards. Comparisons of the same 2009 water quality data with acute aquatic and wildlife habitat standards indicate 86 percent of analytical results met these standards (PWCC 2010b). As shown in **Table 3.7-2**, most exceedances of water quality standards are for TDS and sulfate. There currently are no livestock water quality criterion for TDS and sulfate in the NNSWQS and HTWQS. Samples collected from storm water runoff events that are not filtered and are analyzed for trace elements using the total or total recoverable methods often yield high values due to the high-suspended solids concentrations (PWCC 2008). Storm water runoff typically carries very high concentrations of suspended solids, which are often greater than 10,000 mg/L (PWCC 2005b).

3.7.1.5 Pond Water Quality

Sediment control structures (or impoundments) are earthen embankments constructed across ephemeral drainages from materials excavated locally using standard engineering and construction methods. These impoundments (or ponds) are necessary to provide treatment of disturbed area runoff (settle out entrained sediment) prior to discharge into receiving streams. In 2010, 156 sediment control structures provided treatment of disturbed area runoff from mined areas within the PWCC Lease Area. Water quality data collected between 1986 and 2008 and in 2009

Table 3.7-2 Mean Chemical Parameters in Storm Water (1986 to 2008)

Chemical Parameter	Most Protective Standard (NN:Navajo Nation;HT: Hopi Tribe)	WQS	Livestock Watering Criterion	Streams with Monitoring Sites												
				Dinnebito Wash			Reed Valley Wash	Yellow Water Wash	Yazzie Wash	Coal Mine Wash			Red Peak Valley Wash		Moenkopi Wash	
				Site Numbers												
				34	78	37[1]	50	15	157	16	18[2]	25	14	155	35	26
pH (s.u.)	Livestock (both)	6.5-9.0	6.5-9.0	8.0	8.0	8.0	8.0	8.0	8.1	8.1	8.0	8.0	8.2	8.3	8.1	8.1
TDS (mg/L)	Aquatic and Wildlife Habitat (HT)	500	NCNS	1,179	1,462	1,485	755	686	229	471	1,335	1,503	271	324	292	924
Alkalinity (s.u.)	NNS	n/a	n/a	98	87	121	86	85	112	80	123	130	95	94	68	100
Sulfate (mg/L)	Aquatic and Wildlife Habitat (HT)	250	NCNS	671	919	694	437	398	112	242	809	917	106	135	118	525
Calcium (mg/L)	NNS	n/a	n/a	160	194	162	125	127	48	87	165	165	46	44	52	128
Magnesium (mg/L)	NNS	n/a	n/a	62	95	105	44	34	8	19	80	92	12	12	11	53
Sodium (mg/L)	NNS	n/a	n/a	64	96	100	19	16	4	13	104	135	15	33	5	68
Chloride (mg/L)	Aquatic and Wildlife (HT)	230	NCNS	15	22	213	17	10	3	8	27	21	10	11	4	40

Source: PWCC (2010b) for data; PWCC 2012 and BOR (2016) for standards.

[1] Excludes chemical data for two samples that were influenced by magnesium chloride spills up-gradient of this monitoring site.

[2] Includes chemical data from subsites FLUM18 and CG18.

pH = measure of acidity of a solution; s.u. = standard units; mg/L = milligrams per liter; µg/l = micrograms per liter; NNS = no numeric standard; NCNS = no current numeric standard. NN = Navajo Nation standard; HT = Hopi Tribe standard.

at proposed permanent impoundments located within or adjacent to reclaimed areas were compared to Navajo Nation and Hopi Tribe livestock-watering standards and aquatic and wildlife habitat standards. The comparisons indicate more than 95 percent of the analytical results compared met the livestock standards, and more than 98 percent of the analytical results compared met the aquatic and wildlife habitat standards (PWCC 2010b). The quality of water in these impoundments is similar to the water quality of storm water collected from natural drainages; however, TDS, sulfate, calcium, magnesium, sodium, and chloride concentrations are typically lower in the impoundments than in natural drainages (**Table 3.7-3**). Based on the water quality of permanent impoundments located in reclaimed areas, runoff from reclaimed areas that contribute to the impoundments had similar water quality composition (PWCC 2010b). Permanent impoundments must meet performance standards outlined in 30 CFR 816.49(b), and meet applicable federal, state, and tribal water quality standards. The quality of impounded water must be suitable on a permanent basis to support the approved post-mining land uses of livestock grazing and wildlife habitat at final bond release.

Pond water quality reported in PWCC (2010b) consisted of calcium-sodium bicarbonate water with elevated sulfate. When compared to livestock water quality standards exceedances of one or more NNSWQS or HTWQS for pH, aluminum, cadmium, copper, Pb, mercury, and aluminum were noted (OSMRE 2011b). TDS ranged from 163 to 9,509 mg/L with most pond samples falling in the range of 100 to 700 mg/L. Exceedances for livestock watering standards and agricultural irrigation standards were noted for pH (6.5 – 9.0 s.u.); exceedances of HTWQS aquatic and wildlife standards were noted for pH (6.0-9.0), sulfate (250 mg/L), and TDS (500 mg/L).

Monitored ponds in the J1/J3/J7 area (southwestern part of the Lease Area) exceed the most protective water standards for aluminum about 70 percent of the time, and total iron about 40 percent of the time. Exceedances for other constituents are infrequent. Livestock water quality standards are consistently met, with the exception of pH in one sample (BOR 2016, Appendix WR-2).

Ponds monitored in the J16/J19/J28/J21 area (eastern part of the Lease Area) showed total aluminum and total iron exceeding the most protective water quality standard 45 and 30 percent of the time, respectively. TDS exceed the most protective standard in 70 percent of the samples. Sulfate and chloride exceed the most protective standard in 45 and 20 percent of the samples, respectively. No other constituents exceed the most protective water quality standard. All constituents are within livestock water quality standards (BOR 2016, Appendix WR-2).

Ponds monitored in the N10/N11/N2/N6 area (northern part of the Lease Area) show that total aluminum exceeds the most protective standard in 25 percent of the samples. Total iron exceeds the most protective standard in less than 10 percent of the samples. TDS and sulfate consistently exceed the most protective standard and selenium exceeds the most protective standard in 50 percent of the samples. All other constituents are within livestock standards, except for one sample with elevated pH (BOR 2016, Appendix WR-2).

Table 3.7-3 Mean Chemical Parameters, Impoundments (1986 to 2008)

Chemical Parameter	Most Protective Standard	WQS	Livestock Watering Criterion	Permanent Impoundment Site Numbers													
				116	124	118a	N1- RA	122[1]	123[1]	112[1]	113[1]	119[1]	N7- D	N2- RA	N2- RB	N2- RC	N8- RA
pH (s.u.)	Livestock (both)	6.5-9.0	6.5-9.0	8.2	7.8	8.6	9.5	8.0	7.5	7.8	7.9	7.9	8.1	8.6	8.1	8.6	8.0
TDS (mg/L)	Aquatic and Wildlife Habitat (HT)	500	NCNS	459	205	144	440	143	177	281	603	165	939	9509	566	227	133
Alkalinity (s.u.)	NNS	n/a	n/a	84	100	105	142	96	102	109	205	116	74	261	113	97	56
Sulfate (mg/L)	Aquatic and Wildlife Habitat (HT)	250	NCNS	225	68	16	197	15	21	98	252	25	595	6557	297	79	34
Calcium (mg/L)	NNS	n/a	n/a	63	44	24	35	25	26	24	46	29	155	359	108	44	26
Magnesium (mg/L)	NNS	n/a	n/a	25	13	11	24	9	9	12	21	12	56	432	34	12	4
Sodium (mg/L)	NNS	n/a	n/a	29	4	5	70	4	7	44	117	9	41	1934	12	6	2
Chloride (mg/L)	Aquatic and Wildlife (HT)	230	NCNS	10	3	5	7	5	6	4	8	2	20	45	7	4	4

Source: PWCC (2010b) for data; PWCC (2012) and BOR (2016) for standards

[1]Pre-law area ponds.

pH = measure of acidity of a solution; s.u. = standard units; mg/L = milligrams per liter; µg/l = micrograms per liter; HT=Hopi Tribe: NN = Navajo Nation; NCNS = no current numeric standard; n/a = not applicable.

Evaporative conditions exist at all of the ponds and prolonged retention of water in a pond can result in an increase in constituent concentrations, especially for TDS and sulfate. Although total aluminum and iron commonly exceed the most protective standard for water quality, their values in pond samples are less than five percent of corresponding values in runoff-generated stream flows. Typical values are usually one percent or less of the values found in storm water runoff or mixed runoff/baseflow samples from streams. Overall, the main potential use of pond water is livestock watering and most ponds meet livestock water standards (BOR 2016, Appendix WR-2).

3.7.1.6 Seep Water Quality

Seepage through the embankment of impoundments or surrounding geology (e.g., thin coal seams) can react with naturally occurring constituents in the embankment materials or the more permeable geologic formations in the vicinity. These reactions can result in elevated concentrations of water quality parameters such as pH, nitrate, aluminum, selenium, iron, and other trace elements in the seep water. On occasion, water quality samples collected from seeps below impoundments have exceeded water quality standards for these parameters within the Permit Area.

Since mining began, over 220 sediment impoundments have been built, and seeps have been observed at 33 of these impoundments since 1972. At some sediment ponds, impounded water persists in large enough amounts and for sufficient durations to seep through the bottom of the embankment or more permeable underlying geologic formations. The seeps range in size from damp areas less than 0.10 acre at the embankment toe to areas with persistent water flow at rates up to several gallons per minute (gpm). The EPA required PWCC to conduct a comprehensive study of seeps below NPDES ponds in 1995. This study concluded that constituent concentrations in seep water greater than applicable water quality standards were attributable to natural processes, and/or the geologic material within the Permit Area (Brogan-Johnson Consultants Inc. 1996). PWCC developed a Seepage Management Plan (PWCC 2005a) to manage seeps below NPDES-permitted sediment-control structures. The plan was approved by EPA and subsequently incorporated into the NPDES permit.

From 2009 to 2010, 13 NPDES impoundments had seeps with sufficient water for water quality sampling. The water quality samples were measured in the field for electrical conductivity, pH, temperature, and salinity and analyzed in the laboratory for cadmium, nitrate/nitrite, selenium, aluminum, and copper. The analytical results were compared to Navajo Nation and Hopi Tribe standards established for livestock drinking water and the most protective water quality standard for a given constituent listed by either NNSWQS or HTQQS. The comparisons indicated that 10 of the 13 seeps sampled had one or more constituent concentrations greater than the standards (**Table 3.7-4**). The cadmium value measured at BM-A1-SP1 was qualified as being between the method detection limit and the practical quantitation limit, and is therefore not considered to be a statistically valid analytical result. Local geologic materials may have contributed to the cadmium detection, or the lab result may be anomalous. Sheep and other livestock waste in the vicinity likely influence nitrate levels at BM-A1-SP2. The aluminum value measured at J3-E-S2 was the first value that exceeded the standard, and is the only exceedance at the two seeps monitored below Pond J3-E since monitoring began, and may be anomalous. The copper value measured at J7-JR-S1 was qualified as being between the method detection limit and the practical quantification limit, and is therefore not considered to be a statistically

valid analytical result. Local geologic materials may have contributed to the copper detection, or the lab result may be anomalous.

Table 3.7-4 Seep-Water Sample Exceedances (2009 to 2010)

Seep Monitoring Site	Water Quality Parameter(s)	Most Protective Standard (NN: Navajo Nation; HT: Hopi Tribe)	Associated Water Quality Criterion	Livestock Watering Criterion	Result and Sample Year
BM-A1-SP1	Total cadmium (ug/L)	Fish Consumption (NN)	8	50	8.0 ug/l (2009)
	Aluminum	Agric Water, Livestock (HT)	5	5	14 mg/L (2010)
	pH	Livestock (Both)	6.5-9.0	6.5-9.0	4.9 s.u. (2010)
	Selenium	Aquatic and Wildlife, chronic (Both)	2	50	24 ug/L (2010)
BM-A1-SP2	Nitrate/Nitrite	Full Body Contact (HT)	1,493	NCNS	260 mg/L (2009)
	Total Selenium	Aquatic and Wildlife, chronic (Both)	2	50	36 ug/L (2009)
BM-A1-S1A	Nitrate	Full Body Contact (HT)	1,493	NCNS	278 mg/L (2011)
	Selenium	Aquatic and Wildlife, chronic (Both)	2	50	67 ug/L (2011)
BM-A1-S2	Aluminum	Agric Water, Livestock (HT)	5	5	14 mg/L (2010)
	pH	Livestock (Both)	6.5-9.0	6.5-9.0	4.9 s.u. (2010)
	Selenium	Aquatic and Wildlife, chronic (Both)	2	50	36 ug/L (2010)
BM-A1-S3	Aluminum	Agric Water, Livestock (HT)	5	5	5.12 mg/L (2010)
	pH	Livestock (Both)	6.5-9.0	6.5-9.0	3.82 s.u. (2010)
	Selenium	Aquatic and Wildlife, chronic (Both)	2	50	24 ug/L (2010)
J3-D-S1	Selenium	Aquatic and Wildlife, chronic (Both)	2	50	114 ug/L (2010)
J3-D-S2	Selenium	Aquatic and Wildlife, chronic (Both)	2	50	27 ug/L (2010)
J3-E-S2	Total Aluminum	Aquatic and Wildlife, chronic (NN)	0.087	NCNS	2.18 mg/L (2009)
J7-JR-S1	Total Copper	Livestock (HT)	500	500	60 ug/L (2009)
J7-DAM-S5	Aluminum	Agric Water, Livestock (HT)	5	5	0.76 mg/L (2010)
J16-E-S2(a)	Aluminum	Agric Water, Livestock (HT)	5	5	5.85 mg/L (2010)
N6-F-S1	Total Aluminum	Aquatic and Wildlife, chronic, (NN)	0.087	NCNS	172 mg/L (2009)
	pH	Livestock (Both)	6.5-9.0	6.5-9.0	3.62-4.12 s.u. (2009)

Seep Monitoring Site	Water Quality Parameter(s)	Most Protective Standard (NN: Navajo Nation; HT: Hopi Tribe)	Associated Water Quality Criterion	Livestock Watering Criterion	Result and Sample Year
WW-9-S1	TDS	Aquatic and Wildlife Habitat (HT)	500	NCNS	5790 mg/L (2010)
	Sulfate	Aquatic and Wildlife Habitat (HT)	250	NCNS	3200 mg/L (2010)

Source: PWCC 2010c for data; PWCC (2012) and BOR (2016) for standards
NCNS: No Current Numeric Standard.
Concentrations in mg/L unless otherwise noted.
pH = measure of acidity or alkalinity of a solution; s.u. = standard units; mg/L = milligrams per liter; µg/l = micrograms per liter

Finally, the aluminum value that exceeded the standard at Seep N6-F-S1 and the low pH measurements are similar to historical measurements at this site. Reclamation in the fall of 2009 removed the sediment control structure at Pond N6-F, which removed Seep N6-F-S1 permanently. At the remaining eight NPDES sediment ponds, seeps met all Navajo Nation and Hopi Tribe standards established for livestock drinking water and aquatic and wildlife habitat (PWCC 2010c). Livestock watering criteria were exceeded at seven of the seeps, with most exceedances being for aluminum, selenium, and pH.

Flow rates of the seeps monitored in 2009 were within the historical range of seep flows (ranging from pooled water [no flow] to 9.5 gpm). During 2009, there were fewer NPDES ponds exhibiting poor seep-water quality than in prior years. The constituent results that exceeded water quality standards were comparable to historical ranges.

3.7.1.7 Spring Water Quality

Flow rates range up to a maximum around 240 gpm (spring NSPG561), with mean flow rates mostly in the range of 0-6 gpm and a maximum mean flow of 32 gpm at spring NSPG561. Median flow rates for most springs are in the range of 0-2 gpm, with a maximum of 6.6 gpm at spring NSPG561. Spring water quality is dominated by calcium-sodium-magnesium sulfate. TDS can range up to 15,000 mg/L, while the mean TDS is in the range of 1,000 to 10,000 mg/L for each set of springs sampled (BOR 2016, Appendix WR-3).

Water quality in the northern part of the PWCC coal Lease Area at springs NSPG91, NSPG95, and NSPG111 is dominated by magnesium sulfate or mixed sulfate type with TDS generally greater than 5,000 mg/L. Sulfate values are around 4,000 mg/L and the water quality reflects the origin of the springs in the Wepo Formation. No livestock water standards are exceeded, but the most protective water quality standards are exceeded by boron in 25 percent of the samples and by total iron in 30 percent of samples. Sulfate and TDS consistently exceed most protective criteria for several beneficial uses (BOR 2016, Appendix WR-3).

Springs along Coal Mine Wash show a mixed sulfate or sodium sulfate dominated water quality. TDS and sulfate are variable. Total cadmium and total aluminum exceed the most protective water quality standard in 35 percent and 30 percent of samples, respectively. Selenium exceeds the most protective standard in 20 percent of samples, and TDS and sulfate consistently exceed the most protective standard. Livestock watering standards are met by all constituents except dissolved aluminum, which exceeds the standard in 15 percent of samples (BOR 2016, Appendix WR-3).

Springs in the southwestern part of the Lease Area, along Moenkopi Wash, have water quality dominated by sodium sulfate with TDS in the range of 6,000 to 12,000 mg/L. Selenium exceeds the chronic aquatic and wildlife habitat standard in most samples. Livestock watering standards are met by all constituents (BOR 2016, Appendix WR-3).

Springs NPGS151 and NSPG162 located along Moenkopi Wash in the eastern part of the Lease Area, near mine operations area J16, have water quality reflecting a mixed sulfate or sodium sulfate type of water with TDS ranging from 6,650 to 12,800 mg/L. Sulfate values are over 4,000 mg/L. Spring NSP162 is acidic and has no detected bicarbonate concentrations. The maximum flow at spring NSP162 recorded from 2010 to 2014 was 0.5 gpm. Selenium values exceed both wildlife and livestock criteria at both springs. Dissolved cadmium, chloride, and zinc concentrations exceed the most protective criteria in 30-55 percent of samples. Boron exceeds the most protective criteria in 50 to 100 percent of samples, depending on which tribal criteria value is chosen (BOR 2016, Appendix WR-3).

3.7.2 Groundwater

Coal mining at the Kayenta Mine occurs in the Wepo Formation of the Mesa Verde Group (**Figure 3.2-1**). In some locations, this formation is connected hydraulically to alluvium in the stream channels that drain the study area. PWCC utilizes groundwater from three active water supply wells completed in the N-Aquifer within the Permit Area to provide water for mining, dust control, and other infrastructure needs. These wells withdraw water from the N-Aquifer, which is comprised of (in ascending stratigraphic order) the Wingate Sandstone, the Kayenta Formation, and the Navajo Sandstone beneath the leasehold. The N-Aquifer is used by the Hopi and Navajo communities for domestic water supply. The D-Aquifer, which is comprised of (in ascending stratigraphic order) the Entrada Sandstone member of the Summerville Formation, the Cow Springs Sandstone, sandstone members of the Morrison Formation, and the Dakota Sandstone, is utilized only in isolated areas where the water quantity and quality supports domestic or livestock use (OSMRE 2011a). A third regional aquifer system, the Coconino (C)-Aquifer (Coconino Formation) exists below the N-Aquifer and is separated from the N-Aquifer by a confining layer consisting of siltstone, mudstone, and claystone comprising the Chinle Formation. The C-Aquifer is not used for water supply in the Permit Area.

3.7.2.1 Groundwater Regulatory Requirements

Thirty (30) CFR 816.41(h) states that "water supply of an owner of interest used for domestic, agricultural, industrial, or other legitimate use that is adversely impacted by contamination, diminution, or interruption proximately resulting from surface mining activities shall be replaced" (OSMRE 2011a). PWCC use of groundwater for mining operations is authorized based on current lease agreements. The coal leases from the Navajo Nation and the Hopi Tribe state that PWCC may "develop and utilize water obtained from wells located on the leased premises for use in mining operations…" (Stetson 1966). Pumped water is metered and payment is made to the tribes based on a royalty rate that is periodically renegotiated. PWCC commits to proper protection and maintenance of the production wells in accordance with the lease agreements. PWCC provides potable water to the public and mine personnel under a Public Water System permit issued by the Navajo EPA Public Water Systems Supervision Program. This permit requires compliance including monitoring and reporting of water quality related to supplying

domestic drinking water. PWCC monitors groundwater levels and quality in accordance with 30 CFR Parts 780.21 (i and j) and 30 CFR Part 816.41 as required by OSMRE.

3.7.2.2 Alluvium

Geomorphic mapping of the alluvium and colluvium along the principal washes and tributaries in the Permit Area and adjacent areas in 1980 identified Dinnebito, Reed Valley, lower Coal Mine, and lower Moenkopi (two-mile segment downstream from permit boundary) washes as having the largest amount of alluvium and saturated alluvial material (PWCC 2011). Studies conducted to determine the presence of alluvial valley floors (AVFs) concluded that the potential for agricultural practices in alluvial areas adjacent to the mine is limited, and that AVFs do not exist on or immediately adjacent to the mine (PWCC 2011). The degree of saturation in the alluvium is variable across the leasehold, and some headwater reaches of the major washes and tributaries contain little or no alluvial water. Since monitoring efforts began around 1980, PWCC has installed 89 monitoring wells to characterize the hydrogeologic conditions of the alluvium (**Appendix D**, Figure 13). Seismic refraction studies were completed to evaluate alluvial thickness and water saturation.

The channel alluvium is recharged from infiltration of surface water runoff, from direct precipitation, and from groundwater emanating from the saturated areas of the Mesa Verde Group that are hydraulically connected to the alluvium, mainly the Wepo Formation. The results of seismic refraction studies noted the occurrence of water level gradients from the Wepo Formation to the alluvium at monitoring stations 31R, 77, 100R, 103, 107, and 110R (PWCC 2011). Typically, alluvial monitoring hydrographs show a gradual decline in water levels in the spring and late fall, and water level rises during the summer monsoon season and during wet winters in response to infiltration of snowmelt runoff.

Pre-mining water use was mainly from shallow wells, springs, and ponds developed in the alluvium and the Wepo Formation aquifer. Approximately 40 wells have been identified by PWCC along with about 50 springs and 25 ponds (PWCC 2011). Of these, 29 wells are in the alluvium and 11 springs are in the alluvium. Many of the historic wells are deep wells screened in units below the alluvium and the Wepo Formation.

Alluvial Baseline Water Quantity

Saturated thickness and saturated cross-sectional areas were determined for the primary washes within the Permit Area using borehole lithology, groundwater monitoring wells, and seismic refraction. The major washes investigated include Reed Valley Wash, Red Peak Valley Wash, Yellow Water Canyon Wash, Coal Mine Wash, Yucca Flat Wash, Moenkopi Wash, and Dinnebito Wash.

Average saturated thickness ranges from three to 34 feet, while saturated cross-sectional areas ranged from 900 to 40,000 square feet. The thinnest saturated areas within the Permit Area are present at Upper Red Peak Valley Wash, Upper Yellow Water Canyon Wash, and Upper Yucca Flat Wash, while the greatest saturated thicknesses were found at Lower Yellow Water Canyon Wash, Lower Coal Mine Wash, Lower and Upper Dinnebito Wash, and Middle Reed Valley Wash. The greatest cross-sectional areas were along Dinnebito, Lower Moenkopi, and Coal Mine washes (PWCC 2011). Groundwater gradients ranged from 0.007 to 0.025 feet/feet over large distances and from 0.002 to 0.028 feet/feet on a local scale over shorter distances (PWCC 2011).

Depth to water ranges from 3 to 10 feet below ground surface (bgs) to around 30 feet bgs maximum for most alluvial wells. Fluctuations in the water table for 2015 were generally less than 1.0 foot and for period from 2005 to 2015 water table fluctuations were generally less than 2-3 feet and mostly less than 1.0 foot.

A review of borehole lithology indicated that the alluvium consists of poorly sorted sediments ranging from silty clays to gravels and cobbles. The variation is a result of previous channel scour and associated sediment deposition. Variations in alluvial material lithology and grain size influence the hydraulic conductivity and transmissivity (hydraulic conductivity x saturated thickness) of the saturated material. The transmissivity of the alluvial material was evaluated at 19 locations using time-distance drawdown aquifer tests in pits excavated into the alluvium or slug injection tests into the well bores (**Appendix D**, Figure 15). Transmissivity values from pit pumping tests near alluvial wells 74, 84, 88, and 95 ranged from 1,870 to 5,100 gallons per day per foot (gpd/ft); transmissivity derived from slug injection tests ranged from 21 to 1,517 gpd/ft (PWCC 2011). The heterogeneity of the channel alluvium identified in the borehole lithology is evident in the range of transmissivity results for the various washes. Transmissivity typically can vary by an order of magnitude within the same wash. Alluvial ground water flow rates are driven by local hydraulic gradients, which vary depending on magnitude, frequency, and duration of the surface runoff and subsequent infiltration of runoff water.

Alluvial Baseline Water Quality

Water quality in the alluvial drainages was evaluated for agricultural livestock water use in 2011 using monitoring data collected from the alluvial monitoring network (**Appendix D**, Figure 13). Water quality for upstream locations in Dinnebito Wash and Moenkopi Wash are presented in **Appendix D**, Table 3. Overall, groundwater quality in the alluvium is dominated by calcium-magnesium sulfate or sodium-magnesium sulfate (mixed sulfate water) and TDS ranges from 764 mg/L to 12,500 mg/L with most values in the range of 2,000 to 6,000 mg/L (PWCC 2011). Monitoring of wells in the alluvial groundwater show that alluvial groundwater meets Hopi Tribe (2010) and Navajo Nation (2008) water quality standards for livestock use. Only wells ALUV 199 and ALUV 99R did not meet these standards, and these exceedances were for pH.

Groundwater quality in alluvial monitoring wells can vary depending on the season due to seasonal variations in recharge mechanisms for the alluvium in the drainages of the study area. The majority of alluvial recharge occurs during the monsoon season of July through September when surface water flow events infiltrate into the channel alluvium. Recharge also occurs as a result of surface water runoff during snowmelt, typically in February and March. During other months, recharge to the alluvium may be minimal along reaches with no hydraulic connection to saturated portions of the Wepo Formation. However, recharge may occur year-round along channel reaches where saturated portions of the Wepo Formation are in direct hydraulic communication with the adjacent alluvial deposits. Where alluvial recharge is primarily from the Wepo Formation it occurs as groundwater base flow into the alluvial material (OSMRE 2011a). Thus, water quality can vary seasonally in the alluvial material.

PWCC (2011) noted that TDS was typically lower during rainfall recharge and elevated during the dry season recharge from the Wepo Formation. TDS also was elevated during snowmelt recharge. OSMRE (2011a) stated that the major control on water quality variability in the alluvial material was location. Different areas within a wash can show variations in water quality.

Upstream water quality in the washes reviewed by OSMRE (2011a) showed elevated sulfate concentrations and water quality that did not vary appreciably, except for the upper reach of Coal Mine Wash.

Water levels vary in the alluvial aquifer due to seasonal variations, increasing drought, and mining activity in the Wepo Formation, which can affect groundwater flowing from the Wepo into the alluvial aquifer. Water levels in Coal Mine Wash have risen in some wells (ALUV 17, 19, 80R,83, 193, and 200) and declined in others (ALUV 72). Water level trends in Moenkopi Wash, Yellow Water Canyon, Red Peak Valley, and Dinnebito Wash also show mixed trends depending on location relative to mining activity (BOR 2016, Appendix WR-4).

Water quality in the alluvial aquifer varies by drainage. Alluvial water is sometimes used for irrigation and livestock watering, but is not used for domestic consumption. Only the livestock water standard applies to alluvial groundwater. In Yellow Water Canyon, alluvial water is the mixed sulfate type with TDS ranging from 2,900 to 5,700 mg/L. No exceedances of livestock water standards have been noted. Similarly, alluvial groundwater in Coal Mine Wash is of the mixed sulfate type with more bicarbonate than noted in Yellow Water Canyon. Livestock watering standards are met in Coal Mine Wash alluvial water (BOR 2016, Appendix WR-4).

In Moenkopi Wash, alluvial groundwater is dominated by magnesium-sodium sulfate with TDS in the range of 2,400 to 9,900 mg/L and bicarbonate ranging from 320 to 680 mg/L. Sulfate ranges from 1,470 to 6,300 mg/L. The water meets livestock watering standards. Downstream in Moenkopi Wash at well ALUV93 the groundwater is dominated by sodium sulfate and is mineralized due to the well being located near a greasewood-dominated terrace. TDS ranges from 9,770 to 24,700 mg/L (BOR 2016, Appendix WR-4).

Alluvial water in Reed Valley Wash is similar to that in Moenkopi Wash and is the mixed sulfate type of groundwater with TDS ranging from 1,260 to 9,150 mg/L. In the Red Peak Valley/Yucca Flat/Sagebrush Wash tributaries to Moenkopi Wash, wells ALUV 104, 105, and 106 show a range of water types varying from calcium-bicarbonate water to mixed sulfate water with sulfate in the range of 210 to 1,140 mg/L and bicarbonate ranging from 193 to 354 mg/L. TDS ranges from 3,820 to6,550 mg/L and the water quality meets livestock watering standards (BOR 2016, Appendix WR-4).

Along Dinnebito Wash, alluvial groundwater quality is a mixed sulfate or calcium sulfate type with TDS in the range of 2,550 to 4,990 mg/L. Bicarbonate values range from 290 to 430 mg/L. The concentration of sulfate, bicarbonate, and other constituents varies considerably along Dinnebito Wash, but the water quality meets livestock watering standards (BOR 2016, Appendix WR-4).

3.7.2.3 Wepo Formation

The Mesa Verde Group is the uppermost lithologic unit in the study area and includes the Yale Point Sandstone, the Wepo Formation, and the Toreva Formation in stratigraphic order from top to bottom. The Wepo Formation contains the coal mined at the Kayenta Mine and mining operations occasionally intercept local areas of groundwater within the Wepo Formation. In addition, the Wepo Formation provides recharge to the channel alluvium in locations where saturated portions of the Wepo Formation are in hydraulic communication with the channel alluvium. To date, three windmill wells completed in the Mesa Verde Formation (Wepo and

Toreva) have been removed by mining. PWCC has committed to replacing all three windmill wells once reclamation is complete and a grazing unit is established at the relocated sites and prior to final bond release or termination of jurisdiction.

Wepo Formation Baseline Water Quantity

The Wepo Formation contains low yielding perched aquifers that are not continuous and usually pinch out stratigraphically, or are vertically displaced by minor structural deformation (PWCC 2011). The primary alluvial drainages in the study area (Yellow Water Canyon Wash, Coal Mine Wash, Moenkopi Wash, and Dinnebito Wash) and their associated tributaries truncate the Wepo Formation. Throughout the study area, the Wepo Formation receives direct recharge from precipitation because it is exposed on the surface (Repenning and Page 1956). Infiltrated precipitation flows towards areas of lower elevation until the groundwater discharges to the surface as springs, or to the alluvial drainages as base flow. Groundwater flow paths are typically oriented toward the primary alluvial drainages or the mine pits (**Appendix D**, Figure 8). Groundwater contours in the Wepo Formation, based on 46 wells installed by PWCC, generally parallel surface topography. **Appendix D**, Figure 16 shows the location of PWCC Wepo Formation and Spoil monitoring locations. Depth to water in PWCC Wepo Formation wells ranges from a low value of 0.5 feet bgs to a maximum value of 207.0 feet bgs, with most wells showing a depth to water in the range of 30-150 feet bgs. Water table fluctuations in Wepo wells are generally less than 1.0 foot, with maximum fluctuations up to 5.6 feet in the period from 2006 to 2014 (PAP). PWCC monitors pits backfilled with overburden (spoils) where there is the potential for the spoils in the backfilled pits to become saturated with groundwater. These spoil monitoring locations are used to monitor groundwater quality in the Wepo Formation near these backfilled pits.

Groundwater flow in the Wepo Formation is generally toward the southwest and locally toward the alluvial drainages (**Appendix D**, Figure 8). For this reason, groundwater impacts to the Wepo Formation are not expected to extend north of the mined areas in the Permit Area. Also, Dinnebito Wash provides a hydrologic boundary to the flow in the Wepo Formation on the east. Yellow Water Canyon Wash and Coal Mine Wash act as hydrologic boundaries on the west of the study area.

Wepo Formation wells tested to characterize the water production showed transmissivity ranges from 0.01 gpd/ft at well 62 to 666 gpd/ft at well 51 (**Appendix D**, Figure 18). Most transmissivity values obtained from the well tests were less than 100 gpd/ft and the median value of 23 well tests was 40 gpd/ft (OSMRE 2011). The Wepo Formation perched aquifers provide flow to springs and base flow to the alluvial channels, but are not suitable for domestic, irrigation, or stock water use due to the low productivity of most areas in the Wepo Formation.

Wepo Formation Baseline Water Quality

Background water quality in the Wepo Formation prior to 2011 is presented in **Appendix D**, Table 4. Major cations and anions in Wepo Formation water include TDS, sulfate, magnesium, calcium, bicarbonate, sodium, and chloride. Water quality is generally dominated by either sodium bicarbonate or calcium-sodium sulfate. TDS ranged from 446 to 5,540 mg/L (OSMRE 2011). The median TDS for all background wells was 779 mg/L. The median sulfate value 121 mg/L and the range for sulfate was from 2.0 to 1,200 mg/L. Calcium ranged from 1.0 to 188 mg/L with a median

value of 9.8 mg/L; sodium values ranged from 160 to 744 mg/L with a median value of 270 mg/L. Monitor wells sampled in 2015 (PAP) showed most wells (50 percent) with TDS between 1,000 and 2,000 mg/L and about 25 percent of the wells with TDS in the range of 2,000 to 5,000 mg/L. Water quality was dominated by calcium-sodium sulfate and sodium bicarbonate, with individual wells in different drainages showing either bicarbonate or sulfate dominated groundwater. Wells with higher TDS values showed groundwater dominated by calcium-sodium sulfate water. Monitoring of Wepo Formation wells shows that groundwater in the Wepo Formation meets Hopi Tribe (2010) and Navajo Nation (2008) standards for livestock use. Only well WEPO068 did not meet these standards and the exceedance was for pH.

Wepo monitoring wells have been grouped based on their general location or conditions within the PWCC coal lease areas into the following:

- KMC northwest Wepo wells 41, 42, 51, 52
- KMC northeast Wepo wells 49, 54, 62R
- KMC southeast Wepo wells 66, 68
- Former Black Mesa mine area: Wepo wells 40, 43R, 44, 45, 46, 53, 58, 60
- Background Wepo wells 55, 56, 57, 59, 61, 65, 67, 68

The Wepo Formation is the main unit mined for coal in the PWCC lease areas. Thus, some areas of the Wepo Aquifer have been affected by past and present mining and mine reclamation. However, none of the Wepo monitoring wells indicate exceedances of tribal water quality criteria for livestock watering. Wells in the KMC northwest area generally have mixed sulfate water with fairly high bicarbonate concentrations. Sulfate ranges from 60 to 1,600 mg/L with a median value of 760 mg/L. Bicarbonate concentrations range from 172 to 791 mg/L with a median value of 306 mg/L. TDS ranges from 270 to 2,990 mg/L with a median value of 1,370 mg/L. Dissolved metals are low and within livestock watering standards (BOR 2016, Appendix WR-5).

Wepo monitoring wells in the northeast part of the Lease Area show a mixed carbonate or sodium bicarbonate water type with bicarbonate concentration ranging from 264 to 1,930 mg/L, with a median value around 1,018 mg/L. Sulfate ranges from 264 to 780 mg/L with a median value of 531 mg/L. TDS ranges from 1,340 to 2,240 mg/L with a median value of 1,665 mg/L. Dissolved trace metals are low and water quality meets livestock watering standards (BOR 2016, Appendix WR-5).

Water quality in the Wepo monitoring wells in the southeast part of the KMC lease is dominated by sodium sulfate. The median TDS value is around 3,065 mg/L. In the former Black Mesa mine area, overall water quality in the Wepo Aquifer is dominated by sodium bicarbonate and water is similar to groundwater in the northeast part of the KMC Lease Area. Dissolved trace metals are low and water quality in both areas meets livestock watering standards (BOR 2016, Appendix WR-5).

Background monitoring wells in the Wepo Aquifer are located throughout the KMC Lease Area, but concentrated in the southwest part of the Lease Area. Recent background data reflect a mixed but generally bicarbonate-dominated water quality dominated by sodium bicarbonate. Bicarbonate concentrations range from 190 to 1,880 mg/L, with a median value around 168 mg/L. TDS ranges from 420 to 1,850 mg/L with a median of about 862 mg/L. Dissolved trace metals are

low and the background water quality meets livestock watering standards (BOR 2016, Appendix WR-5).

3.7.2.4 N-Aquifer System

The N-Aquifer system includes several prominent well-sorted massive sandstones and is known for its high water production potential and drinking water quality. The N-Aquifer system is comprised of (in ascending stratigraphic order) the Wingate Sandstone, the Kayenta Formation, and the Navajo Sandstone. The combined thickness of these hydraulically interconnected units ranges from less than 100 feet around the perimeter of the Black Mesa to approximately 1,700 feet in the central part of Black Mesa (**Appendix D**, Figure 24). In the central part of Black Mesa, the N-Aquifer lies within a synclinal basin and the aquifer system is confined. The N-Aquifer is separated from the stratigraphically lower C-Aquifer by the low permeability Chinle Formation and effectively confined from the overlying D-Aquifer (**Section 3.7.2.5**) by the Carmel Formation (OSMRE 2011a). The Carmel Formation is approximately 140 to 170 feet thick beneath the leasehold, but thins appreciably in the southern portion of the Black Mesa. Studies conducted by the USGS (Truini and Longsworth 2003; Truini and Macy 2006) indicate leakage of water from the D-Aquifer to the N-Aquifer where the Carmel Formation is relatively thin (less than 120 feet thick) in the southern part of Black Mesa has been occurring for thousands of years. Around the perimeter of Black Mesa, the N-Aquifer is generally unconfined and a source of water for springs.

N-Aquifer Baseline Water Quantity

The N-Aquifer underlies most of Black Mesa (**Appendix D**, Figure 24). The N-Aquifer is thickest in the northwestern part of Black Mesa beneath the Permit Area. The N-Aquifer is recharged from infiltration of precipitation that falls on the outcrops of the units comprising the N-Aquifer along the rim of Black Mesa (OSMRE 2011a). Recharge estimates range from 2,500 to 3,500 af/yr for the outcrop area of the N-Aquifer north of Black Mesa to 20,248 af/yr for the Black Mesa Basin, with an estimated median recharge rate of 13,000 af/yr (Zhu 2000; Brown and Eychaner 1988) (**Appendix D**, Figure 25). Groundwater withdrawals from the N-Aquifer in 2012 (Macy and Truini 2016) totaled 4,010 af with industrial use totaling 1370 af (34 percent) and municipal use totaling 2,640 af (66 percent).

Total groundwater storage in the N-Aquifer occurs primarily in the Navajo Sandstone, where total water storage has been estimated by the USGS at 180 million af (Eychaner 1983). Three-dimensional hydrologic modeling by PWCC has determined that the Navajo Sandstone storage may be 140 million af and that total storage in the N-Aquifer may be 450 million af (PWCC 1999). Transmissivity in the N-Aquifer ranges from 560 to 2,600 gpd/ft and storativity estimates from well tests range from 2.2E-4 to 8.0E-3 for the confined portions of the aquifer in the central part of Black Mesa; specific yield estimates for the unconfined portion of the aquifer along the southern part of Black Mesa range from 0.1 to 0.15 (PWCC 2005a). The underlying Kayenta and Wingate formations contain an estimated 450 million af of water (PWCC 1999).

Groundwater flow in the N-Aquifer system is shown in **Appendix D**, Figure 27. A groundwater divide exists in the north-central part of Black Mesa, just south of the Permit Area**.** Groundwater in the N-Aquifer system north of the divide flows to the northeast; groundwater south of the divide flows to the southwest. Groundwater flow in the N-Aquifer is affected by the locations of

streams in the unconfined areas of the aquifer, and locally affected by pumping, especially municipal pumping. Groundwater flow patterns in the N-Aquifer system are based on well data from around Black Mesa and modeling by GeoTrans and Waterstone (PWCC 1999).

N-Aquifer Baseline Water Quality

Since 1971, the USGS has been jointly funded by PWCC, the BIA, the Hopi Tribe, and Navajo Nation to perform regular monitoring of wells, springs, and stream flows outside the Permit Area. PWCC performs the monitoring within the Permit Area (**Appendix D**, Figure 28).

The primary water types found in the N-Aquifer are calcium bicarbonate in the recharge areas along the margin of Black Mesa, and sodium bicarbonate in the central confined portions of the aquifer system (Macy and Brown 2011). Water quality in the N-Aquifer typically meets water quality standards for domestic water supply with TDS generally less than 500 mg/L and rarely exceeding 1,000 mg/L (OSMRE 2011b), except along the eastern edge of Black Mesa where sodium concentrations are elevated (OSMRE 2011a). In the southern part of Black Mesa, downward leakage of water from the D-Aquifer (**Section 3.7.2.5**) to the N-Aquifer influences water quality in the N-Aquifer (Truini and Longsworth 2003). The pH values in the N-Aquifer can occasionally exceed the drinking water standard range of 6.5 to 8.5 standard units and range up to 9.4 standard units (PAP). Water quality in the N-Aquifer from monitoring wells NAV2 through NAV9 measured from 2010 to 2014 is summarized in BOR (2016), Appendix WR-7.

The N-Aquifer beneath the NGS lies at a depth of at least 900 feet bgs and is an unconfined aquifer at this location. Units above the N-Aquifer include Dune Sand (15 feet thick), the Carmel Formation (10-70 feet thick), the Page Sandstone (100-150 feet thick), and the unsaturated portion of the N-Aquifer system. The Navajo Sandstone is around 1400 feet thick in the area of the NGS. The Carmel Formation contains perched groundwater, but has low vertical permeability. Depth to groundwater in the N-Aquifer beneath the NGS ranges from 840 to 920 feet. Water quality in the N-Aquifer at the NGS is good with TDS in the range of 95-160 mg/L and the water is dominated by calcium bicarbonate and meets drinking water standards. The Carmel Formation, which lies directly below the NGS in most locations, contains elevated metals and TDS and is being pumped by NGS as part of its groundwater protection plan to prevent any further migration of the elevated constituents. All storage facilities at NGS are either lined or have very impermeable bases to prevent future seepage to the Carmel Formation.

3.7.2.5 D-Aquifer System

The D-Aquifer is found throughout the study area (**Appendix D**, Figure 19). Water is primarily withdrawn from the D-Aquifer system by windmills for stock water use, and by some communities in the Black Mesa area. Historically, several of the PWCC production wells produced water from screened casing adjacent to the D-Aquifer system. Two of these wells have been completely reclaimed, and one has been rehabilitated by cement grouting the screened portion that was previously open to the D-Aquifer. The D-Aquifer system consists of, in order from oldest to youngest, the Entrada Sandstone member of the Summerville Formation, the Cow Springs Sandstone, sandstone members of the Morrison Formation, and the Dakota Sandstone (OSMRE 2011a). The D-Aquifer is generally thickest in the northern part of the Black Mesa beneath the Permit Area. Complex stratigraphic intertonguing and facies changes in the formations of the D-Aquifer result in hydraulic interaction between the sandstone members of

the aquifer system. The Mancos Shale confines the D-Aquifer system above and the Carmel Formation confines the system on the base, allowing for the interconnected formations of the D-Aquifer system to behave as a single regional aquifer (OSMRE 2011a).

D-Aquifer Baseline Water Quantity

Water quantity for the D-Aquifer system is based on the hydraulic properties of the formations comprising the regional aquifer and on the water levels (potentiometric surface) and flow patterns in the aquifer system. Stetson (1966) installed a test well in the PWCC Permit Area as part of a wellfield development feasibility study and pump-tested the Entrada, Morrison, and Dakota formations for 700 minutes at a rate of 23 gpm, producing 59 feet of drawdown in the test well. Analysis of the pump test results by Stetson (1966) indicated a transmissivity of 440 gpd/ft for the D-Aquifer system with an estimated average hydraulic conductivity of 0.056 feet/day (OSMRE 2011a).

GeoTrans and Waterstone developed a three-dimensional groundwater model that incorporated the D-Aquifer system and calibration of the model yielded a range of hydraulic conductivity values for the D-Aquifer (PWCC 1999). Using water level data from 188 wells and springs, the calibrated horizontal conductivity values obtained by GeoTrans were 0.0984 feet/day for the Dakota Formation, 0.0197 feet/day for the Morrison Formation, 0.0656 feet/day for the Entrada Formation (sandy facies) and 0.0131 feet/day for the Entrada Formation (silty facies). The bulk average hydraulic conductivity for the D-Aquifer was 0.056 feet/day (OSMRE 2011a). **Appendix D**, Figure 21 shows the resulting steady-state potentiometric surface for the D-Aquifer developed by GeoTrans (PWCC 1999).

Modeled groundwater flow in the D-Aquifer system south of the Permit Area is generally to the southwest, except for areas of municipal pumping, which created local drawdown in the D-Aquifer. Northeast of the Permit Area, groundwater flow is toward the northeast (**Appendix D**, Figure 21).

D-Aquifer Baseline Water Quality

The Dakota, Morrison, Cow Springs, and Entrada lithologic members of the D-Aquifer system show consistent water quality, with sodium plus potassium dominating over calcium plus magnesium and sulfate generally exceeding bicarbonate, making the groundwater sodium sulfate dominant (Cooley et al. 1969). The TDS ranges from 165 to 5,560 mg/L and generally is above 1,000 mg/L, thus exceeding the recommended limit of 500 mg/L for drinking water (OSMRE 2011b). Chloride is exceptionally high in the Entrada Sandstone and sulfate is elevated in the Dakota Sandstone. Fluoride often exceeds the drinking water recommended limit of 4 mg/L. For comparison, the Navajo Sandstone, which is part of the N-Aquifer system (**Section 3.7.2.4**), is dominated by sodium bicarbonate and generally has good water quality with TDS below 1,000 mg/L.

Potential vertical flow from the D-Aquifer through the Carmel Formation (confining layer) to the N-Aquifer was investigated by Truini and Longsworth (2003) using geochemical and isotopic analyses. Their work suggested that vertical leakage from the D-Aquifer to the N-Aquifer has been occurring for the past few thousand years and is more common in the southern part of Black Mesa where the Carmel Formation is 120 feet thick or less. Truini and Macy (2006)

compared the thickness of the Carmel Formation confining unit and potentiometric head differences between the D-Aquifer and the N-Aquifer to groundwater leakage in the southern Black Mesa**. Appendix D**, Figure 22 shows the potentiometric head differences and **Appendix D**, Figure 23 shows where groundwater leakage from the D-Aquifer to the N-Aquifer is most likely in the southern part of Black Mesa.

3.7.3 Water Resource Use and Designation

Water resource uses identified by OSMRE (2011a) for the Black Mesa area include: 1) domestic water supply, 2) industrial (mine) water supply, 3) agricultural water supply, 4) livestock water use, 5) human contact water use, 6) aquatic and wildlife habitat water needs, 7) ceremonial water use (Hopi Tribe), and 8) groundwater recharge (Hopi Tribe).

3.7.3.1 Domestic Water Supply

Domestic water supply includes all water supply wells within the potential cumulative impact area in both the D- and N-Aquifers. **Appendix D**, Figure 10 shows the water supply wells and their estimated annual withdrawal as of 2009. Concern has been expressed by the Hopi Tribe and the Navajo Nation that drawdown from PWCC wells may impact one or more of the community wells in either the D- or N-Aquifers.

PWCC provides access to two public water supply standpipes as part of its water distribution system within the Permit Area. Water accessed by the two public standpipes is hauled by residents and used for both domestic and livestock consumption (OSMRE 2011a). The two public supply standpipes are located near CRAs N-6 and N-14 and provide approximately 61 af/yr of water (PWCC 2011).

3.7.3.2 Industrial (Mine) Water Supply

The Kayenta Mine is the only location in the study area using water from the confined portion of the N-Aquifer for industrial purposes. The coal lease agreements with the Hopi Tribe and the Navajo Nation allow PWCC to develop and utilize water for its mining operations, provided that all wells will be left properly cased at the end of mining and water not utilized for mining will be made available for local Navajo use (OSMRE 2011a).

PWCC began pumping in 1968 at 100 af/yr (Macy and Brown 2011). The water use rate increased to 3,680 af/yr in 1972 and from 1972 to 2005, PWCC pumped at an annual rate that fluctuated between 2,520 and 4,740 af/yr, averaging around 3,980 af/yr. Water pumped was used for transportation of coal via the coal slurry pipeline to the Mojave Generating Station (now decommissioned), dust suppression, and for potable water use at mine facilities. Approximately 70 percent of the water used was for the coal slurry pipeline (OSMRE 2011a). The coal slurry pipeline ceased operation in December 2005, and PWCC pumping decreased to an average of 1,243 af/yr from 2006 to 2009 (Macy and Brown 2011). Average water use from 2009 to 2012 was 1,330 af per year for industrial, 2,860 af per year for municipal water use, and 4,190 af per year for total water use (Macy and Truini 2016).

3.7.3.3 Agricultural Water Supply

Agricultural water supply covers water used for irrigation of corn and bean fields found in the Black Mesa area. Perennial springs are often used as the source of irrigation water

(OSMRE 2011a). In the southern Black Mesa, these springs emanate from the Toreva Formation and formations comprising the D-Aquifer system.

During the growing season, Hopi and Navajo farmers may dig a pit in the Moenkopi channel alluvium and pump water for use in adjacent fields. Hopi Tribe water quality standards designate all aquifers as Agricultural Irrigation Water. NNSWQS designate Moenkopi Wash as an agricultural water supply. HTWQS designate Moenkopi Wash and Dinnebito Wash as agricultural water (OSMRE 2011a).

3.7.3.4 Livestock Water Use

Livestock watering utilizes springs and in-channel pools along with wind-powered pumps for water supply. HTWQS and NNSWQS designate Moenkopi Wash, and Dinnebito Wash as agricultural livestock watering sources (OSMRE 2011).

3.7.3.5 Human Contact Water Use

Water designated to support secondary human contact means "the water body supports the use of water which may cause the water to come into direct contact with the skin, but not normally to the point of submergence or ingestion of the water" (OSMRE 2011). Examples of secondary human contact are waters used for boating and fishing. The NNSWQS and the HTWQS designate Dinnebito Wash and Moenkopi Wash as meeting the partial body contact use.

3.7.3.6 Aquatic and Wildlife Habitat Water Use

Aquatic and Wildlife Habitat water means "the use of water by animals, plants, or other organisms, including salmonids and non-salmonids, and non-domestic animals for habitation, growth, and propagation" (NNEPA 2008). The Hopi Tribe has established a similar designation (Hopi Tribe 2010). Such designated waters are protected under agreements with the Navajo Nation and Hopi Tribe.

3.7.3.7 Ceremonial Water Use (Hopi Tribe)

The HTWQS designate that primary ceremonial contact means "the use of a spring, stream reach, lake, or other water body for religious or traditional purposes by members of the Hopi Tribe" (OSMRE 2011a). Such designated water bodies require protection of sensitive and valuable aquatic life and riparian habitat (Hopi Tribe 2010).

3.7.3.8 Groundwater Recharge and Unique Waters (Hopi Tribe)

Groundwater recharge use means any surface water that recharges an aquifer. Surface waters designated as groundwater recharge must meet the standards for an aquifer being recharged as well as for surface water standards (Hopi Tribe 2010). The NNSWQS and the HTWQS designate partial body contact use for Dinnebito Wash and Moenkopi Wash. The Moenkopi Wash watershed from Blue Canyon Springs to the confluence with Begashibito Wash has been classified as unique by the Hopi Tribe. In addition, the N-Aquifer and all areas recharging the N-Aquifer are classified as unique groundwater (Hopi Tribe 2008).

3.7.4 Coal Combustion Residuals

Pollutants contained in the residuals from the combustion of coal in power plants and disposed of through burial can be conveyed into groundwater aquifers. The Kayenta Mine's coal is transported from the mine by electric rail to the NGS. CCRs consist of fly ash, economizer ash, bottom ash, and flue-gas desulferization gypsum byproduct produced from the combustion of coal at the NGS. CCRs that are not recycled are disposed of and secured in a dry disposal site within the NGS Lease Area. The EPA issued a final rule on April 17, 2015 to regulate CCRs under Subtitle D of the RCRA. The CCR rule has an effective date of October 19, 2015, and the rule regulates CCRs at electric utilities. The only CCR unit regulated at the NGS under the rule is the Ash Disposal Landfill. The disposal site is located 1.5 miles east of the NGS facility and is regulated as an existing CCR landfill under the CCR federal rule. The 765-acre disposal site is set against the western edge of a mesa outcrop with a design capacity of 38 million cubic yards. Depending on market conditions, about 50 percent to 90 percent of the fly ash is transported off-site and recycled**.** The existing site can hold all the anticipated CCR generated by the NGS through 2019, the study area for indirect effects from CCRs disposal at the NGS on groundwater is shown on **Figure 3.7-1**.

The use of dry disposal in conjunction with the dry climate and geology of the region reduces the mobility and leachability of any of the coal constituents. Furthermore, the retention of stormwater runoff, dust control, and groundwater monitoring procedures regulated under the federal CCR rule are used to ensure containment of the CCR constituents.

The final rule contains key milestones for implementation and requires the NGS to provide demonstration of compliance with the requirements, including posting documents to an operating record, publicly accessible internet site, and notification to the Navajo Nation. The final rule establishes self-implementing requirements, primarily performance standards that owners or operators of regulated units can implement without any interaction with regulatory officials.

Additionally, the EPA enhanced the protectiveness of the standard by requiring certified demonstrations by a qualified professional engineer to provide verification that the regulatory requirements were being adhered to. The EPA believes that the recordkeeping and notification requirements will minimize the danger of owners or operators abusing the self-implementing system established in this rule through increased transparency and by facilitating the citizen suit enforcement provisions applicable to the rule.

SRP provides a monthly summary on the amount of materials hauled off-site, stored on-site, and water usage. The NGS environmental department personnel conduct weekly landfill inspections per CCR regulations for any appearances of actual or potential structural weakness and other conditions which are disrupting or have the potential to disrupt the operation or integrity of the landfill. Corrective actions are identified and implemented if concerns or issues are noted during inspections. In addition, the CCR landfill is inspected annually by a qualified professional engineer to ensure that the unit is designed, constructed, operated, and maintained in a manner consistent with generally accepted good engineering standards. The engineer must prepare a report following each inspection. If a deficiency or release is identified during the inspection, the NGS would be required to remedy the deficiency or release as soon as feasible.

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. Annual groundwater monitoring and triggers for corrective actions will be developed and implemented per the schedule and requirements set out in the CCR rule.

3.8 VEGETATION

The direct effects study area for general vegetation (not special status) consists of the Lease Area and those surrounding areas that may be directly impacted by mining activities (**Figure 3.1-1**). The indirect effects study area includes the area potentially indirectly impacted by coal combustion surrounding the NGS (**Figure 3.7-1**). For the direct effects study area and indirect effects study areas, sampling investigation reports (SIRs) (Ramboll Environ 2016a, 2016b) and ecological risk assessments (ERAs) (Ramboll Environ U.S. Corp [Ramboll Environ] 2016a, 2016b) were developed to examine the baseline conditions of terrestrial and aquatic habitats. These areas are defined as the following:

- **Kayenta Mine:** The Kayenta Mine study area was based on consideration of the existing lease property boundaries, the influence of active and proposed future mining activities (deposition area), the presence of human residential areas (to support the human health evaluation), and the presence of special status species and important ecological features (Ramboll Environ 2016d). Total suspended particulate emissions (TSP) were identified as the primary source of emission sources at the Kayenta Mine that may be generated from mining/pit activities, handling of topsoil, overburden (i.e., soil layer overlying coal deposits) and coal, coal processing, pit reclamation, road travel, and heavy equipment tailpipe emissions. This area includes key ecological habitats (e.g., seeps and springs), soil, sediment, locations of special status species (i.e., Navajo sedge and Mexican spotted owls), and surface water features that may be affected by potential transport off-site (i.e., via overland flow and/or wind-generated erosion, via groundwater and other release and transport mechanisms).

- **NGS Near-field:** The NGS Near-field study area was defined by the maximum deposition rate of selenium from NGS stacks relative to 10 percent of the lowest selenium ecological soil screening level. Selenium was chosen to represent all potential HAPs because it showed the highest rate of deposition among the contaminants evaluated. The results indicated the deposition area to be within a 9.9-mile (16-km) radius of the source and confirmed the applicability of using AERMOD (versus more long-range models) to model emissions-dispersion and deposition from NGS (Ramboll Environ 2016a). The 9.9-mile (16-km) radius was conservatively rounded upward to a 12.4-mile (20-km) radius, which is defined as the NGS Near-field study area. The 20-km extent of the study area was subsequently verified by consideration of background soil data collected within a 20-km radius of NGS (Ramboll Environ 2016a) in combination with the AERMOD data deposition profile for selenium (Ramboll Environ 2016a).

Baseline conditions, both within the Permit Area and within the NGS Near-field study area, were also ascertained through the development of SIRs (Ramboll Environ 2016a, 2016b). These reports describe the baseline constituent concentrations of metals (arsenic, mercury, methylmercury, and

selenium), organics, and other measurements (e.g. pH, total organic carbon, etc.) in the soil and water in each area. These reports describe the baseline conditions that the ERAs (Ramboll Environ 2016a, 2016b) then build from.

- Within the Permit Area, the SIR (Ramboll Environ 2016a) found the following: Key constituents at low concentrations are dispersed through the Permit Area with no distinct patterns of occurrence.
- Arsenic is a naturally occurring constituent and is widely distributed at low concentrations.
- Selenium, while naturally occurring, is not detected in surface soil and rarely detected in sediment and surface water. Where detected, it occurs in low concentrations.
- Total mercury also is widely distributed across the Permit Area at low concentrations.
- Methlymercury and organics are infrequently detected.

Within the near-field area, the SIR (Ramboll Environ 2016b) found the following:

- Key constituents are detected at low concentrations and are dispersed throughout the near-field area with no distinct patterns of occurrence.
- Selenium, while also naturally occurring, is infrequently detected in all media. Where selenium is detected, the detections are low.
- Arsenic is a naturally occurring constituent and as expected, it is widely distributed across the near field area at low concentrations.
- Similarly, total mercury, methylmercury, and organics are infrequently detected among all media where analyzed.

Elevation, temperature extremes, landforms, and local precipitation patterns influence the development of the various plant communities within the study area (AGFD 2006). The study area is located within the Great Basin conifer woodland biotic province and the Colorado Plateau physiographic province (AGFD 2006; Brown 1994; Reichenbacher et al. 1998). The study area includes five plant communities: mixed-conifer, piñon/juniper woodland, sagebrush shrubland, saltbush and greasewood shrubland, and tamarisk dominated riparian and disturbed areas. A reclaimed plant community occurs where previously mined areas in the Lease Area have been backfilled, graded, topsoil added to the surface, and revegetated (**Table 3.8-1**). Based upon the results of selenium analysis in plants at a representative cross section of sites where accumulator plants were found, the soils in which they were growing are not seleniferous (PAP, Ramboll Environ 2016a); therefore, there is no environmental hazard related to high selenium concentrations in plants (**Section 3.3**).

Table 3.8-1 Vegetation Communities and Landcover Within Lease Area

Vegetation Community	Acres[1]	Percent (%)[2]
Pinyon-juniper woodland	23,557	37.5
Disturbed	24,575	38.9
Sagebrush shrubland	13,161	20.9
Saltbush and greasewood shrubland	1,225	1.9
Riparian	230	<1.0
Open Water	87	<1.0
TOTAL	62,835	100

Source: BIOME (2003); Brown et al. (2007); USGS GAP (2004); and ESCO Associates (2000a, 2000b, 2003, 2010)
[1] The total does not include 2,023 acres in upper Coal Mine Wash northeast of the Permit Area.
[2] Totals may differ due to rounding. Approximately 87 acres (0.1 percent) were not assigned a cover type and are not included in table total.

3.8.1 Piñon-juniper Woodland

Piñon-juniper woodland is the most common plant community and occupies 37.5 percent of the Lease Area. Piñon pine (*Pinus edulis*) and Utah juniper (*Juniperus osteosperma*) are the common over-story tree species. Common under-story shrubs include big sagebrush (*Artemisia tridentata*), four-wing saltbush (*Atriplex canescens*), Mexican cliffrose (*Cowania mexicana*), Douglas rabbitbrush (*Chrysothamnus viscidiflorus*), and rubber rabbitbrush (E*ricameria nauseosa*) (Brown 1994). Grasses and forbs provide a small amount of cover, with the most common of these being bottlebrush squirreltail (*Sitanion hystrix*), Indian ricegrass (*Oryzopsis hymenoides*), and muttongrass (*Poa fendleriana*) (Brown 1994).

Total vegetation cover is low, often less than 22 percent. Some piñon-juniper stands appear to have very little understory vegetation, while others have a lesser presence of shrubs (Jacobs 2008). Piñon-juniper woodland has extensive areas of bare soil, rock, and litter below trees (Brown 1994). This vegetation community occurs at an elevation range of 6,300 feet to over 7,200 feet in the Lease Area.

3.8.2 Disturbed

Within the Lease Area, the disturbed landcover occupies approximately 24,575 acres, including the 12,200 acres of reclaimed land within the Permit Area. Vegetation cover in reclaimed lands is usually higher than in native vegetation types and other disturbed lands, averaging 23 percent (BIOME 2003; ESCO Associates 2000a, 2000b, 2003). Rock cover is low, but litter cover is high (BIOME 2003; ESCO Associates 2000a, 2000b, 2003).

Native and introduced grasses and native shrubs dominate reclaimed lands in the Lease Area. Cool-season native grass species include western wheatgrass, thickspike wheatgrass (*Agropyron dasystachyum*), Indian ricegrass, needle and thread, big squirreltail, and bottlebrush squirreltail; and common warm-season native grass species include blue grama, galleta, and alkali sacaton (*Sporobolus airoides*). The most abundant introduced perennial grass species is Russian wildrye (*Elymus junceus*). Crested wheatgrass (*Agropyron desertorum*) and intermediate wheatgrass (*Agropyron intermedium*) also are present. Four-wing saltbush is the dominant shrub species, but several other species are common. Fourwing saltbush is long-lived, spreads primarily by seed

dispersal, and could slowly spread into reclamation areas from adjoining plant communities (U.S. Department of Agriculture 2011). Several noxious weeds occur primarily in newer reclamation areas; these include kochia (*Kochia scoparia*), Russian thistle (*Salsola iberica*), and cheatgrass (*Bromus tectorum*).

3.8.3 Sagebrush Shrubland

Sagebrush shrubland occupies 20.9 percent of the Lease Area. This community occurs on deeper soils that develop in flatter areas and in valley bottoms. Total vegetation cover is often less than 20 percent with low rock cover and sparse understory vegetation (Brown 1994). Sagebrush shrubland usually occurs up to 7,000 feet (2,134 m) in elevation on Black Mesa. Above that elevation, it often is interspersed with piñon-juniper woodland.

Sagebrush shrubland is dominated by big sagebrush and blue grama (*Bouteloua gracilis*) (Brown 1994). Other common shrub species include four-wing saltbush, Douglas rabbitbrush, Greene's rabbitbrush (*Chrysothamnus greenei*), and rubber rabbitbrush (Brown 1994). Blue grama and galleta (*Hilaria jamesii*) are the common warm-season grasses in this plant community. Cool-season grasses are less common and include big squirreltail (*Sitanion jubatum*), bottlebrush squirreltail, needle and thread (*Stipa comata*), Indian ricegrass, and western wheatgrass (*Agropyron smithii*).

3.8.4 Saltbush and Greasewood Shrublands

Saltbush and greasewood shrublands are two additional upland shrub communities that occupy relatively small, linear areas along washes in the Lease Area. These shrublands grow on the margins of terraces associated with the higher order drainages. The terraces typically lie 5 to 20 feet above a wash channel where saline-alluvial soil has accumulated. Four-wing saltbush dominates the saltbush community, and greasewood (*Sarcobatus vermiculatus*) dominates the greasewood community (Brown 1994). Annual forbs and grasses form sparse to dense understories (Brown 1994).

3.8.5 Riparian

Riparian vegetation occurs along major drainage ways, forming linear bands of vegetation within the Lease Area. These form patches that are typically between 10 feet and 20 feet wide and from a few yards to more than 0.5 mile (800 meters) long. This vegetation occurs on the bottoms of the washes and typically occupies the depositional side of a channel. In the Lease Area, surface water in riparian areas usually is ephemeral but short reaches of intermittent streams are sometimes present.

Tamarisk (*Tamarix* sp.) dominates the riparian vegetation. Small amounts of greasewood and four-wing saltbush associate with tamarisk in drier areas. Coyote willow (*Salix exigua*) occurs with tamarisk in wetter areas. Herbaceous understory vegetation is limited and is often composed of cheatgrass, European alkali grass (*Puccinellia distans*), stickseed (*Lappula occidentalis*), and desert seepweed (*Suaeda torreyana*).

Aquatic plants are limited to some impoundments in the Permit Area, which include freshwater ponds, sediment ponds, and internally draining ponds in reclaimed areas. Some of the larger

impoundments have emergent wetland plants along the margin, including tamarisk, coyote willow, bulrush (*Zanichellia palustris*), pondweeds (*Potamogeton* spp.), and holly-leafed water nymph (*Najas marina*).

3.8.6 Noxious Weeds and Invasive Plant Species

Noxious weed or invasive plant species are known or expected to occur in the Lease Area. Potential noxious weeds include common purslane (*Portulaca oleracea*), diffuse knapweed (*Centaurea diffusa*), field bindweed (*Convolvulus arvensis*), puncture vine (*Tribulus terrestris*), Russian knapweed (*Acroptilon repens*), and Scotch thistle (*Onopordum acanthium*) (BIOME 2003). Invasive species occurring or potentially occurring in the study area include tamarisk, bull thistle (*Cirsium vulgare*), musk thistle (*Carduus nutans*), kochia, Russian thistle, and cheatgrass (California Information Node 2010; ESCO Associates 2003; USGS 2004). These species, with the exception of tamarisk, are ubiquitous, early successional invasive species found in newly reclaimed and disturbed areas that diminish as perennial vegetation develops and out-competes these species. The vegetation management program includes monitoring and treating annual weeds (PAP). Other areas with noxious weeds and invasive plants are mostly found along U.S. Highway 160 and Arizona Route 41; these could represent a source of weeds in the study area (California Information Node 2010; USGS 2007).

3.8.7 Special Status Plant Species

The study area for special status plant species is the Black Mesa coal field (**Figure 3.1-1**). The analysis of threatened, endangered, and special status species included review of USFWS county lists (USFWS 2016), the Navajo Nation endangered species list (Navajo Nation 2016), Navajo Natural Heritage Program (NNHP) endangered species accounts (2008), and Arizona Natural Heritage Program lists (AGFD 2010) (**Appendix E**). Threatened and endangered plant species within the NGS indirect impact area (**Figure 3.7-1**) (Ramboll Environ 2016a) would not be impacted by emissions from the NGS (Ramboll Environ 2016a), and are therefore not discussed further. Species potentially present are provided in **Table 3.8-2**.

Table 3.8-2 Sensitive Plant Species Potentially Present in the Study Area

Common Name	Scientific Name	Status[1]
Brady pincushion cactus	*Pediocactus bradyi*	FE
Fickeisen plains cactus	*Pediocactus peeblesianus var. fickeiseniae*	FE
Welsh's milkweed	*Asclepias welshii*	FT
Navajo sedge	*Carex specuicola*	FT, G3
Alcove bog orchid	*Platanthera zothecina*	G3
Rydberg's thistle	*Cirsium rydbergii*	G4
Parish's alkali grass	*Puccinellia parishii*	G4
Alcove death camas	*Anticlea vaginata*	G3

[1] FT = federal threatened, FE = federal endangered, G1 – G4 Navajo Nation

There are no Federally listed, proposed, or candidate plant species known or expected to occur within the Permit Area but some do occur in the larger study area as discussed below. Species that are listed on the Navajo Nation endangered species list are assigned a ranking of 1, 2, 3, or 4. Group 1 (G1) species are those that no longer occur on the Navajo Nation. Group 2 (G2)

species are those whose prospects of survival or recruitment are in jeopardy. Group 3 (G3) species are those whose prospects of survival or recruitment are likely to be jeopardy in the foreseeable future. Group 4 (G4) species are any species for which the Navajo Nation does not have sufficient information to support their being listed as G2 or G3 but has reason to consider them.

Traditional Navajo and Hopi collect numerous species of plants for food, materials for making craft items, and for use in rituals and ceremonies. No populations of highly restricted plant species used for traditional purposes have been identified within the study area.

3.8.7.1 Brady Pincushion Cactus

The Brady pincushion cactus (*Pediocactus bradyi*) is a federally endangered species found sporadically within sparsely-vegetated desert scrub communities dominated by shadscale (*Atriplex concertifolia*), snakeweed (*Gutierrezia sarothrae*), Mormon tea (*Ephedra viridis*), and desert trumpet (*Eriogonum inflatum*). It occurs as sporadic, dense populations along sloped benches in sunny locations (USFWS 2012c) and is restricted to habitat composed of Kaibab limestone chips over soil derived from sandstone outcrops and Moenkopi shale.

The Brady pincushion cactus has known occurrences and potential habitat within the NGS Near-field study area (Ramboll Environ 2016a). The species range overlaps the Lower Colorado River portion of the NGS near-field study area at Marble Canyon.

3.8.7.2 Fickeisen Plains Cactus

The Fickeisen plains cactus (*Pediocactus peeblesianus var. fickeiseniae*) is a federally endangered species that is a narrow endemic and is restricted to exposed layers of Kaibab limestone, in shallow gravelly loam soils formed from alluvium or limestone deposits on the Colorado Plateau. The plant community associated with Fickeisen plains cactus is Great Basin Desertscrub and most populations occur on the margins of canyon rims, flat terraces or benches, or toes of well-drained hills having less than 20 percent slope. Populations are widely scattered and found at approximately 4,200 to 5,959 feet amsl (USFWS 2015c). Fickeisen plains cactus is known to be present in Coconino, Mohave, and Navajo counties.

Potential habitat for Fickeisen plains cactus occurs within the NGS near-field study area within desert scrub vegetation communities if they are underlain with the appropriate substrate. No designated critical habitat occurs in the study area.

3.8.7.3 Welsh's Milkweed

The Welsh's milkweed (*Asclepias welshii*) is a federally threatened species that grows on open, sparsely vegetated semi-stabilized sand dunes and the lee slopes of actively drifting sand dunes (USFWS 2015d). These active sand dunes are found within sagebrush, juniper, and ponderosa pine communities and occur from 5,000 to 6,230 feet amsl. This species occurs in Coconino, Navajo, and Apache counties (Mikesic and Roth 2008; USFWS 2015d). Potential habitat also exists on the Navajo Nation on active sand dunes between Page and Tuba City, east to Chinle Creek drainage (Mikesic and Roth 2008).

There are known occurrences of Welsh's milkweed within the NGS near-field study area, west of the NGS across the Colorado River.

3.8.7.4 Navajo Sedge

The Navajo sedge (*Carex specuicola*) is a federally threatened and Navajo Nation Group 3, perennial plant found in springs and seeps associated with hanging gardens, on vertical sandstone cliffs, and alcoves comprised of Navajo sandstone (NNHP 2008). The species is confined to higher elevations that generally support Great Basin conifer forests and woodlands (NNHP 2008). The Navajo sedge was federally listed as threatened with critical habitat in 1985.

Navajo sedge is not anticipated to occur in the Permit Area but has limited distribution in the study area. The only known populations in the study area include the Tsegi Canyon population, about 12 miles north of the N-9 CRA, and the population where Moenkopi Wash and Ho No Geh Canyon overlap the unconfined portion of the N-Aquifer.

3.8.7.5 Alcove bog-orchid

The alcove bog-orchid (*Platanthera zothecina*) also is a Navajo Nation Group 3, perennial plant found in the same types of habitats as the Navajo sedge (NNHP 2008). The Navajo Nation lists the alcove bog orchid as a G3 endangered species (NNHP 2008). The alcove bog-orchid sedge has limited distribution in the study area. One population occurs approximately 12 miles north of the Permit Area in Tsegi Canyon and is associated with seeps and springs originating from the unconfined portion of the N-Aquifer.

3.8.7.6 Rydberg's Thistle

Rydberg's thistle (*Cirsium rydbergii*) is a Navajo Nation Group 4, perennial herb 40 to 120 inches tall. It is found in hanging gardens, seeps, and occasionally stream banks below the hanging gardens. It typically occurs between 3,300 and 6,500 feet amsl (Mikesic 2008b). The Navajo Nation lists the Rydberg's thistle as a G4 endangered species. Rydberg's thistle is known to occur in northern Coconino County and Apache County but no population is known to be present in the study area.

3.8.7.7 Parish's Alkali Grass

Parish's alkali grass (*Puccinellia parishii*) is a Navajo Nation Group 4, short-lived tufted annual dwarf grass that grows from one to eight inches tall. The Navajo Nation lists this species as a G4 endangered species (Roth 2008). This species has been a candidate for federal listing as threatened and endangered since 1990, but was removed from candidacy in 1998 (NatureServe 2016). Parish's alkali grass occurs in only alkaline (saline) seeps and springs (Roth 2008). It is found in open areas (marshes) below perennially flowing springs, often in moist soils with a salty crust and without dense vegetation cover (AGFD 2004). There are at least five extant locations on the Navajo Nation including Echo Cliffs north of the Carrizo Mountains (Coconino and Apache Counties), and a population located near Bagdad in Yavapai County in a tributary to the Little Shipp Wash (AGFD 2004). Surveys conducted within the Permit Area indicated that suitable habitat is found at seepage sites near CRA N-11 and along Wild Ram Wash although no occurrences of this species were found. This survey detected only saltmarsh alkali grass (*Puccinellia fasciculata*), an introduced species, in the alkaline wet soils (ESCO 2003).

3.8.7.8 Alcove Death Camas

The Alcove death camas (*Anticlea vaginata*) is a Navajo Nation Group 3, stout perennial that sprouts from rhizomes. The Navajo Nation lists the alcove death camas as a G3 endangered

species, which are those species whose survival and recruitment are likely to be in jeopardy in the foreseeable future. It is not currently listed under the ESA. This species is only found in hanging gardens in seeps and alcoves, mostly on Navajo sandstone. It occurs between 3,700 and 6,700 feet amsl (Roth 2001). In Arizona, there are six populations found in Apache, Coconino, and Navajo Counties. No populations are known to occur in the study area.

3.9 WILDLIFE AND FISH

The direct effects study area for fish and wildlife is the Black Mesa coal field (**Figure 3.1-1**). The indirect effects study area includes the area potentially indirectly impacted by coal combustion surrounding the NGS and extends to include part of the Colorado and San Juan River Basins (**Figure 3.7-1**).

The study area used for wildlife and fish consists of several parts: areas that may be directly impacted by mining activities, and areas that may be indirectly impacted by the combustion of coal at the NGS. For the direct and indirect impact areas, SIRs (Ramboll Environ 2016a, 2016b) and near-field ERAs (Ramboll 2016a, 2016b) were developed to examine the baseline conditions of terrestrial and aquatic habitats. Detailed information on the direct and indirect near-field SIRs and ERAs can be found **in Section 3.8**, Vegetation. Additional ERAs were conducted to further characterize areas that may be indirectly impacted by the combustion of coal at NGS. These areas are defined as the following:

- **Colorado River:** Analysis of the Colorado River Regions was conducted to address potential risks to aquatic and aquatic-oriented wildlife in the Colorado River upstream and downstream of Lake Powell, in areas that were not specifically evaluated in the NGS Near-field (Ramboll Environ 2016b). The Colorado River study area, for which one ERA was prepared with separate results provided for the Northeast and the Southwest Colorado River regions, fall outside of the 12.4-mile (20-km) NGS Near-field study area and the San Juan River study area. They are briefly described as follows:

- **Northeast Colorado River Region:** This includes the portion of Lake Powell beyond the 12.4-mile (20-km) NGS Near-field study area and the Colorado River northeast of Lake Powell upstream to the confluence of the Colorado and Green rivers (approximately 170 miles [274 km] upstream of the Glen Canyon Dam).

- **Southwest Colorado River Region:** This includes the lower Colorado River downstream of the 12.4-mile (20-km) NGS Near-field study area, from Lees Ferry to the confluence of the Colorado and Little Colorado rivers (approximately 62 miles [100 km] downstream of the Glen Canyon Dam).

- **San Juan River**: The San Juan River study area includes the San Juan River basin extending downstream and into the San Juan arm of Lake Powel within the modeling domain developed by the Electric Power Research Institute (EPRI). EPRI conducted a watershed-scale assessment of trace metal deposition and dynamics within the San Juan River watershed attributed to emission of arsenic, mercury, and selenium from three regional power plants (NGS, San Juan Generating Station, and Four Corners Power Plant). Atmospheric modeling of arsenic, mercury, and selenium was conducted using a suite of

regional air quality models (WRF, CMAQ-APT, CMAQ, GEOS-Chem) and the output was incorporated into a watershed biogeochemical cycling and aquatic biota bioaccumulation model (WARMF) to estimate concentrations in surface water (arsenic, mercury, and selenium) and invertebrate and fish tissue (mercury).

Wildlife populations in the study areas reflect the quantity of available vegetation and landscape habitat features. Landscape features such as washes, rock formations, the hillside slope and aspect, alcoves and cave entrances, and ponds produce a variety of habitats and in turn, influence the natural and reclaimed land communities that contribute to the available habitats. Combined, these features and the vegetation communities support a diverse mix of wildlife in the area by providing a complex of micro and macro habitats for which species are adapted to or dependent on. Piñon-juniper habitat predominates in the Permit Area (greater than 50 percent), with the remaining evenly split between sagebrush shrubland habitat and reclaimed lands.

Annual wildlife monitoring is conducted in the Permit Area and supports baseline studies, documents wildlife population characteristics, and monitors for special status species.

3.9.1 Mammals

Twenty-six mammal species were recorded in the Lease Area during 1979 to 1983 and 2003 wildlife studies (PWCC 1992; BIOME 2003). Two additional mammal species were observed during monitoring in 2008 (Ecosystem Management Inc. [EMI] 2009). Big game species, while present are not abundant. A 1979-1980 census for game species recorded two observations of mule deer (*Odocoileus hemionus*), both north of the lease area. In 2003, ten mule deer and numerous pellet groups of mule deer and elk (*Cervus canadensis*) were observed (BIOME 2003). More recent monitoring has documented the presence of elk, mule deer, white-tailed deer (*Odocoileus virginianus*), bobcat (*Lynx rufus*), red fox (*Vulpes vulpes*), and coyote (*Canis latrans*) within the Permit Area (EMI 2009, 2010). Increased elk presence has coincided with the increase in higher quality reclaimed land vegetation within the Permit Area.

Sagebrush shrublands and piñon-juniper woodlands support the largest variety of mammal species. Deer mice (*Peromyscus maniculatus*) are one of the most common species observed in the Permit Area, both in native and reclaimed lands. Also common are ground squirrels (*Ammospermophilus spp.*). Piñon-juniper woodland supports piñon-mice (*Peromyscus truei*), brush mice (*Peromyscus boylii*), Ord's kangaroo rat (*Dipodomys ordii*), Stephen's woodrat (*Neotoma stephensi*), and Colorado chipmunk (*Tamias quadrivittatus*). Gunnison's prairie dogs (*Cynomys gunnisoni*) occur in low statured, sparse cover shrubland habitats adjacent to the Permit Area. Black-tailed jackrabbits (*Lepus californicus*) and desert cottontails (*Sylvilagus audubonii*) occur in all habitats within the Permit Area, as do coyotes, red foxes, and gray foxes.

Bat studies were conducted in 1999 in reclaimed lands and piñon-juniper within and adjacent to the Permit Area (SWCA Environmental Consultants 2000). Nine bat species were identified including the big brown bat (*Eptesicus fuscus*), long-legged myotis (*Myotis volans*), silver haired bat (*Lasionyctris noctivagans*), pallid bat (*Antrozous pallidas*), fringed myotis (*Myotis thysanodes*), Mexican free-tailed bat (*Tadarida brasiliensis*), big free-tailed bat (*Nyctinomops macrotis*), canyon bat (*Parastrellus hesperus*), and an unknown myotis species. Only the first six species were found in the piñon-juniper habitat, but all nine species were found on reclaimed lands.

3.9.2 Birds

The Migratory Bird Treaty Act (MBTA) makes it illegal for anyone to take, possess, import, export, transport, sell, purchase, barter, or offer for sale any migratory bird, or the parts, nests, or eggs of such a bird except under the terms of a valid permit issued pursuant to Federal regulations. The MBTA (916 USC 703-711) provides protection for 1,007 species of native migratory birds. Bird surveys have recorded 235 bird species in the Lease Area, more than half of which are known to or potentially nest in the area (LaRue 1994). Nearly all of the birds recorded are protected under the MBTA. The highest number of birds and the greatest diversity of species have been observed in summer, partly due to fledged offspring and species that are breeding residents only (LaRue 1994; BIOME 2003). Ongoing monitoring continues to document these trends (EMI 2016).

Raptor studies in the 1980s recorded a total of 22 raptor species with nine of those likely to nest in the Permit Area. Red-tailed hawks (*Buteo jamaicensis*) were the most abundant raptor species; Cooper's hawks (*Accipiter cooperii*) and sharp-shinned hawks (*Accipiter striatus*) were relatively common in coniferous woodland habitats. Later raptor surveys in 2003 recorded American kestrel (*Falco sparverius*) and Cooper's hawk. A historic red-tailed hawk nest remained inactive in 2003 (BIOME 2003). Four active red-tailed hawk nests were documented in the Permit Area in 2015 (EMI 2016). Other less common species that may breed include northern goshawk (*Accipiter gentilis*), prairie falcon (*Falco mexicanus*), western screech owl (*Otus kennicottii*), great horned owl (*Bubo virginianus*), northern pygmy owl (*Glaucidium gnoma*), and long-eared owl (*Asio otus*). Comprehensive raptor studies have been conducted on and adjacent to the Permit Area for red-tailed hawk, peregrine falcon (*Falco peregrinus*), and Mexican spotted owl. These surveys have shown that these species have the potential to occur within the study area. Information on the peregrine falcon and Mexican spotted owl is presented in **Section 3.9.5**. Bald and golden eagles are protected under the MBTA and the Bald and Golden Eagle Protection Act.

A high diversity of migratory waterfowl and shorebirds utilize many of the larger impoundment ponds in the Permit Area. Mallards (*Anas platyrhynchos*) are likely the only nesting species, though redheads (*Aythya americana*), ruddy ducks (*Oxyura jamaicensis*), and American coots (*Fulica americana*) also may nest in the vicinity (Corman and Wise-Gervais 2005). Many other species may utilize the ponds during migration such as the eared grebe (*Podiceps nigricollis*), great blue heron (*Ardea herodias*), blue-winged teal (*Anas discors*), green-winged teal (*Anas crecca*), cinnamon teal (*Anas cyanoptera*), northern shoveler (*Anas clypeata*), gadwall (*Anas strepera*), American wigeon (*Anas americana*), and lesser scaup (*Aythya affinis*) (Corman and Wise-Gervais 2005). Killdeer (*Charadrius vociferous*) is the only shorebird that may nest in the Permit Area (Corman and Wise-Gervais 2005).

3.9.3 Reptiles and Amphibians

Reptile and amphibian species observed during baseline studies from 1979 to 1983 and during the 2003 field reconnaissance include whiptail lizard (*Aspidoscelis* spp.), collared lizard (*Crotaphytus collaris*), sagebrush lizard (*Sceloporus graciosus*), fence lizard (*Sceloporus undulatus*), short-horned lizard (*Phyrnosoma douglassi)*, side-blotched lizard (*Uta stansburiana*), gopher snake (*Pituophis melanoleucus)*, western rattlesnake (*Crotalus viridis*), western spadefoot toad (*Scaphiopus*

hammondi), Woodhouse's toad (*Bufo woodhousei)*, and red-spotted toad (*B. graciosus*) (BIOME 2003; PWCC 1992).

3.9.4 Fisheries

Aquatic habitat within the direct impact study area is limited to intermittent and ephemeral streams, springs, and temporary and permanent sediment impoundment ponds. Intermittent streams include Moenkopi Wash, Dinnebito Wash, Orabi Wash, Polacca Wash, Chinle Wash, Jeddito Wash, Begashibito Wash, Shonto Wash, and Laguna Creek. The occurrence of fish species within the Permit Area is limited to a few sediment ponds where fish may be present from unauthorized introductions. For example, sediment pond N14-G contains largemouth bass (*Micropterus salmoides*); however, no public fishing is allowed in the pond. Channel catfish (*Ictalurus punctatus*) were stocked in Cow Springs in 2015 by the NNDFW. Fish species could be present in portions of additional streams or washes that contain water on a more persistent basis. If present, species could include mosquitofish (*Gambusia affinis*), western killifish (*Fundulus zebrinus*), or other species that are adaptable to waterbodies with minimal flow and higher water temperatures.

Within the study area but outside of the Permit Area, fish habitat includes the Colorado River and tributaries, the San Juan River and tributaries, and Lake Powell. These waterbodies are not likely to be directly impacted by mining activities but may be indirectly impacted by coal combustion at NGS and are therefore considered here. Numerous non-special status native and non-native fish species occur in this area and are presented in **Table 3.9-1.** Special status fish species are discussed below in **Section 3.9.6**.

Table 3.9-1 Non-Special Status Fish Species Potentially Present in the Study Area

Common Name	Scientific Name	Lake Powell	Colorado River	San Juan River
Black bullhead	*Ameirus melas*	X	X	X
Black crappie	*Pomoxis nigromaculatus*	X	X	
Bluegill	*Lepomis macrochirus*	X	X	X
Bluehead sucker	*Catostomus discobolus*		X	X
Brown trout	*Salmo trutta*		X	X
Carp	*Cyprinus carpio*	X	X	X
Channel catfish	*Ictalurus punctatus*	X	X	X
Fathead minnow	*Pimephales promelas*	X	X	X
Flannelmouth sucker	*Catostomus latipinnis*	X	X	X
Gizzard shad	*Dorosoma cepedianum*	X	X	
Green sunfish	*Lepomis cyanellus*	X	X	X
Largemouth bass	*Micropterus salmoides*	X	X	X
mosquitofish	*Gambusia affinis*	X	X	X
Northern pike	*Esox lucius*		X	
Plains killfish	*Fundulus zebrinus*	X	X	X
Rainbow Trout	*Oncorhynchus mykiss*	X	X	X
Red shiner	*Notropis lutrenis*	X	X	X
Redside shiner	*Richardsonius balteatus*		X	

Common Name	Scientific Name	Lake Powell	Colorado River	San Juan River
Roundtail chub	*Gila robusta*		X	
Sand shiner	*Notropis stramineus*		X	
Smallmouth bass	*Micropterus dolomieui*	X	X	X
Speckled dace	*Rhinichthys osculus*		X	X
Striped bass	*Morone saxatilis*	X	X	
Threadfin shad	*Dorosoma petenense*	X		
Walleye	*Sander vitreus*	X	X	
White sucker	*Catostomus commersoni*		X	X
Yellow bullhead	*Ameiurus natalis*	X	X	X

3.9.5 Special Status Wildlife Species

Special status species considered for analysis included federally listed species under the ESA, endangered species listed by the Navajo Nation, and wildlife species of concern tracked by the AGFD. The analysis of special status species included reviews of USFWS county lists (USFWS 2016), the Navajo Nation endangered species list (NNDFW 2008), Navajo Nation Natural Heritage Program Endangered Species Accounts (NNHP 2008), Arizona Natural Heritage Program lists (AGFD 2015), and evaluation of habitats and ranges of the species. **Table 3.9-2** presents the special status wildlife species potentially present in the study area. There are no federally listed, proposed, or candidate animal species known or expected to occur within the Permit Area or Lease Area due to the lack of suitable habitats.

Table 3.9-2 Sensitive Wildlife Species Potentially Present in the Study Area

Common Name	Scientific Name	Status[1]
California Condor	*Gymnogyps californianus*	FE, G4
Mexican Spotted Owl	*Strix occidentalis lucida*	FT, G3
Southwestern Willow Flycatcher	*Empidonax traillii extimus*	FE, G2
Black-footed Ferret	*Mustela nigripes*	FE, G2
Yellow-billed Cuckoo	*Coccyzus americanus*	FE/FT, G2
Sora	*Porzana carolina*	G4
Bald Eagle	*Haliaeetus leucocephalus*	G2
Golden Eagle	*Aquila chrysaetos*	G3
Ferruginous Hawk	*Buteo regalis*	G3
Northern Goshawk	*Accipter gentilis*	G4
Peregrine Falcon	*Falco peregrinus*	G4
Northern Saw-whet Owl	*Aeoglius acadicus*	G4
Northern Pygmy Owl	*Glaucidium gnoma*	G4
Flammulated Owl	*Otus flammeolus*	G4
Burrowing Owl	*Athene cunicularia*	G4
Mogollon (Mexican or Navajo Mountain) vole	*Microtus mogollonensis (mexicanus)*	G4

Common Name	Scientific Name	Status[1]
Townsend's Big-eared Bat	*Corynorhinus townsendii*	G4
Northern Leopard Frog	*Lithobates pipens*	G2
Red-tailed hawk	*Buteo jamaicensis*	Hopi sensitive

[1] FT = federal threatened, FE = federal endangered, G1 – G4 Navajo Nation (**Section 3.8.7)**

3.9.5.1 California Condor

The California condor (*Gymnogyps californianus*) was federally listed as an endangered species in 1967 under the Endangered Species Preservation Action and listed under the ESA in 1975. The reintroduced population in Arizona is managed as a threatened species outside the reintroduction area. It is listed as a G4 endangered species by the Navajo Nation. Primary threats to this species are lead poisoning, predation, starvation, and shooting. From 1992 to 2012, there was only one recorded incident of powerline related mortality (USFWS 2013a). The current recovery plan for this species was issued in April 1996 and the most recent five-year review was completed in June 2013. As of December 31, 2015, the wild population totaled 268 individuals (155 in California, 80 in Arizona/Utah, and 33 in Baja Mexico) (USFWS 2015a).

California condors are opportunistic scavengers that feed only on carrion. Typical foraging behavior consists of long-distance reconnaissance flights, circle-soaring over a carcass, and hours of waiting at roosts or on the ground near a carcass (USFWS 1996). Condors rely primarily on sight and not smell to locate carrion with 95 percent of their diet consisting of cattle, domestic sheep, ground squirrels, mule deer, and horses (USFWS 2013a).

California condors have an extensive home range and can travel from 50 to 100 miles in a single day. They require open habitat for soaring and to easily locate feeding opportunities. The California condor is a species that utilizes canyon country and mountainous habitats for nesting and roosting, and can forage widely in a variety of habitats around these areas (NNHP 2008). The reintroduced population in Arizona (Vermillion Cliffs population) has been expanding its foraging range to the north and northeast of its release site near the Grand Canyon but has not utilized areas south of the Grand Canyon since around 2000 (NNHP 2008). This may represent a natural pattern related to the scarcity of carrion from big game

There are no records of occurrence for the California condor within the Permit Area. A map of telemetry relocations of tagged individuals associated with the Vermillion Cliffs population indicates that one or two individuals have flown in the general vicinity of the Permit Area (Parish 2013). The closest of these occurred approximately 25 miles west of the permit boundary. While it is unlikely that the condor would forage in the Permit Area, the presence of livestock and big game could provide a limited source of carrion for the condor in the study area. Outside of the permit area, but within the study area, habitat is restricted to canyons and gorges along the Colorado River. Condors have been observed flying near the NGS (Parish 2014).

While this species is addressed in this EA, neither the Navajo Nation nor the Hopi Tribe have identified this species as occurring within the Permit Area itself (Navajo Nation 2016; Hopi Tribe 2016). Therefore, it is not addressed in the Biological Evaluation (BE) prepared for this project.

3.9.5.2 Mexican Spotted Owl

The Mexican spotted owl is federally listed as a threatened species and a G3 endangered species by the Navajo Nation. It was listed under the ESA on March 16, 1993. A recovery plan was initially released on June 6, 1995, with a revision in September 2012. Critical habitat for the Mexican spotted owl was established on August 31, 2004. No critical habitat exists within the Permit Area.

The Mexican spotted owl is a permanent resident in the interior mountain ranges of western North America, ranging from southern Utah and central Colorado south through the mountains of Arizona, New Mexico, and west Texas. The species typically occupies old growth forest in mixed conifer, pine-oak woodland, deciduous riparian forest, or a combination of these habitats that will support a home range of 1,400 to 4,500 acres (Ehrlich et al. 1988; Gutierrez et al. 1995). An undisturbed core area, or protected activity center (PAC), of approximately 600 acres centered on the nest site is the currently recommended disturbance buffer (Gutierrez et al. 1995).

Mexican spotted owls have been reported at elevations ranging from 3,700 feet amsl to the subalpine transition zone (Ganey et al. 1998; Gutierrez et al. 1995; Johnsgard 1988). The species typically inhabits steep canyons with mature or old growth forest, but they also may occur in canyons with steep cliffs and relatively little forest habitat. Mexican spotted owl habitat typically has a structured canopy, a perennial water source, and a rodent-dominated prey base of adequate size (Gutierrez et al. 1995). The Mexican spotted owl diet varies with geography (Ward and Block 1995).

Mexican spotted owls exhibit high nest fidelity and construct nests in rock crevices, tree cavities (usually in live trees), or on constructed platforms on tree limbs. In northern Arizona, owls have been reported in both canyon and montane forest situations (USFWS 2012). Mexican spotted owls also will utilize abandoned raptor or corvid platform nests (Ehrlich et al. 1988; Terres 1980).

Threats to this species include altered forest structure, grazing by domestic and wild ungulates when it reduces prey habitat, noise disturbance, and climate change (USFWS 2012).

In 2003, the Mexican spotted owl was considered a year-round resident of the northeastern part of the study area (BIOME 2003); individuals had been observed within two miles of the northeastern boundary of the Permit Area. Areas in which the species was documented and PACs were designated to include upper Yellow Water Canyon, the side canyons of Coal Mine Wash, and upper Moenkopi Wash (BIOME 2003). The upper northeastern portion of the Permit Area overlaps one of these PACs. Mexican spotted owl surveys conducted in 1999 detected six unpaired male owls and one breeding pair, the latter of which was observed in upper Coal Mine Wash. From 2000 and 2010, no spotted owl surveys were conducted because there was no mine-related activity in the vicinity of the PACs. With implementation of mining activities in CRA N-9, Mexican spotted owl surveys resumed in 2011 and have been conducted annually since. In 2015, there were two Mexican spotted owl detections within approximately 1.9 miles of CRA N-9 (EMI 2016). These detections are thought to have been of the same individual due to their close temporal and spatial proximity (EMI 2016).

Although there is some potential for Mexican spotted owls to occur in canyons in the vicinity of the NGS (e.g., Navajo Canyon, Paria River Canyon), the lower portions of these canyons within the 12.4-mile radius NGS emissions deposition area do not contain suitable spotted owl habitat

(Willey 2016). Species-specific surveys conducted in lower Paria River Canyon from 2013 to 2015 did not detect any Mexican spotted owls in this area (Willey 2015).

3.9.5.3 Southwestern Willow Flycatcher

The southwestern willow flycatcher (*Empidonax traillii extimus*) is federally listed as an endangered species and is listed by the Navajo Nation as a G2 endangered species. It was listed under the ESA on February 27, 1995 and a final recovery plan released in August 2002. Critical habitat was designated on July 22, 1997 and due to a court ruling, revised critical habitat was issued on January 3, 2013.

The southwestern willow flycatcher is a neotropical migratory bird species that breeds in the U.S. Southwest and winters in the rain forests of Mexico, Central America, and northern South America. Nests are constructed as open cup nests approximately eight centimeters high and eight centimeters wide and typically are placed in the fork of a branch. Egg-laying can begin as early as late May but typically occurs in early to mid-June. Clutch size is usually three or four eggs for initial nests. Incubation last between 12 and 13 days from the date the last egg is laid, and eggs typically hatch within 24 to 48 hours of each other. Chicks can be present in the nest from mid-June through early August and fledging typically occurs from late June through mid-August. Adults then depart from breeding areas between mid-August to mid-September (Sogge et al. 1997).

The breeding season diet of southwestern willow flycatchers is almost exclusively insectivorous. Willow flycatchers (*Empidonax traillii*) forage on a wide range of prey taxa including wasps, bees, flies, beetles, butterflies/moths, caterpillars, and spittlebugs (USFWS 2002). Diet studies of adult southwestern willow flycatchers have shown the subspecies' diet to be similar with major prey items ranging from small (e.g., flying ants) to large (e.g., dragonflies) flying insects with bees, flies, and true bugs comprising half of the prey items (DeLay et al. 2002; Drost et al. 1997). Diet can vary between years and among different habitat types. Foraging is done primarily by sallying from a perch to perform aerial hawking and gleaning. Foraging frequently takes place at edges and openings with a habitat patch, or at the top of the upper canopy (Sogge et al. 2010).

The southwestern willow flycatcher is considered a riparian obligate species during the breeding season. Four specific types of riparian communities have been described as southwestern willow flycatcher breeding habitat. The first is comprised of dense stands of willows 10 to 23 feet in height with no distinct overstory. This community is often associated with sedges, rushes, or other herbaceous wetland plants. A second habitat type includes dense stands of salt cedar or Russian olive, up to 33 feet in height. These species form a dense, closed canopy with no distinct understory layer. Native broadleaf-dominated communities form a third habitat type, and the fourth habitat type is a mixture of native and exotic riparian species (Sogge et al. 2010).

The most critical threats to this species include extensive loss, fragmentation, and modification of riparian breeding habitat with consequent reductions in population levels (USFWS 2002). This species also is affected directly by factors that impact their survival and reproductive success such as brood parasitism.

Willow flycatchers have been documented on Black Mesa during migration, but it is unknown whether these observations have been of southwestern willow flycatchers (BIOME 2003). Potential habitat is present in the Permit Area in larger blocks of riparian shrubs and trees along

perennial streams, springs, and/or seeps in Yellow Water Canyon Wash, Moenkopi Wash, and Dinnebito Wash (BIOME 2003). No critical habitat is present in or adjacent to the Permit Area.

There are no known occurrences of the southwestern willow flycatcher in the vicinity of the NGS and its associated facilities. Riparian woodland and scrubland habitat in the action area that may be suitable for southwestern willow flycatchers occurs largely in patches along the Colorado River, the San Juan River, Salt and Verde rivers, and associated tributaries. Scattered riparian patches also occur throughout the action area within northern Arizona (Hatten 2015).

3.9.5.4 Yellow-billed Cuckoo

The western U.S. distinct population segment of the yellow-billed cuckoo became a candidate species for listing as threatened or endangered on October 30, 2001. On October 3, 2013, the yellow-billed cuckoo was proposed for listing under the ESA and on November 3, 2014, the species was listed as threatened by the USFWS. On August 15, 2014, the USFWS proposed critical habitat for the yellow-billed cuckoo; however, no critical habitat has been designated. The Navajo Nation lists the western yellow-billed cuckoo as a G2 endangered species.

The yellow-billed cuckoo is a neotropical migrant that spends the winter in South America, east of the Andes and primarily south of the Amazon Basin. In Arizona, most cuckoos do not arrive on their breeding grounds until mid-June (Corman and Wise-Gervais 2005). Nesting typically occurs between late June and late July but may begin as early as May and continue into September (Halterman et al. 2015). Yellow-billed cuckoos typically have one brood per year (Ehrlich et al. 1988), but double broods have been regularly observed on the lower Colorado and Bill Williams rivers (McNeil et al. 2013).

Yellow-billed cuckoos are considered riparian obligates because they nest almost exclusively in low- to moderate-elevation riparian woodlands that are 50 acres or more in size, located within arid to semiarid landscapes, and contain native broadleaf trees and shrubs (Hughes 1999, 79 FR 59992). The species is most commonly associated with cottonwood and willow-dominated vegetation, but the composition of its habitat varies across its range.

Breeding sites often have a distinct overstory of willow, cottonwood, or other broadleaf trees with discernible sub-canopy layers and an understory of mixed trees and shrubs, including tamarisk (Halterman et al. 2015). In Arizona, yellow-billed cuckoos most commonly occur in cottonwood/willow/ash/mesquite habitat and least commonly occur in habitat comprised of greater than 75 percent tamarisk cover (Johnson et al. 2010). Cuckoos eat a variety of prey items with large arthropods (e.g., cicadas, katydids, grasshoppers, and caterpillars) as their primary prey. Other prey includes small lizards, frogs, spiders, tent caterpillars, and a variety of other insects (Halterman et al. 2015). There is evidence to suggest that population levels and breeding may be closely tied to the abundance of certain food items (Halterman 2009; McNeil et al. 2013; and multiple other authors cited in: Halterman et al. 2015).

Habitat loss is the primary threat to the yellow-billed cuckoo (Corman and Wise-Gervais 2005; Floyd et al. 2007). Yellow-billed cuckoos appear to require large tracts of contiguous habitat (Sutter et al. 2005), and population declines across the western U.S. primarily are due to the loss of cottonwood-dominated riparian habitat. This loss is usually a result of conversion to agriculture, dams and river flow management, bank protection, overgrazing, competition from

exotic plants such as tamarisk, urban development including transportation infrastructure, and increased wildfire (Bennett and Keinath 2003; USFWS 2013b). Yellow-billed cuckoos are further threatened by their low population size, extreme population fluctuations, and patchy distribution (Bennett and Keinath 2003). Heavy pesticide usage during the last 50 years also has likely contributed to population declines by removing prey, directly poisoning birds, and causing egg shell thinning (Bennet and Keinath 2003).

There are no records of this species occurring within the Permit Area. The lack of multi-layered, predominately native riparian woodlands in the Permit Area and Lease Area suggests that it is unlikely cuckoo would nest in the area, though it is possible they could occur there as temporary residents during migration.

There are no known occurrences of the yellow-billed cuckoo in the vicinity of the NGS and associated facilities. However, numerous patches of riparian habitat occur throughout the study area, including the San Juan River, in side canyons to Lake Powell (e.g., Navajo Canyon) and the Lower Colorado River. There are known occurrences of yellow-billed cuckoo along the San Juan River within the study area. Surveys conducted by USGS between Mexican Hat and Montezuma Creek on the San Juan River detected cuckoos in multiple years between 1998 and 2015 (Johnson 2016). Habitat along the San Juan River is mixed exotic riparian woodland, consisting of Fremont cottonwood overstory with an understory of Russian olive and tamarisk (Johnson et al. 2004).

Within the study area, proposed critical habitat occurs along the San Juan River at Lake Powell, and from upstream of the confluence with Chinle Creek to near Aneth, Utah.

3.9.5.5 Sora

The sora (*Porzana carolina*) is listed as a G4 endangered species by the Navajo Nation. It also receives protection under the MBTA. The sora inhabits a variety of natural and man-made wetland habitats (Corman and Wise-Gervais 2005). Suitable habitat has dense emergent vegetation, and shallows are needed for adequate foraging (Corman and Wise-Gervais 2005).

The closest breeding site to the Permit Area is about 70 miles southwest near Tuba City (Corman and Wise-Gervais 2005). However, potential habitat exists at impoundments within the Permit Area. LaRue (1994) described the location of seven records of soras at various impoundments within the Lease Area. These likely are limited as stop-over habitat during migration (LaRue 1994).

3.9.5.6 Bald Eagle

The bald eagle (*Haliaeetus leucocephalus*) is listed by the Navajo Nation as a G2 species. It has been de-listed as a federally threatened species but remains protected under the Bald and Golden Eagle Protection Act and the MBTA. In Arizona, bald eagles typically nest in riparian areas with mature trees, particularly large mature cottonwoods that are adjacent to large bodies of water (major rivers, lakes, or reservoirs) with abundant prey (large fish and waterfowl) (NNHP 2008). Winter roost sites occur in the same type of large mature trees, but can include mature pine forests as well as riparian river bottoms, or canyon rims (NNHP 2008). Winter roost areas are typically used by a congregation of bald eagles and are usually within a few miles of a foraging site – a large lake or river with adequate prey (NNHP 2008).

LaRue (1994) described the bald eagle as a sparse early winter transient on Black Mesa. Records include a single adult observed in Coal Mine Wash on December 16, 1982; an immature bird observed over lower Yellow Water Canyon on December 4, 1984; an immature bird observed over lower Moenkopi Wash on December 20, 1988; two adults observed at the CRA J-7 pond in January 1985; and one eagle observed over Dinnebito Wash on March 16, 1993 (LaRue 1994). The bald eagle has not been observed in the most recent annual wildlife monitoring surveys conducted in the Permit Area (EMI 2015, 2016)

3.9.5.7 Black-footed Ferret

The black-footed ferret (*Mustela nigripes*) is listed as an endangered species and was considered extinct in the wild after the last known population was removed from the wild in 1987 near Meeteetse, Wyoming. It has since been reintroduced to numerous sites in the western U.S., Canada, and Mexico following a successful captive breeding program. Two release sites are in Arizona, one north of Williams and one near Seligman. These are categorized as non-essential experimental populations. It is listed as a G2 species by the Navajo Nation.

Black-footed ferrets are highly specialized predators that depend on prairie dogs for food and shelter. More than 90 percent of the ferrets' diet is made up of prairie dogs. Ferrets live in prairie dog towns, nest in prairie dog burrows, and usually forage in the tunnel complexes of prairie dogs. Although Gunnison's prairie dogs occur near the Permit Area, the colonies remain too small to support a population of black-footed ferrets (BIOME 2003).

Prairie dog colonies within and adjacent to the Permit Area are censused and reported on annually. There has been no indication of the presence of black-footed ferrets, and habitat conditions remain unsuitable for ferrets within this area (EMI 2010). To the extent that there are Gunnison prairie dog colonies greater than 400 acres in size within the study area, there is potential for black-footed ferrets to occur there. However, it is very unlikely that any wild populations of the species survive on the Navajo Nation and there have been no observations of ferrets on the Navajo Nation in several decades (Smith and Hazelton 2014).

3.9.5.8 Golden Eagle

The golden eagle (*Aquila chrysaetos*) is listed as a G3 endangered species by the Navajo Nation. The species also receives protection under the Bald and Golden Eagle Protection Act and the MBTA. The golden eagle typically inhabits mountainous terrain and canyon country where it nests on steep cliffs, typically more than 30 meters (98 feet) in height. Nesting cliffs are normally directly adjacent to foraging habitat that provides the primary prey of cottontails and jackrabbits (NNHP 2008). Perch sites can occur in tall trees or on structures that occur in habitat otherwise only suitable for foraging. The species has been documented from the north end of Black Mesa at Lolomai Point to Kayenta Point, and golden eagles occasionally utilize the Permit Area for foraging (EMI 2010). The most recent record was on April 12, 2009 of an individual seen following a northern harrier (*Circus cyaneus*) along the main drainage in CRA J-16 (EMI 2010). Golden eagles also are known to occur in the vicinity of the NGS.

3.9.5.9 Ferruginous Hawk

The ferruginous hawk (*Buteo regalis*) is listed as a G3 species by the Navajo Nation. It also receives protection under the MBTA. The ferruginous hawk is an open-country inhabitant in western

North America. The species occurs in grasslands, sagebrush scrub, saltbush-greasewood shrubland, and the periphery of piñon-juniper and other western forests (Bechard and Schmutz 1995). The ferruginous hawk usually avoids dense montane forests, aspen parkland, and habitats recently altered by agricultural cultivation (Bechard and Schmutz 1995). It typically forages on rabbits (*Lepus* spp.), ground squirrels (*Spermophilus* spp.), and prairie dogs (*Cynomys* sp.) (Bechard and Schmutz 1995). It nests on a variety of elevated sites and structures in the landscape that are typically less than 30 meters (98 feet) above the ground.

Potential suitable breeding and foraging habitat for the ferruginous hawk is present within the Permit Area; however, there are no known ferruginous hawk nests (EMI 2015, 2016). The lack of nesting ferruginous hawks in the area suggests that hawks utilize the area primarily for foraging.

3.9.5.10 Northern Goshawk

The northern goshawk (*Accipter gentilis*) is listed as a G4 endangered species by the Navajo Nation. It also receives protection under the MBTA. The northern goshawk inhabits a variety of mature forest types in North America (Kennedy 2003). In the western U.S., it typically nests in mature ponderosa or mixed-conifer forests with high canopy closure and moderately steep slopes (Kennedy 2003). Adjacent foraging habitat has a similar structure but may require a less dense understory (Kennedy 2003). Wintering and post-fledgling habitats are more variable, less dependent on tree density, and more dependent on the availability of prey (Kennedy 2003).

The northern goshawk has been documented at several sites on the northeastern end of Black Mesa (BIOME 2003). One nesting record has been reported from this area, but the northern goshawk seems to be more common on Black Mesa during the winter months (BIOME 2003). The nearest sighting of a northern goshawk to the Permit Area has been a possible breeding female located about two miles north of the Permit Area (BIOME 2003). Potential habitat for the species occurs in CRA N-9 (BIOME 2003). Goshawks are not thought to occur in the vicinity of the NGS due to a lack of suitable habitat.

3.9.5.11 Peregrine Falcon

The peregrine falcon (*Falco peregrinus*) is listed as a G4 endangered species by the Navajo Nation. The species also receives protection under the MBTA. The peregrine falcon nests in a variety of habitats, with steep cliffs typically more than 45 meters (148 feet) tall (NNHP 2008). Suitable habitat requires an abundance of prey (birds of various species) near nest and roost sites (NNHP 2008). These areas typically occur along wetlands, riparian forests, and other forest habitats.

Peregrine falcons have been documented in the northeastern part of Black Mesa (BIOME 2003). Suitable breeding habitat occurs along the mesa escarpment and many of the taller, steeper canyons (BIOME 2003). Peregrine falcons occasionally forage in the Permit Area and the species could be expected in CRA N-9 and other places with piñon-juniper woodlands (BIOME 2003). In addition to the area surrounding the mine, peregrine falcons are known to nest in Glen Canyon and the canyon reaches of San Juan, Colorado, and Little Colorado rivers (Mikesic and Roth 2008). Peregrine falcons also may forage near the NGS; however, nesting potential may be limited for the species given the lack of suitable habitat.

3.9.5.12 Northern Saw-Whet Owl

The northern saw-whet owl (*Aeoglius acadicus*) is listed as a G4 endangered species by the Navajo Nation. The species also receives protection under the MBTA. The northern saw-whet owl typically utilizes relatively open ponderosa pine, Douglas-fir, or mixed conifer forests for foraging and nesting activities (NNHP 2008). The species also may occur in old growth riparian woodlands (NNHP 2008). It nests in tree cavities in these habitats (NNHP 2008).

The species has been documented from the northeastern part of Black Mesa, but its breeding status there is unconfirmed (BIOME 2003). Suitable habitat for the species is absent within the Permit Area as well as the area surrounding the NGS (BIOME 2003).

3.9.5.13 Northern Pygmy Owl

The northern pygmy owl (*Glaucidium gnoma*) is listed as a G4 endangered species by the Navajo Nation. The species also receives protection under the MBTA. The northern pygmy owl nests in tree cavities and uses habitats often near forest openings (e.g., meadows, lakes and ponds) (NNHP 2008). The species occurs in a variety of montane forest habitats, and possibly wooded canyons that include coniferous forest (spruce, fir, and ponderosa pine), mixed conifer-hardwood with oak and aspen, hardwood bottomlands, and occasionally aspen stands (NNHP 2008).

The northern pygmy owl has been documented on the northern part of Black Mesa (BIOME 2003). It occurs in Coal Mine Wash and Yellow Water Canyon outside of a two-mile buffer zone adjacent to the Permit Area (BIOME 2003). No suitable habitat occurs within the Permit Area.

3.9.5.14 Flammulated Owl

The flammulated owl (*Otus flammeolus*) is listed as a G4 endangered species by the Navajo Nation. The species also receives protection under the MBTA. The flammulated owl nests in tree cavities in open conifer (usually ponderosa pine) or aspen forests, often with brushy understory of dense saplings or oak shrubs and clearings (NNHP 2008). It usually prefers to use old-growth stands with dense cover and large-diameter trees as roosting habitat (NNHP 2008).

The flammulated owl has been documented on the northeastern part of Black Mesa (BIOME 2003). It occurs in Yellow Water Canyon outside of the Lease Area (BIOME 2003). No suitable habitat occurs within the Permit Area.

3.9.5.15 Burrowing Owl

The burrowing owl (*Athene cunicularia*) is listed as a G4 endangered species by the Navajo Nation. It also receives protection under the MBTA. The burrowing owl inhabits flat, open areas with short-grass grasslands, sparse desert scrub, agricultural lands, and other areas with human disturbance (NNHP 2008). The species relies on areas with prairie dogs and other digging mammals in order to provide burrows for nesting (NNHP 2008). Suitable habitat also includes perch sites with unobstructed views (NNHP 2008). This species occurs both east and south of Black Mesa, and potential habitat occurs in prairie-dog towns in reclamation areas in the Permit Area. LaRue (1994) stated that potential habitat could be used by transient burrowing owls during migration.

3.9.5.16 Mogollon (Mexican or Navajo Mountain) Vole

The Mogollon vole (*Microtus mogollonensis*) is listed as a G4 endangered species by the Navajo Nation. The Navajo mountain vole typically inhabits dry grassy vegetation in conifer forests and forest openings (BIOME 2003). The species also inhabits patches of sagebrush, greasewood, desert-olive (*Forestiera neomexicana*), and tamarisk with a heavy cover of grasses (NNHP 2008). The species has been documented in the Permit Area in places with rocky substrates, in continuous stands of sagebrush, near permanent impoundments on mine reclamation, and along drainage bottoms (BIOME 2003). Its abundance varies from rare to common and can vary with the annual precipitation and habitat (BIOME 2003). While not documented in the vicinity of the NGS, if suitable habitat is present, it may occur there.

3.9.5.17 Townsend's Big-eared Bat

Townsend's big-eared bat (*Corynorhinus townsendii*) is listed as a G4 endangered species by the Navajo Nation. It has no further designations. Townsend's big eared bat forages in a variety of habitats that include coniferous forests, piñon-juniper woodlands, deciduous riparian woodlands, and desert scrub habitats (NNHP 2008). It roosts, hibernates, and raises its young in caves, mine tunnels, and man-made structures (NNHP 2008). Townsend's big-eared bat has not been documented in the Permit Area, but suitable foraging habitat occurs in the mine complex, and suitable foraging and roost habitat occurs in the surrounding habitats on Black Mesa (BIOME 2003).

3.9.5.18 Northern Leopard Frog

Northern leopard frogs (*Lithobates pipens*) (formerly *Rana*) is listed as a G2 endangered species by the Navajo Nation. They are a member of the family *Ranidae*, which includes both Old and New World species (Mikesic 2008a). There are seven species of leopard frogs in Arizona (six native and one introduced species) (AGFD 2002).

Northern leopard frogs are found through northern and central Arizona from 2,640 to 9,155 feet (805 to 2,790 meters) amsl. The northern leopard frog uses a variety of habitats including grasslands, brush lands, woodlands, and forests usually in areas with permanent/perennial water and rooted aquatic vegetation, undercut banks, and high vegetation structural heterogeneity. The species uses canals, ponds, marshes, springs, streams, reservoirs, and lakes (AGFD 2002; Mikesic 2008a).

The study area is within the historic range of the northern leopard frog; however, the nearest known extant populations are approximately 150 miles west near Seligman or 150 miles southwest near Flagstaff. Potential suitable habitat for the northern leopard frog is present within the study area where permanent impoundments or fresh water ponds could meet the species requirements.

3.9.5.19 Red-tailed hawk

The red-tailed hawk (*Buteo jamaicensis*) is a Hopi sensitive species that typically inhabits open areas with scattered, elevated perches for hunting and nesting (Cottrell 1981; Janes 1985). They occur in a variety of habitats, including deserts, grasslands, coniferous and deciduous woodlands, agricultural fields, and urban areas.

On Black Mesa, the primary nesting substrate is cliffs, with piñon pine as the second preferred substrate (Cottrell 1981; Janes 1985). Nests on Black Mesa have been found in piñon pines, junipers, ponderosa pines, and cliffs (Monson 1998). Tree nests are generally found high in trees on small support branches in areas with little canopy cover that provide a view of the surrounding area (Bednarz and Dinsmore 1982).

Surveys in 2015 found four active nest sites within the Lease Area (EMI 2016). Nest N-8 has been active from 2011 to 2015 and multiple years before 2010 when it was inactive. This nest is located directly behind a spoils pile in CRA N-9. Activity was observed for this nest when it was first checked on April 9, 2015, and incubation by one adult was detected. Continuous adult activity suggests there was active breeding and the nest was likely a successful attempt.

Nest Old Haul Road was established in 2010 and has been active every year since. It was located on a cliff by the old haul road between CRAs J-14 and J-4 across from a larger cliff complex that typically had red-tailed hawk nests until 2010 when the current nest was built. An adult was on the nest on April 7, 2015. Continuous adult activity suggests there was active breeding and the nest was likely a successful attempt.

Nest Hwy 41 is located on a small cliff immediately east of Hwy 41 north of the main office near the top of a hill. An adult bird was incubating on April 9, 2015. However, on May 19, 2015, no birds were observed in the area.

Nest J-2 was observed on May 27, 2015, and was located within the CRA J-2 area adjacent to a pond. On May 27, 2015, two dark nestlings were observed in the nest, but there was no adult activity observed. Continuous adult activity suggests there was active breeding and the nest was likely a successful attempt.

3.9.6 Special Status Fish Species

In addition to the special status wildlife species, there are several federally listed and Navajo Nation listed fish species that have the potential to be impacted by the Renewal (**Table 3.9-3**). While none of these species occur within the wildlife and fish direct effects study area, they do occur in the vicinity of the NGS (indirect effects study area; **Figure 3.7-1**) and may therefore be indirectly impacted by the Renewal. Development of the indirect effects study area is related to ERAs that were conducted to further characterize areas that may be indirectly impacted by the combustion of coal at the NGS; additional information on the ERAs study areas is presented in **Section 3.8**.

Table 3.9-3 Special Status Fish Species

Common Name	Scientific Name	Status
Bonytail	*Gila elegans*	FE
Colorado Pikeminnow	*Ptychocheilus lucius*	FE
Humpback Chub	*Gila cypha*	FE
Razorback sucker	*Xyrauchen texanus*	FE

FE = federal endangered

Source: USFWS 2016

Current water quality conditions in the Colorado River northeast of the NGS are not likely to pose a risk to any of the special status fish species in **Table 3.9-3** or the water element of their critical habitats.

Current water quality conditions in the Colorado River southwest of the NGS may pose risk to the bonytail chub, humpback chub, razorback sucker, and roundtail chub and the water element of their critical habitats (Ramboll Environ 2016a). Water quality conditions below the Glen Canyon Dam reflect post-dam and ongoing conditions. In the post-dam era, the extent of variations in temperature, salinity, turbidity, and nutrient concentrations have moderated and shown an overall improvement in water quality. The primary water input that affects the water quality below Glen Canyon Dam includes the deep water releases from Lake Powell and several large tributaries such as the Little Colorado and Paria rivers. The release of water from Lake Powell results in cooler temperatures as well as slight increases in salinity until mixing from larger tributaries occurs in the river. In general, these tributaries tend to carry water at higher temperatures than the mainstem river, thus warming the regions where they join. In addition, tributaries, such as Paria River and Little Colorado River, can carry large amounts of fine sediment and organic materials during flood events. Sediment levels in the river near the confluence with these tributaries range from 20 to 133,000 milligrams per liter depending on the season and year.

Current water quality issues in the San Juan River may pose a risk to Colorado pikeminnow and the water element of its critical habitat (EPRI 2016). These issues include metals, sediment, salinity, temperature, fecal matter, and dissolved oxygen. Land uses within the basin contribute metals, salts, fossil fuel residuals (e.g., polycyclic aromatic hydrocarbons [PAHs]), and pesticides to the San Juan River and its tributaries. Irrigation and mineral development have been identified as major sources of pollution. Fish consumption advisories for mercury in fish tissue have been issued for Navajo Reservoir and other smaller reservoirs in the basin (New Mexico Environment Department 2012; fishadvisoryonline.epa.gov/Advisories.aspx). The Nature Conservancy (2013) reported that aquatic integrity of the San Juan River Basin was generally fair. Reviews by the USFWS (2011a; 2012b) have identified pesticides and other pollutants as potential contaminants to Colorado pikeminnow and razorback sucker. Osmundson and Lusk (2011), AECOM (2013), and Electric Power Research Institute (2014) identified mercury and selenium as moderately elevated contaminants of concern in biota and fish tissues collected from the San Juan River Basin.

3.9.6.1 Existing Habitat Conditions

As discussed in USFWS (1994), Primary Constituent Elements for the critical habitat of the four Colorado River federally endangered fish species include the following components:

- Water – This component includes a quantity of water of sufficient quality (i.e., temperature, dissolved oxygen, nutrients, turbidity, lack of contaminants, etc.) that is delivered to a specific location in accordance with the hydrologic regime that is required for a particular life stage for each species.

- Physical Habitat – This component includes areas of the Colorado River system that are inhabited or potentially habitable by fish for use in spawning, nursery, feeding, and rearing, or corridors between these areas. In addition to river channels, these areas also include bottom lands, side channels, oxbows, backwaters, and other areas in the 100-year

floodplain, which when inundated provide spawning, nursery, feeding, and rearing habitats, or access to these habitats.

- Biological Environment – Food, predation, and competition elements of the biological environment are considered important components. Food supply is a function of nutrient supply, productivity, and availability to each life stage of the species. Predation and competition, although normal components of the biological environment, can be out of balance due to introduced non-native fish species.

Bonytail

Bonytail (*Gila elegans*) were once widespread in the large rivers of the Colorado River Basin (USFWS 2002a). Currently, no self-sustaining populations of bonytail exist in the wild and very few individuals have been captured throughout the Upper and Lower River Colorado basins (USFWS 2002a). The total adult population size is unknown, but it is considered to be small due to the limited numbers that have been collected. Since 1977, only 11 bonytail have been captured (USFWS 2002a). Captures of wild bonytail have occurred in three lakes in the lower basin (Powell, Mohave, and Havasu), but the numbers are less than 50 total fish (USFWS 2002a). In the Upper Colorado River Basin, a recovery goal of establishing a self-sustaining population of 4,400 adults over a five-year period in the Green River subbasin has been set, but the criterion has not been met (USFWS 2012a). One of the recovery goals in the Lower Colorado River Blower basin is to establish two self-sustaining populations where naturally produced fish exceed the mean annual adult mortality. Abundance information for the portions of the action area analyzed for bonytail is provided below.

The occurrence of bonytail in Lake Powell is rare. Four fish were captured in Lake Powell at the Colorado River inflow during 2014 (Francis et al. 2014). The fish were stocked in the Colorado and San Rafael rivers and traveled approximately 143 to 277 miles, respectively, to the inflow area. Bonytail do not occur in the lower portion of Lake Powell near the NGS pump station and intakes.

Bonytail occurs in the Cataract Canyon portion of the Colorado River, which also has been designated as critical habitat for the species. Population estimates in 2003 indicated a population size of 264 individuals in Cataract Canyon (Badame 2008). All bonytail were stocked fish that originated from the Green River.

The general types of habitat used by bonytail consist of mainstem riverine areas and impoundments in the Colorado River system. Deep pools and eddies with slow to fast currents are characteristic of the riverine habitat (Kaeding et al. 1986). Based on five specimens captured in the Upper Colorado Basin, four were captured in deep, swift, rocky canyon areas (i.e., Yampa Canyon, Black Rocks, Cataract Canyon, and Coal Creek Rapid) (USFWS 2002a). The fifth specimen was collected in Lake Powell. All fish collected in the Lower Colorado River Basin since 1974 were in reservoir habitats. Critical habitat includes river channels and flooded, ponded, or inundated riverine areas, especially where competition from non-native fishes is absent or reduced (USFWS 1994).

Bonytail was listed as endangered under the ESA on April 23, 1980 (45 FR 27710). On March 21, 1994, the USFWS designated seven reaches of the Colorado River system as critical habitat for

bonytail (USFWS 1994). Critical habitat is designated in portions of the Colorado, Green, and Yampa rivers in the Upper Colorado River Basin and the Colorado River in the Lower Colorado River Basin. In total, 312 miles of critical habitat for bonytail exists in seven reaches. One of these reaches overlaps with portions of the action area analyzed for this species, which includes 12.8 miles of bonytail critical habitat in the Southwest Colorado River Region.

A recovery plan for bonytail was completed in 1984, revised in 1990, and then updated in 2002 (USFWS 2002a). The upper basin subunit is composed of the Green River and Upper Colorado River, and the lower basin unit includes the mainstem and tributaries of the Colorado River from Lake Mead downstream to the International Boundary with Mexico. The most recent recovery review in 2012 indicated that bonytail has not yet achieved demographic recovery goals that are indicative of a healthy, viable, and sustainable population level (USFWS 2012a). The review also concluded that the most meaningful threats to bonytail include habitat availability, protection from predation, and degraded water quality. Bonytail will be considered eligible for downlisting from endangered to threatened and for removal from ESA protection when all the following conditions are met:

- Self-sustaining fish populations reach the required numbers in the areas of the Green and Upper Colorado river subbasins and the Lower Colorado River Basin, and a genetic refuge is established in the Lower Basin;
- Essential habitats, including required instream flows, are legally protected; and
- Other identifiable threats that could significantly affect the population are removed.

Cataract Canyon contains habitat occupied by bonytail, which is located in the upper portion of the Southwest Colorado River Region. Cataract Canyon begins four miles downstream of the confluence with the Green River and extends approximately 37 miles (Badame 2008). The upper ten miles of the canyon is within Canyonlands National Park and the lower 27 miles is within the Grand Canyon National Recreation Area. Habitat in the upper section of the canyon mainly consists of large eddy/pool complexes interspersed between large rapids. Some of the larger pools are 75 feet deep. The lower 32 miles of Cataract Canyon are inundated by Lake Powell at full-pool elevation (Badame 2008).

Limiting factors for bonytail in the Southwest Colorado River Region include streamflow reductions due to water diversions; habitat fragmentation; competition with and predation by non-native fish species; and water quality changes due to pesticides and pollutants (USFWS 2002a).

Colorado Pikeminnow

Colorado pikeminnow (*Ptychocheilus lucius*) were once widespread in the large rivers of the Colorado River Basin and its major tributaries (Gunnison, White, Yampa, Dolores, San Juan, Uncompahgre, Animas, and Green rivers), from Mexico and Arizona to Wyoming) (USFWS 2016, 2002b). By the mid-1980s Colorado pikeminnow occurred only in the Upper Colorado River basin of Colorado, Utah, New Mexico, and Wyoming; mainly in the Green River in Utah and in the Yampa and Colorado rivers in Colorado and portions of Utah.

Colorado pikeminnow is represented by three wild populations which occur in the Green River, upper Colorado River, and the San Juan River subbasins (NatureServe 2013b). The species is found in approximately 1,029 miles of riverine habitat in these three subbasins (USFWS 2011a). The population estimate for the Green River was approximately 4,500 adults in 2009, while the Colorado River estimate in 2006 was approximately 750 fish (USFWS 2011a). Wild population in the San Juan River subbasin is relatively small with 19 to 50 wild fish (Bestgen et al. 2010). The population trend over the last 10 years or three generations has been relatively stable (NatureServe 2013b). The self-sustaining population estimates are 2,600 adults for the Green River and 700 adults for the Upper Colorado River (USFWS 2011a). A target of 1,000 age five fish or older has been established for the San Juan River through augmentation and/or natural reproduction (USFWS 2011a).

Two Colorado pikeminnow were captured in the Colorado River arm of Lake Powell in 2014. The fish traveled 143 and 144 miles to Lake Powell from their stocking locations (Francis et al. 2014). In 2011 and 2012, 25 Colorado pikeminnow were captured in the San Juan River arm of Lake Powell below the waterfall. This large waterfall exists where the river enters Lake Powell when the water surface elevation is below 3,661 feet, which prevents upstream movement of fish after they have entered the lake. Sampling below the waterfall in 2015 captured 15 tagged pikeminnow (McKinstry et al. 2016). Both marked (stocked) and unmarked (stocked or wild) fish have been captured; however, capture efforts are not targeting Colorado pikeminnow because they usually do not survive capture by nets. Captured fish usually are in poor condition. Colorado pikeminnow do not occur in the lower portion of Lake Powell near the NGS pump station and intakes.

Based on abundance information provided in the recovery goals document (USFWS 2002b), 600 to 900 Colorado pikeminnow individuals are estimated to occur in the Colorado River subbasin. Recent estimates of Colorado pikeminnow in the Colorado River indicated an upward trend, with adult abundance increasing from approximately 200 to 890 adult fish in the period from 1992 to 2005 (Osmundson and White 2009; USFWS 2011a). In years when surveys were conducted, the population estimate was more than 700 in 1993, 2000, and 2005. The Colorado pikeminnow population in the San Juan River primarily consists of stocked juvenile fish; adults are rare in occurrence (Durst and Franssen 2014). Approximately 3.2 million pikeminnow were stocked between 2002 and 2011 (USFWS 2015a). The duration of pikeminnow that have been in the river for one or more winters has shown an increasing trend since 2003. This trend is the result of fish ages dominated by 1st year or one-year or older fish as opposed to less than one-year-old fish. The number of larger fish is small, although their numbers have increased. Schleicher and Ryden (2013) estimated approximately 1,000 pikeminnow with total lengths greater than 300 millimeters. The wild population in the San Juan River subbasin is relatively small, with 19 to 50 wild fish (Bestgen et al. 2010).

Habitat requirements of Colorado pikeminnow vary depending on the life stage and time of year. Young-of-year and juveniles prefer shallow backwaters, while adults use pools, eddies, and deep runs that are maintained by high spring flows (USFWS 2002b). Survey efforts for Colorado pikeminnow in the Green River during high flow periods consisted of nearshore areas, flooded tributary mouths, canyon washes, and large backwater areas (Bestgen et al. 2010).

Adults are highly mobile during the spawning period, which occurs after peak runoff in mid-June to mid-August. Movements have been documented up to 400 miles and involved multiple rivers within the Upper Colorado River Basin (i.e., Green and Colorado rivers) (Osmundson and White 2009). In the San Juan River, Colorado pikeminnow move long-distances upstream from spring to summer, and then move back downstream in the winter (Durst and Franssen 2014). Spawning activity begins after the peak of spring runoff at water temperatures typically 16 degrees Celsuis (°C) or higher (USFWS 2002b).

Colorado pikeminnow was listed as endangered on March 11, 1967 (32 FR 4001). With the passage of the ESA in 1973, this fish species retained its endangered status. On March 21, 1994, the USFWS designated six reaches of the Colorado River system as critical habitat for the species (59 FR 13374). Critical habitat consists of three primary constituent elements: water (temperature, turbidity, and lack of contaminants), physical (areas used for spawning, feeding, rearing within the 100-year floodplain), and biological environment (adequate food supply and ecologically appropriate levels of predation and competition (USFWS 1994). Critical habitat is designated in portions of the Colorado, Green, Yampa, White, and the San Juan rivers. In total, 1,148 miles of critical habitat for Colorado pikeminnow exists in these reaches. Two of these reaches overlap with portions of the action area that were analyzed for this species. This includes the Southwest Colorado River Region, which contains 48.8 miles of critical habitat. The other reach is the San Juan River, which contains 233.3 miles of critical habitat.

A recovery plan for Colorado pikeminnow was published in 2002 (USFWS 2002b). As part of the recovery process, five-year reviews have been conducted to evaluate whether the status of the species has changed since its original listing in 1967. The most recent recovery review in 2011 indicated that there is a moderate degree of threat and a high degree of recovery potential at the species level taxonomically (USFWS 2011a). Recovery of the species is considered necessary only in the Upper Colorado Basin (Green River, upper Colorado River, and San Juan River subbasins); historic populations for this species in the Lower Colorado River Basin are extirpated. Colorado pikeminnow will be considered eligible for downlisting from endangered to threatened and for removal from ESA protection when all of the following conditions are met:

- Self-sustaining fish populations reach the required numbers in the areas of the Green River, Upper Colorado River, and San Juan River subbasins;
- Essential habitats, including required instream flows, are legally protected; and
- Other identifiable threats that could significantly affect the population are removed.

Colorado pikeminnow occurs throughout the Southwest Colorado River Region, which includes Lake Powell upstream to the Colorado River confluence with the Green River. Habitat in this area consists of Lake Powell, slow-moving inflow areas in the Colorado arm, and relatively narrow riverine reaches with flow. A major portion of the Southwest Colorado River Region consists of Cataract Canyon, where the upper section of the canyon consists of large eddy/pool complexes interspersed between large rapids. Some of the larger pools are 75 feet deep. The lower 32 miles of Cataract Canyon is inundated by Lake Powell at full-pool elevation (Badame 2008). Limiting habitat factors in the Southwest Colorado River Region would be the same as discussed for bonytail.

Factors affecting existing conditions in the San Juan River are described in the Four Corners Power Plant and Navajo Mine Energy Biological Opinion (USFWS 2015a). A summary of these factors is provided below. These factors are applicable to the Colorado pikeminnow and its critical habitat in the San Juan River.

Humpback Chub

The historic distribution of the humpback chub (*Gila cypha*) is unknown, although early records reported this species in the Upper Colorado River Basin and Colorado River below Lee's Ferry (USFWS 2002c). It is estimated from various reports and collections that indicate the species presently occupies about 68 percent of its historic habitat.

Humpback chub is represented by six populations. Five of the populations occur in the upper basin recovery unit: 1) Black Rocks, Colorado River, Colorado; 2) Westwater Canyon, Colorado River, Utah; 3) Yampa Canyon, Yampa River, Colorado; 4) Desolation/Gray Canyons, Green River, Utah; and 5) Cataract Canyon, Colorado River (USFWS 2002c). The only population in the lower basin recovery unit occurs in the mainstem of the Colorado River in Marble and Grand canyons and the Little Colorado River. The species is found in approximately 470 miles of riverine habitat in these population areas (USFWS 2011b). In studies conducted in 2006 through 2008, the estimated number of adults in the upper basin recovery units included approximately 200 at Black Rocks, 1,000 at Westwater Canyon, 25 at Desolation-Gray Canyon, and 300 at Cataract Canyon. No estimate was made for the Yampa River population due to low capture numbers. None of the upper basin recovery unit is considered to be self-sustaining as a result of poor recruitment. The Black Rocks/Westwater Canyon or Desolation Canyon is a core population, with a recovery criterion of 2,100 adults. The lower basin recovery unit is a self-sustaining population, with the Grand Canyon adult population estimate of 7,650 in 2008. The Grand Canyon and Little Colorado River population is considered a core population. Recent estimates indicate the Grand Canyon and Little Colorado River population is stabilizing after a decade of decline (USFWS 2011b).

Humpback chub occurs in the Cataract Canyon portion of the Colorado River immediately upstream of Lake Powell. Population estimates in 2003 through 2005 ranged from 273 to 468 individuals in Cataract Canyon (Badame 2008). Growth rates and condition factors for humpback chub in these Cataract Canyon surveys were the lowest values observed for any of the populations in the Colorado River Basin.

Humpback chub occurs from river mile 30 downstream and throughout the Colorado River in the Grand Canyon, with the highest densities within and adjacent to the Little Colorado River at approximate river mile 62. It is noted that these river mileages start at 0 at Lees Ferry, which is approximately 16 river miles below Glen Canyon Dam. Thus, the first recognized chub population at river mile 30 is actually approximately 46 river miles below Glen Canyon Dam. The Grand Canyon humpback chub population has shown increasing trends in numbers since 2001 (BOR and NPS 2015). The population is currently estimated at 11,000 adults compared to a population low of 5,000 in 2001 (Yackulic et al. 2014). Approximately 300 humpback chub are estimated to be present at the river mile 30 aggregation.

Humpback chub mainly occurs in river canyons where they utilize a variety of habitats including deep pools, eddies, upwells near boulders, and areas near steep cliff faces (NatureServe 2016).

As young humpback chub mature, they shift toward deeper and swifter offshore habitats (USFWS 2002c). Within the Grand Canyon, humpback chub occurs primarily in the vicinity of the Little Colorado River confluence, with adults being associated with large eddy complexes. Converse et al. (1998) reported that subadult humpback chub in the Colorado River downstream of the Little Colorado River showed higher densities along shoreline areas with vegetation, talus slopes, and debris fans.

Humpback chub are broadcast spawners with a relatively low fecundity rate compared to other minnow species of similar size (USFWS 2002c). Spawning primarily occurs in March through May in the lower basin and during April through June in the upper basin. Spawning temperatures typically range from 16°C to 22°C. The main spawning area for humpback chub in the Grand Canyon is the Little Colorado River, which provides warm water temperatures and shallow velocity pools for larvae (Gorman 1994).

Humpback chub was listed as endangered on March 11, 1967. On March 21, 1994, the USFWS designated seven reaches of the Colorado River system as critical habitat for humpback chub (USFWS 1994). Critical habitat is designated in portions of the Colorado, Green, and Yampa rivers in the Upper Colorado River Basin and the Colorado and Little Colorado rivers in the Lower Colorado River Basin. In total, 379 miles of critical habitat exists for humpback chub in these seven reaches. Two of these reaches overlap with portions of the potential indirect effects area that were analyzed for this species. This includes 12.9 miles in the Southwest Colorado River Region and 34.2 miles in the Southwest Gap Region. The upper end of the habitat is located approximately 27 miles upstream of the confluence with the Little Colorado River.

A recovery plan for humpback chub was first published in 1990 and then amended in 2002 (USFWS 2002c). Five-year reviews of the recovery goals were initiated in 2007 for the humpback chub and the other three Colorado River system endangered fish species (72 FR 19549-19551). For the purposes of recovery goals for humpback chub, the upper and lower basins are divided at the Glen Canyon Dam in Arizona. Separate objective, measurable recovery criteria were developed for each of the recovery units (i.e., the upper basin including the Green River and Upper Colorado River subbasins; and the lower basin including the mainstem of the Colorado River and its tributaries downstream to the Lake Mead National Recreation Area) to address the unique threats and use site-specific management actions necessary to minimize or remove these threats. The recovery units encompass three management areas under three separate recovery or conservation programs: Upper Colorado River Endangered Fish Recovery Program, the Glen Canyon Dam Adaptive Management Program, and the Lower Colorado River Multi-Species Conservation Program. Humpback chub will be considered eligible for downlisting from endangered to threatened and for removal from ESA protection when all the following conditions are met:

- Maintain six self-sustaining populations;
- Essential habitats, including required instream flows, are legally protected; and
- Other identifiable threats that could significantly affect the population are removed.

Factors affecting baseline conditions in the Southwest Gap Region of the Colorado River for humpback chub are described in the Glen Canyon Dam Long-term Experimental and Management

Plan (BOR and NPS 2015). A summary of these factors is provided below. These factors are applicable to the humpback chub and its critical habitat in the Southwest Gap Region.

Dams and Reservoirs – This factor applies humpback chub and the water and physical elements of its critical habitat. The construction of Lake Powell and Glen Canyon Dam altered riverine habitat and resulted in coldwater releases that have affected water temperatures. Cold water temperatures in the main channel are below the temperature for spawning, egg incubation, and growth of humpback chub. The survival of humpback chub young in the mainstem portion of the river is considered to be low because of cold water temperatures. However, water temperatures in the mainstem Colorado River have generally increased over the past 10 years (approximately 1 to 4°C maximum water temperature increase depending on the river location). Although the current water temperatures are not optimal for humpback chub, juvenile fish can now successfully rear to the adult stage. Population estimates for humpback chub in the Grand Canyon have been increasing since 2000, with suggested reasons being experimental water releases, drought-induced warming, trout declines due to removal and lower dissolved oxygen levels during 2006. This warmer water appears to have benefited the humpback chub and other native fish, but they also may have benefited non-native warmwater species (e.g., channel catfish, striped bass) that are more abundant farther downstream in the Grand Canyon.

Water Diversions – Flow changes from diversions and withdrawals in the Colorado River apply to humpback chub and the physical element of its critical habitat. Numerous non-federal diversions are currently in place on the mainstem Colorado River and tributaries in Colorado and Utah, and on the San Juan River in Colorado, Utah, and New Mexico. Collectively, these ongoing diversions reduce flows in the Upper Colorado River Basin, which reduce the volume of water stored in Lake Powell.

Non-native Fish – This factor applies to humpback chub and the biological environment element of its critical habitat. The occurrence of non-native fishes in the Colorado River affects humpback chub due to predation and completion. Predation by rainbow trout and brown trout in the Little Colorado River confluence area is a mortality threat to humpback chub survival, reproduction, and recruitment. Channel catfish and black bullhead prey on humpback chub in the Grand Canyon. Because of their size, adult humpback chub are less likely to be preyed on by trout. Experimental removal of non-native brown and rainbow trout was conducted in the Colorado River in Grand Canyon between 2003 and 2006.

Razorback Sucker

Historically, the razorback sucker (*Xyrauchen texanus*) occupied the mainstem Colorado River and many of its tributaries from northern Mexico through Arizona and Utah into Wyoming, Colorado, and New Mexico (USFWS 2002d). In the late 19th and early 20th centuries, it was reported that razorback sucker occurred in the Lower Colorado River Basin and common in parts of the Upper Colorado River Basin.

Existing populations of razorback sucker occur in the Green River, upper Colorado River, San Juan River subbasins; lower Colorado River between Lake Havasu and Davis Dam; Lake Mead and Lake Mohave; and in small tributaries of the Gila River subbasin (Verde and Salt rivers and Fossil Creek as well as in the deltas of rivers that empty into Lake Powell and in the upper reaches of Lake Powell (USFWS 2002d). Razorback suckers do not occur in the lower portion of Lake

Powell near the NGS pump station and water intakes. Fish in most of the populations consist of aged fish with little or no recruitment. Two spawning populations exist in Lake Mead and the middle Green River. The largest population occurs in Lake Mohave with approximately 2,000 fish (NatureServe 2013c). The Green River subbasin population is estimated to be approximately 500 fish (NatureServe 2013c; USFWS 2002d). The population is very small in the Upper Colorado River, with no evidence of spawning since the 1960s (NatureServe 2013c). It is estimated that the 60-mile reach of the lower Colorado River between Davis Dam and Lake Havasu contains more than 1,000 fish. The population estimate in Lake Mead is approximately 700 to 1,000 fish. The Gila River subbasin populations are small and consist of stocked hatchery fish. The minimum viable population size for razorback is estimated to be 5,800 adults (USFWS 2012b, 2002d). The razorback sucker is still declining from historical records in all the subbasins (NatureServe 2013c).

The types of habitat used by razorback sucker vary depending on the life stage and time of year. Adults use eddies, pools, and backwaters during the nonbreeding period from July through March (Maddux et al. 1993). Seasonal habitat use includes pools and eddies from November through April, runs and pools from July through October, runs and backwaters in May, and backwaters and flooded gravel pits during June. Juveniles prefer shallow water with minimal flow in backwaters, tributary mouths, off-channel impoundments, and lateral canals (Maddux et al. 1993). In the upper basin, bottomlands, low-lying wetlands, and oxbow channels flooded and ephemerally connected to the main channel by high spring flows are important habitats for all life stages of razorback sucker. Flow recommendations have been developed to enhance habitat complexity and restore and maintain ecological processes. In the Lower Colorado River Basin, adult razorback sucker utilize open-water areas except in the breeding season when they congregate in shallow, nearshore areas (USFWS 2002d). Larval razorback sucker in Lake Mohave occupied vegetated areas near the shore.

Spawning usually occurs in April through mid-June when river flows are relatively high and adult razorback sucker congregate in flooded bottomlands and gravel pits, backwaters, and impounded tributary mouths near spawning sites (USFWS 2002d). Thermal preference for spawning is 22°C to 25°C. Razorback sucker typically migrate a long distance in large numbers during the spawning period.

The razorback sucker was first proposed for listing as a threatened species under the ESA in 1978 (43 FR 17375). In 1980, the USFWS withdrew the proposal because it was not finalized within the 2-year time limit from the initial publication in the FR (45 FR 35410). In 1989, the USFWS received a petition requesting that the razorback sucker be added to the list of endangered species. A positive finding was made and subsequently published by the USFWS in 1991 (56 FR 54957). In 1994, the USFWS designated 15 reaches of the Colorado River system as critical habitat (USFWS 1994). Critical habitat consists of three primary constituent elements: water (temperature, turbidity, and lack of contaminants), physical (areas used for spawning, feeding, rearing within the 100-year floodplain), and biological environment (adequate food supply and ecologically appropriate levels of predation and competition) (USFWS 1994). Critical habitat is designated in portions of the Green, Yampa, Duchesne, Colorado, White, Gunnison, and San Juan rivers in the Upper Colorado River Basin and the Colorado and Little Colorado rivers in the Lower Colorado River Basin. Critical habitat in the Colorado River includes reaches in the Upper Colorado River Basin (above and below Westwater Canyon in Colorado and Utah and the Lower Colorado River Basin from the confluence with the Paria River to Hoover Dam). In

total, 1,724 miles of critical habitat for razorback sucker has been designated. Critical habitat overlaps with portions of the action area that were analyzed for this species. This includes 48.8 miles in the Northeast Colorado River Region, 68.4 miles in the Southwest Colorado River Region, and 211.1 miles in the San Juan River. Critical habitat in the Verde River extends between Perkinsville, Arizona and Horseshoe Reservoir.

A recovery plan for razorback sucker was first published in 1990 and then amended in 2002 (USFWS 2002d). Recovery of razorback sucker in the Colorado River Basin is considered necessary in both the upper and lower basins because of the present status of populations and existing information on razorback sucker biology. The upper basin recovery unit is composed of the Green River, Upper Colorado River, and San Juan River subbasins. The lower basin recovery unit includes the mainstem and tributaries of the Colorado River from Lake Mead downstream to the International Boundary with Mexico (USFWS 2002d). Razorback sucker will be considered eligible for downlisting from endangered to threatened and for removal from ESA protection when all the following conditions are met:

- Maintain self-sustaining populations in the Green River subbasin and either the Upper Colorado River subbasin or the San Juan River subbasin in the upper basin recovery unit;
- Maintain two genetically and demographically self-sustaining populations in the lower basin recovery unit;
- Maintain a genetic refuge in Lake Mohave;
- Essential habitats, including required instream flows, are legally protected; and
- Other identifiable threats that could significantly affect the population are removed.

Based on information in the Glen Canyon Dam Long-term Experimental and Management Plan (BOR and NPS 2015), the decline of the razorback sucker throughout its range has been related primarily to habitat loss due to dam construction, loss of spawning and nursery habitats as a result of diking and dam operations, and alteration of flow hydrology. It is estimated that approximately 80 percent of the reduction in the historical distribution of this species has been attributed to the construction of Hoover, Parker, Davis, and Glen Canyon Dams on the Colorado River and Flaming Gorge Dam on the Green River. In addition, competition with and predation by non-native fishes also have been identified as important factors in the decline of this species, as discussed for humpback chub. In the Grand Canyon, the decline of native fish, including razorback sucker, has been attributed in large part to an increased diversity and abundance of non-native fishes along with the effects of Glen Canyon Dam on water temperatures, flow, and sediment (Gloss and Coggins 2005).

3.10 CULTURAL RESOURCES

Cultural resources are finite locations of human activity, occupation, or use identifiable through field survey, historical documentation, or oral evidence. The term includes archaeological, historic, or architectural sites, structures, or places with important public and scientific uses, and may include sites or places of traditional, cultural, or religious importance to specified social

and/or cultural groups, including Native Americans. Cultural resources are concrete, material places and things that are located, classified, ranked, and managed through the system of identification, protection, and utilization for public benefit.

Section 106 of the NHPA requires federal agencies to consider an undertaking's effects on cultural resources that are listed on or eligible for listing on the National Register of Historic Places (NRHP). Cultural resources listed on or eligible for listing on the NRHP are referred to as "historic properties." There are three main standards a property must meet to qualify for listing on the NRHP: age, integrity, and significance. To meet the age criteria, a property generally must be at least 50 years old. To meet the integrity criteria, a property must possess the applicable aspects of integrity, which may include location, design, setting, materials, workmanship, feeling, and association. Finally, a property must be significant according to one or more of the following criteria:

> Criterion A: Be associated with events that have made a significant contribution to the broad patterns of our history;
>
> Criterion B: Be associated with the lives of persons significant in our past;
>
> Criterion C: Embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
>
> Criterion D: Have yielded, or may be likely to yield, information important in prehistory or history (36 CFR 60.4).

Federal law and agency guidance require federal agencies to consult with Native American tribes concerning the identification of cultural values, religious beliefs, and traditional practices of Native American people that may be affected by a federal undertaking. This consultation includes the identification of places (i.e., physical locations) of traditional cultural importance to Native American tribes. Places that may be of traditional cultural importance to Native American people include, but are not limited to:

- Locations associated with the traditional beliefs concerning tribal origins, cultural history, or the nature of the world;
- Locations where religious practitioners go, either in the past or the present, to perform ceremonial activities based on traditional cultural rules or practice;
- Ancestral habitation sites;
- Trails;
- Burial sites; and,
- Places from which plants, animals, minerals, and waters possessing healing powers or used for other subsistence purposes, may be taken.

In 1992, the NHPA was amended to explicitly allow that "properties of traditional religious and cultural importance to an Indian tribe or Native Hawaiian organization may be determined to be eligible for inclusion on the NRHP." If a resource has been identified as having importance in traditional cultural practices and the continuing cultural identity of a community, it may be considered a traditional cultural property (TCP). To qualify for nomination to the NRHP, a TCP must:

- Be more than 50 years old;
- Be a place with definable boundaries;
- Retain integrity; and
- Meet certain NRHP-eligibility criteria as previously listed above for cultural resources.

The study area for cultural resources is the Affected CRAs (**Figure 2.2-1**). Associated haul roads, coal-handling areas, conveyors, coal load out silo facilities, storage areas, shops, offices, and other structures and facilities would continue to be used as they have been in the past.

Previous surveys of the entire Lease Area were conducted from 1967 to 1987 through the Black Mesa Archaeological Project (BMAP) in order to comply with Section 106 of the NHPA. PWCC also conducted a Data Quality Assessment Survey in 2016 as part of the currently-suspended NGS-KMC EIS (**Section 2.2**) (Graves 2015). OSMRE has completed Section 106 consultation for the entire study area through the BMAP, and no further consultation would be required for the Renewal.

A total of 2,710 archaeological sites (1,671 pre-ceramic and Puebloan and 1,039 historic Navajo) were documented in the Lease Area through the BMAP; 215 of these sites have been excavated, and artifacts from 887 other sites have been archaeologically collected, tested, and mapped (Powell et al. 2002). Of these, 35 prehistoric sites and 19 historic Navajo sites are located within the study area, including 15 sites (eight prehistoric and seven historic) in CRA J-19, 22 sites (13 prehistoric and nine historic) in CRA J-21, and 17 sites (14 prehistoric and three historic) in CRA N-9. Four additional cultural resource sites were identified in CRA J-21 as part of the Data Quality Assessment Survey (Graves 2015). In addition, PWCC has discovered three cultural resources (two inadvertent discoveries of human remains and one discovery of three possible historic gravesites) in CRAs J-19 and J-21. Those discoveries were treated in accordance with PWCC's permit terms (**Section 4.10**).

To date, PWCC has identified, documented, and reburied 96 burials found at 30 archaeological sites within the Lease Area in accordance with the Native American Graves Protection and Repatriation Act (NAGPRA) and the Navajo Nation policy for the Protection of Jishchaá: Gravesites, Human Remains, and Funerary Items, before mining was initiated at those locations. Of the 96 burials, 58 were prehistoric burials found at 15 archaeological sites in CRA J-19; 12 were prehistoric burials and one was a historic burial found at six sites in CRA N-9; and, 8 were prehistoric burials and 2 were historic burials found at seven sites in CRA J-21. No additional archaeological sites with the potential for human remains have been identified in the study area. When human remains were encountered, they were either recorded and reburied in locations that would not be disturbed by future mining-related activities or fenced and avoided. The Tribes

participated in the development of reburial protocols and gave their consent for reburial (BOR 2016).

Traditional Hopis and Navajos consider all of Black Mesa (known as *Nayavuwaltsa* to the Hopi and *Dzilijiin* to the Navajo) to be an important traditional cultural resource due to its role in traditional stories and ceremonial and clan traditions. Other mountains in the region, such as the San Francisco Peaks, also are considered sacred. One sacred and ceremonial site has been identified in CRA J-19 (Bungart 1997), 11 have been identified in CRA J-21 (Sandoval 2013b; Spurr 2014, 1998, 1997; Spurr et al. 2004; Tsosie 2007), and three have been identified in CRA N-9 (Sandoval 2003b; Tsosie 2005).

TCP studies were completed for the Navajo Nation and Hopi Tribe as part of the NGS-KMC EIS (HDR 2016, Anthropological Research and HCPO 2016; **Section 1.2**). These studies identified 576 Navajo TCPs and 38 Hopi TCPs. Final NRHP eligibility determinations for these sites were not made.

3.11 INDIAN TRUST ASSETS

The direct impacts study area for Indian Trust Assets is the Permit Area (**Figure 3.1-1**) and the indirect effects study area includes the area around the NGS that may be affected by coal combustion (**Figure 3.7-1**). Indian Trust Assets are legal interests in property held in trust by the U.S. for Native American tribes or individuals, or property protected under U.S. law for Native American tribes or individuals. These assets normally are associated with Native American reservations or land in proximity to reservations; however, some assets may be located some distance from a Native American reservation. Examples of objects that may be trust assets are lands, minerals, federally-reserved hunting and fishing rights, federally-reserved water rights, and instream flows associated with trust land. By definition, Indian Trust Assets cannot be sold, leased, or otherwise encumbered without approval of the U.S. The Indian Trust Assets for the Navajo Nation and Hopi Tribe within the study area are minerals, water rights, lands, hunting and gathering rights, and other natural resources.

The U.S. government has a trust responsibility to protect and maintain rights reserved by or granted to Native American tribes or individuals by treaty, statutes, and executive orders, which are sometimes further interpreted through court decisions and regulations. This responsibility requires federal agencies to take actions necessary to protect Indian Trust Assets. The trust responsibilities of the U.S. shall include, but are not limited to, appropriately managing the natural resources located within the boundaries of Indian reservations and trust lands (25 USC 162a(d)).

According to OSMRE Directive 979, which sets forth policies and procedures the agency follows to ensure that OSMRE action complies with Indian Trust Asset responsibilities, "OSMRE personnel must ensure that Bureau actions identify, conserve, and protect lands and other resources that the Department holds in trust for federally recognized Indian tribes and tribal members." The directive also states that OSMRE must consult with Indian tribes for actions with the potential to impact trust lands or trust resources, and requires OSMRE to "respect Indian tribal self-government and sovereignty, honor tribal treaty and other rights, and strive to meet the responsibilities that arise from the unique legal relationship between the federal government and Indian tribal governments" (OSMRE 2013).

3.11.1 Minerals

The primary statutes governing the leasing of Indian coal assets for the benefit of an Indian tribe or nation are the Indian Mineral Leasing Act of 1938 and the Indian Mineral Development Act of 1982. An American Indian Coal Lease is obtained by direct negotiation with Indian tribal authorities, but is subject to approval and administration by the U.S. Department of the Interior. The authority by which coal reserves that are Indian Trust Assets are leased is described in 25 USC 396a and concerns leases of un-allotted lands for mining purposes. It states the following:

"On or after May 11, 1938, un-allotted lands within any Indian reservation or lands owned by any tribe, group, or band of Indians under Federal jurisdiction, except those specifically excepted from the provisions of Sections 396a and 396g of this title, may, with the approval of the Secretary of the Interior, be leased for mining purposes, by authority of the tribal council or other authorized spokesmen for such Indians, for terms not to exceed ten years and as long thereafter as minerals are produced in paying quantities."

The study area is located on leased land within the boundaries of the Navajo Nation and Hopi Tribe. All of the coal produced in the study area is an Indian Trust Asset and is produced subject to one of three coal leases, which designates land rental rates, royalty rates for the coal, other fees, and additional terms. In 1964, lease No. 14-20-0603-8580 was approved by the Navajo Nation Tribal Council, executed by the Navajo Nation, and approved by the Secretary of the Interior. The lease covers the 24,858 acres of the northern portion of the Kayenta and former Black Mesa mining operations, where the Navajo Nation holds both surface and mineral land ownership. CRAs N-9 and N-11 are within this area. The other two leases, approved by the Hopi Tribe and Navajo Nation in 1966, cover the southern portion of the mining operations, where the tribes have joint and equal interests in the minerals that underlie the former Joint Use Area. Lease No. 14-20-0603-9910 was approved by the Navajo Nation Tribal Council, executed by the Navajo Nation, and approved by the Secretary of the Interior. Lease No. 14-20-0450-5743 was executed by the Hopi Tribe and approved by the BIA. The surface of the southern portion of the leasehold has been partitioned. Approximately 33,863 acres are in Navajo Nation ownership, while 6,137 surface acres are in Hopi Tribe ownership (PWCC 2002). CRAs J-19 and J-21 are within the area owned by the Navajo Nation.

3.11.2 Land

Land within the study area, including the Affected CRAs, is considered an Indian Trust Asset. PWCC has been granted coal mining leases over approximately 64,858 acres by the Navajo Nation and Hopi Tribe. These leases provide PWCC with the rights to prospect, strip, and mine leased lands to produce coal and associated products, including other minerals that may be found, except for oil and gas. PWCC also is granted:

- Rights of ingress and egress;
- The right to construct support facilities, such as buildings, pipelines, tanks, plants, and other structures;
- The right to excavate or build stockpiles, ditches, drains, roads, spur tracks, electric power lines, and make other improvement;

- The right to replace machinery and other equipment and fixtures and perform other activities on the leased lands; and
- The right to develop and use groundwater for the mining operations.

In addition to mineral exploration and development, land uses within and adjacent to the study area include residential uses, livestock grazing, and traditional uses. Many of the residents graze cattle, sheep, goats, and other livestock as a food source and for income. Livestock grazing occurs year-round and was the primary pre-mining land use in the study area.

Regulations require a minimum distance between mining activities and residential properties. PWCC, in cooperation with the Navajo Nation and per approved procedures, relocates households to an agreed upon location, as needed, to accommodate surface coal mining activities. Relocated residents are compensated for the replacement of all structures.

3.11.3 Water

Rights to the surface water and groundwater associated with the Navajo Nation and Hopi Tribe reservations are considered Indian Trust Assets of the respective tribes. However, the Navajo Nation claims that water, not just water rights, is an Indian Trust Asset. All of the existing project components lie within the Little Colorado River watershed. Surface water, including the Moenkopi, Dinnebito, Oraibi, Wepo, Polacca, and Jeddito washes, drain Black Mesa to the southwest and join the Little Colorado River. Surface flows within the study area are highly variable and primarily consist of storm runoff. None of the tributaries or washes in or near the study area is a reliable source of water for irrigation, livestock, or potable use (**Section 3.7**). The Colorado River is included in this analysis because its water quality could be indirectly affected by coal combustion at the NGS.

Within Black Mesa, groundwater in the region can be found in alluvium, the Mesa Verde Group, and the D-, N-, and C-Aquifers. The N-Aquifer is the primary source of potable water for municipal use and the current source of water supply for the coal mining operations; PWCC pumps approximately1,236 af/yr from the N-Aquifer. The D-Aquifer is estimated to have historically contributed 130 af/yr to the total mine supply. PWCC has recently modified the groundwater pumping system to eliminate withdrawals from the D-Aquifer. PWCC's existing leases with the tribes require N-Aquifer wells to be transferred to the tribes properly cased for their use after PWCC successfully completes reclamation and relinquishes the leases (**Section 3.7**).

3.11.4 Hunting and Gathering and Other Natural Resources

The Navajo Nation and Hopi Tribe have rights to continue hunting and gathering, grazing, and other traditional uses on their respective reservations except in specific areas withdrawn for mining purposes (**Section 3.12**). Grazing permit holders whose lands are withdrawn currently are compensated for loss of use, with payments made every five years.

3.12 LAND USE AND RECREATION

3.12.1 Land Use

The study area for land use is the Permit Area plus a 0.5-mile buffer (**Figure 3.1-1**). Land uses in the study area include mineral exploration and development, dispersed residential uses, livestock grazing, and traditional uses (such as hunting, gathering, and ceremonial). The Kayenta Mine is the only industrial operation in the study area (PWCC 2005b).

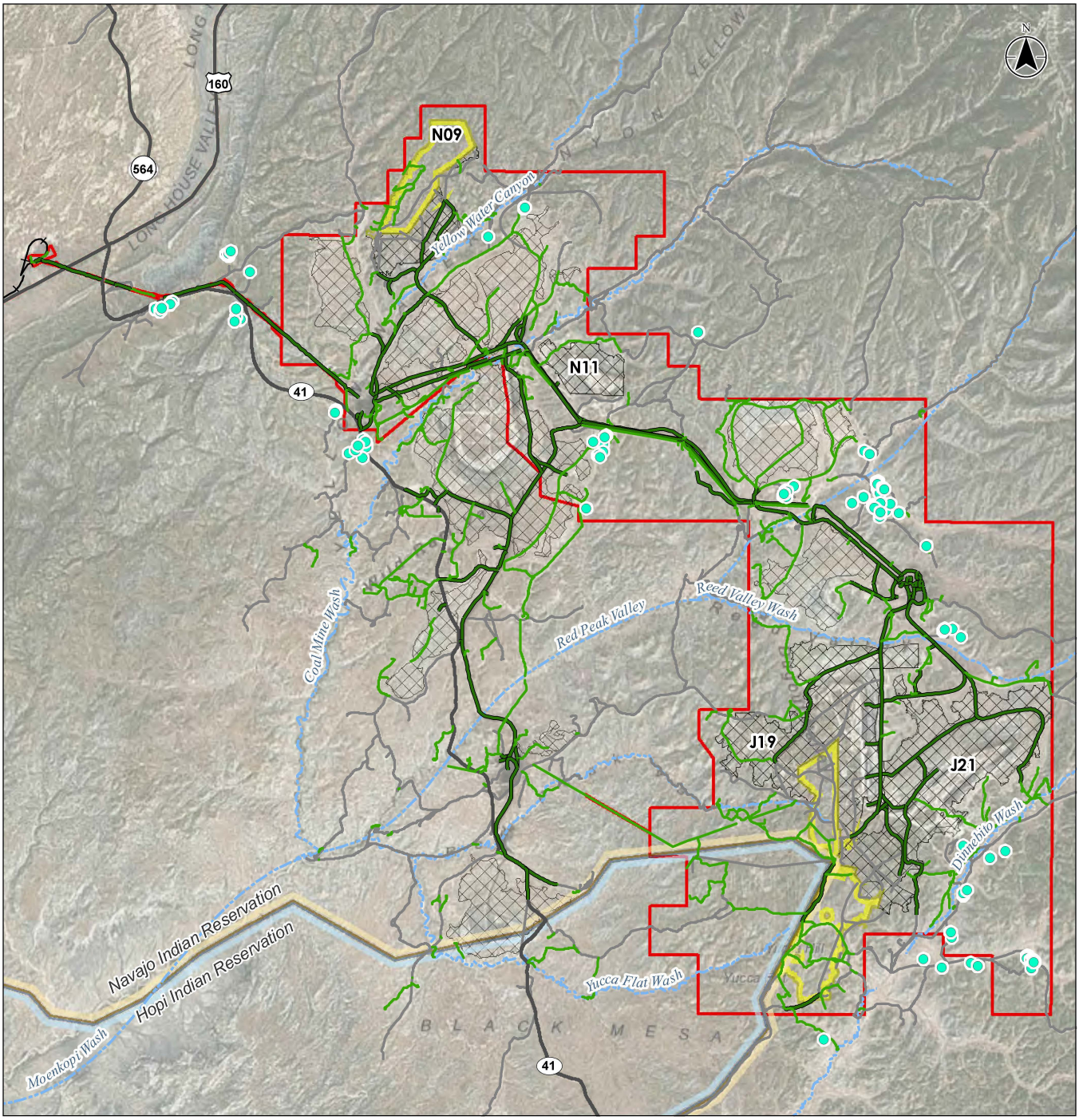
There is little commercial development within the study area. A gas station and convenience store are located north of the mine at the intersection of U.S. Highway 160 and Navajo Route 41. The closest commercial area with food and lodging is Tsegi on U.S. Highway 160 about six miles north of the study area. As of August 2017, both of these businesses have ceased operation.

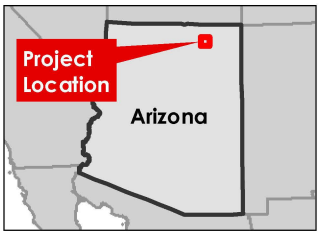
There are 114 occupied residences within the study area (**Figure 3.12-1**). Regulations require a minimum distance between mining activities and residential properties. Residences consist of individual family dwellings or extended family camps with several dwellings. Historically, individual land ownership by Indian tribes did not exist. This perspective persists today within the Navajo and Hopi tribes, in that they consider themselves caretakers of the land and its resources, and that all are entitled to lands' resources. Users' rights are protected and specified in various traditions, but land ownership is not generally part of tribal traditions.

Four households were relocated out of CRA J-21 during the last permit period (2010 – 2015) that were on top of coal resources or within 0.5 mile of the coal recovery line. PWCC, in cooperation with the Navajo Nation and according to approved procedures (PAP), relocated the households to a location suitable to the residents. Relocated residents were compensated for the replacement of all structures, including homes, corrals, and sheds, and for lost grazing acreage if the resident established a customary use area claim (PWCC 2005b; OSMRE 1990). PWCC, through its relocation program, attempts to relocate residents within their customary use areas (i.e., where ranching activities take place or where sociocultural ties exist). Residents would be able to return to their original home sites after reclamation is completed and the land is returned to tribal control after 20 to 25 years.

Livestock grazing is a traditional and predominant land use in the study area. Grazing occurs throughout the year and includes all classes of livestock. There are three range management districts, two Navajo and one Hopi, that are located in the study area. A small percentage of the permitted sheep units for the districts are grazed within the study area. Residents may graze sheep, cattle, and/or horses under a livestock grazing permit issued by the BIA. Range condition on all native grazing lands is generally low due to low quality soils that limit or restrict their use as pasture (**Section 3.3**) and heavy year-round livestock grazing. Based on a stocking rate of 107 acres per animal unit month (AUM) for the piñon-juniper woodland and shrubland vegetation types (PAP), there are 13,225 AUMs of forage available in the study area. As areas are reclaimed to meet post-mining land uses, the reclaimed areas contain higher quality grazing lands (ESCO 2010). PWCC grants permission on a case-by-case basis for residents to graze reclaimed lands prior to bond release within the Permit Area.

V:\2037\Active\203706045\03_data\gis_cad\vsk\mxds\EA Ch 3\Figure 3.12_1 Residences within Study Area.mxd Revised: 2017-09-21 By: cadlepos





Notes

1. Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 Feet
2. Service Layer Credits: Sources: Esri, DeLorme, USGS, NPS
   Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- Occupied Residence (2016)
- Highway
- Road

PWCC Mine Road

- Primary
- Ancillary

- Intermittent Stream/Drainage
- Navajo-Hopi Partition Line
- Proposed Mining & Associated Disturbance 2015-2019
- Mined Out - Reclamation Complete or Ongoing
- Kayenta Mine Permit Area

0 1 2 miles

1:150,000 (at original document size of 8.5x11)

Stantec

Project Location 203706045

T35N R18E, T35N R19E, T36N R17E, T36N R18E, T36N R19E, T37N R18E
Navajo County, AZ

Prepared by CLG on 2017-09-21
Technical Review by SL on 2017-09-21
Independent Review by DK on 2017-09-21

Client/Project
PWCC
Kayenta Mine SMCRA Permit
Environmental Assessment

Figure No.
3.12-1

Title
Residences within Study Area

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

Based upon the results of selenium analysis in plants and soils at a representative cross section of sites where accumulator plants were found, the soils in which they were growing are not seleniferous; and no selenium poisoning of livestock has been reported in or surrounding the mine (**Section 3.3**). Selenium supplements are often added to salt blocks used by the local ranchers (PAP).

Traditional family gardens associated with residences occur within the study area. These small fields are used or have been used for the production of adapted crops, particularly corn for domestic use. The size of individual plots averages approximately 4.5 acres (OSMRE 1990).

Numerous plant species have cultural significance to the Hopi and Navajo people in the study area. Plants are used for construction, heat, medicine, ceremonies, and food. Hundreds of plants culturally important to the Hopi and Navajo have been documented (Rainey and Adams 2004) and one of the missions of the Navajo Nation Natural Heritage Program is to document cultural information on plants and animals important to the Navajo. Unknown quantities of piñon pine, Utah juniper, and one-seed juniper trees are harvested for firewood, fence posts, and construction materials (OSMRE 1990), and PWCC provides firewood to local residents from their slash piles. No specific collection areas have been identified in the study area, and many of the species are widely distributed within their habitats, including the study area. Culturally important plants also are present in reclaimed areas where cultural plant sites have been established (about five percent of the reclaimed area) and where natural recolonization has occurred.

Coal from the mine is provided to the Navajo and Hopi people in the study area for home heating, along with information on the safe use of coal for indoor heating. Other natural resources that may be used for traditional purposes include minerals or clay deposits and sources of surface water or shallow groundwater.

The presence of wildlife habitat and associated species encourages activities such as hunting, which provides a primary or supplemental food source. Hunting is regulated by the Navajo and Hopi tribal governments.

3.12.2 Recreation

The study area for recreation is the Permit Area plus a 0.5-mile buffer. The study area is closed to non-tribal members without a permit or authorization. Hiking may occur to a limited extent north of the study area near the rim of Black Mesa.

There are no developed recreation facilities within the study area and no specific data are available on the use of the study area for recreation. Residents report that the area is sparsely used for sightseeing (OSMRE 1990). Possible recreational activities may include hiking and game and bird hunting; however, the area within the Permit Area is closed to all hunting (PWCC 2005b).

3.13 VISUAL RESOURCES

Visual resources are the natural and man-made features that give an area its visual character. The indirect effects study area for visual resources is the same as the indirect effects study area for

air quality (300-km radius around NGS – **Figure 3.5-2**), additional information regarding the indirect effects study area for visual resources can be found in **Section 3.5.7**, **Regional Haze**.

The direct effects study area for visual resources is defined as a five-mile buffer around the Permit Area and includes the Affected CRAs (**Figure 3.1-1**). The five-mile buffer represents a middleground to background viewing threshold as defined by the Bureau of Land Management's (BLM's) visual resource management (VRM) system (BLM 1984). The viewshed is described in terms of landscape character, viewer sensitivity, and visibility. The study area is on Navajo Nation and Hopi Tribe reservation land; neither tribe classifies lands for visual or scenic resources nor are areas specifically designated for the protection of visual resources.

The study area landscape is characterized using physiographic provinces, or geomorphic regions that are broadscale subdivisions based on terrain texture, rock type, and geologic structure and history. The direct effects study area is contained within the Navajo Section of the Colorado Plateau physiographic province, which exhibits several unique landscape settings and viewing conditions. The Colorado Plateau's major distinguishing features are landforms cut by wind and water erosion from the largely horizontal strata and the relatively high elevations of this province.

Scenic integrity indicates the degree of intactness and wholeness of the landscape character (USFS 1995). Human alterations can raise, maintain, or lower scenic integrity. In general, the landscapes are vast and expansive, permitting extensive views of undisturbed landscapes with rolling piñon-juniper woodlands and rock outcroppings. Often, these same views contain evidence of existing man-made structures or existing coal mining activity. Areas with existing disturbance include active coal mine operations, reclaimed areas with a grassland-shrubland vegetation community, agricultural and rural housing along the Moenkopi and Dinnebito washes, grazing or livestock facilities, transmission lines, and airstrips.

The extent to which new development contrasts with the existing scenic integrity is one of the factors used to analyze potential impacts to visual resources. Visual resource elements consist of form, line, color, texture, and motion. The disturbance in the Affected CRAs (current mining areas) and facilities are notable visual features that currently contrast with the surrounding natural and reclaimed landscapes. Visibility of the mining operations depends upon distance, topography, and screening by vegetation and structures. Changes in form and line range from the gently rolling rounded hills to the horizontal and parallel ridges and troughs. Changes in color range from the dark, olive, and silver greens of the piñon-juniper woodland and sagebrush shrubland, and the reds, tans, and grays of the soil to the blacks and dark grays of the exposed overburden ridges. Changes in texture range from the scattered-medium to course patterns of vegetation to the random to linear relatively fine-textured overburden ridges.

Compared to the natural landscape, reclaimed land in the study area consists of large patches of darker colored soil/rock and various ages of vegetation. The topography is less steep and coarser patterned. The lack of trees in most of the reclaimed areas could widen and extend views. However, as the vegetation matures, reclaimed areas blend into surrounding landscapes and appear to be undisturbed.

Night sky resources include stars, constellations, comets, meteor showers, and other similar astronomical features or phenomena that are typically best viewed during nighttime hours. Urban sky glow, a type of light pollution, which brightens the night sky, is responsible for diminishing the

ability to observe night sky resources in inhabited areas or areas with excessive lighting. Light that is emitted upward and laterally from outdoor artificial lights scatters through the atmosphere and causes a loss in night sky visibility.

The Kayenta Mine generates light that is visible at night in the area. The mine utilizes lights on trucks, active mining areas in the CRAs, loading areas, and parking lots seven nights per week, all night long. Mine lighting is visible from roads approaching the mine and also would be visible from the air and from surrounding elevations that are higher than the mine.

Viewer sensitivity is defined by the type of viewer and circumstance of their activity in a landscape. Residents in a residential neighborhood or natural setting who have continuous potential views of the mining area are considered highly sensitive. Residents surrounded by an agricultural area are considered moderately sensitive. Routine travelers along major roads who have transitory and directed views are considered to be moderately sensitive. Daily mine employees are considered to have low sensitivity.

Within the study area, the occupied structures are usually in clusters of approximately two to 30 structures. The major roads include U.S. Highway 160 and Arizona Route 564. Navajo Route 41 is used by the local residents and mine employees, and the occasional sight-seer (**Section 3.12**).

3.14 TRANSPORTATION AND ACCESS

The transportation study area includes the roads used to support mine related vehicle traffic: Navajo Route 41, Arizona Route 89, and U.S. Highway 160, and mine roads within the Permit Area (**Figure 3.1-1**). Regionally, the transportation network provides access to neighboring communities and the surrounding area. U.S. Highway 160 lies north of the Permit Area and extends from the southwest to the northeast. Arizona Route 89 is located west of the Permit Area, extending northwest from U.S. Highway 160 toward Page, Arizona. Navajo Route 41 is also located west of the Permit Area, extending south from U.S. Highway 160 to the town of Piñon.

Primary roads within the Permit Area are used by major haul vehicles and general access vehicles. Ancillary roads support the primary road system. The Kayenta Mine uses approximately 194 miles of primary and ancillary mine roads. Primary and ancillary roads are located, designed, constructed, used, maintained, and reclaimed in accordance with federal regulations and performance standards. PWCC has constructed or upgraded both primary and ancillary roads within the Permit Area. The primary roads include coal-haul and mine-vehicle roads a minimum of 50 feet wide, and coal-haul, mine-vehicle, and dragline deadheading roads approximately 150 feet wide (OSMRE 1990). To gain access to mine facilities in remote sites, on-highway vehicles most frequently use ancillary roads. There are two types of ancillary roads: two-lane roads a minimum of 24 feet wide, and single-lane roads with a minimum width of a bulldozer blade or a motor-grader blade. The single-lane roads usually follow the natural topography and were established by area residents prior to mining activities (OSMRE 1990).

3.15 SOCIAL AND ECONOMIC CONDITIONS

The Permit Area is located entirely within Navajo County, Arizona and is located within a portion of the Hopi Reservation and the Navajo Nation chapters of Chilchinbito, Forest Lake, Kayenta, and Shonto[4]. The social and economic conditions study area includes areas that could be affected economically and socially by the Renewal due to their proximity to the Kayenta Mine. This includes Navajo, Coconino, and Apache counties; the Hopi and Navajo reservations, and local villages and chapters of government on the Hopi and Navajo reservations (**Figure 3.1-1**). Data also were collected for the State of Arizona, to use for comparison purposes.

3.15.1 Regional Overview of Demographics and Economics

Table 3.15-1 presents an overview of demographic characteristics for the Navajo Nation and Hopi reservation; Apache, Coconino, and Navajo counties; and the State of Arizona. Arizona was one of the fastest growing states in the nation in the 1990s. Rapid growth continued between 2000 and 2004 at the state, county, and tribal levels.

Table 3.15-1 Key Population Characteristics – Regional

	Counties			Tribal		State of Arizona
	Apache	Coconino	Navajo	Hopi Reservation	Navajo Nation	
Total Population						
Census 2000[1]	69,423	116,320	97,470	6,946	180,462	5,130,632
Census 2010	71,518	134,421	107,449	7,185	173,667	6,392,017
Population change (%), 2000-2010	+3.0	+15.6	+10.2	+0.3	-3.8	+24.6
Median age, 2000	27	29.6	30.2	29.1	24.0	34.2
Median age, 2010	N/R	N/R	N/R	32.2	28.8	35.9
Dependency ratio, 2000	67.1	44.2	64.6	68.9	69.7	54.9
Persons per household, 2000	3.41	2.80	3.17	3.49	3.77	2.64
Persons per household, 2010	N/R	N/R	N/R	3.45	3.47	2.63

Source: U.S. Census Bureau 1990, 2000, 2010, 2016a; Hopi Tribe 2001, 2010; Navajo Nation 2005, 2010
N/A = Not reported
[1] Surveys completed for the Hopi Strategic Land Use and Development Plan indicated a year 2000 population of 10,571, rather than the 6,946 reported in Census 2000.

According to the 2000 U.S. Census, the median age of the population in the region is similar to that of the state of Arizona. However, the Navajo Nation, Hopi Reservation, Apache, Coconino, and Navajo County have lower median ages relative to the state of Arizona. The region also has a larger number of persons per household in comparison to the state of Arizona. The dependency ratio is a statistic that compares the size of the economically dependent population age groups (age under 15 and over 65) to the size of the working-age population expressed as a percentage. Areas with dependency ratios over 60 percent tend to have a proportionately small number of

[4] A village is the Hopi unit of local government; a chapter is the Navajo unit of local government.

employed persons supporting the remainder of the residents. While the state of Arizona and Coconino County had dependency ratios less than 60 (in 2000), the other portions of the study area have dependency ratios over 60, and both tribes' dependency ratios are higher than any of the counties in the study area. The dependency ratio reported in the 2010 U.S. Census for the state of Arizona is similar to that reported in the 2000 U.S. Census for the state of Arizona. At this time, no data is available for the dependency ratio at the County and Tribal level.

3.15.2 Employment and Labor Force

In general, the Navajo Nation and Hopi reservations are economically depressed due to limited economic opportunities; unemployment is persistently high in the labor force. Labor force participation on the Navajo Nation and Hopi reservations is low in comparison to the statewide and off-reservation areas (**Table 3.15-2**).

Table 3.15-2 Employment Characteristics

	Navajo Nation (all)	Hopi Reservation	Apache County	Coconino County [1]	Navajo County [1]	State of Arizona [1]
Labor Force Participation (population 16 years & over)	44.2%	54.0%	44.5%	66.0%	50.6%	60.6%
Civilian Labor Force	55,437	3,086	23,447	70,788	40,239	3,038,226
Unemployed	11,988	522	4,853	6,348	7,828	316,360
Unemployment Rate	21.6%	16.9%	26.1%	9.0%	19.5%	10.4%

Source: U.S. Census Bureau 2014
[1] Includes the populations residing on the reservation.

The 2009 – 2013 American Community Survey conducted by the U.S. Census Bureau (2014) estimated unemployment on the Navajo Nation at 21.6 percent and unemployment on the Hopi Reservation at 16.9 percent. In comparison, the statewide unemployment average was 10.4 percent (**Table 3.15-2**). Local estimates of unemployment were much higher (e.g., above 50 percent) on the Navajo Nation (RPI Consulting 2011).

Table 3.15-3 provides employment by major industry and place of employment for the study area. The primary employment industries in the study area are government (public sector) and health care and social assistance. As of Fall 2016, the Kayenta Mine employed 317 individuals, 96 percent of whom were Native American. Nearly all these positions were full-time salaried or hourly wage status and eligible for the company's comprehensive benefits packages.

3.15.3 Earnings and Personal Income

The Navajo Nation and Hopi reservations experience high unemployment, low labor force participation, and factors such as reliance on seasonal and part-time employment. As a result, household incomes are below the statewide and national averages in terms of income distribution, higher than average dependency on public assistance, and poverty rates that are more than double the statewide rate. In 2010, an estimated 38 percent of Navajo and 35 percent of Hopi residents on the reservations had incomes below the poverty level (**Table 3.15-4**).

Table 3.15-3 Employment by Industry, 2014

Industry	Apache County		Coconino County		Navajo County	
	# of jobs	% of jobs	# of jobs	% of jobs	# of jobs	% of jobs
TOTAL EMPLOYMENT	30,414	100	86,938	100	40,585	100
Farm employment	5,570	18	2,261	3	3,980	10
Nonfarm employment	24,844	82	84,137	97	36,605	90
Private nonfarm employment	13,904	46	65,044	75	26,674	66
Forestry, fishing, and related	257	1	229	0	232	1
Mining	213	1	502	1	662	2
Utilities	(D)	(D)	214	0	104	0
Construction	887	3	3,291	4	2,071	5
Manufacturing	563	2	4,872	6	409	1
Wholesale trade	(D)	(D)	1,467	2	416	1
Retail trade	1,845	6	9,018	10	4,500	11
Transportation & warehousing	584	2	2,036	2	1,241	3
Information	140	0	696	1	1,276	3
Finance and insurance	296	1	1,871	2	923	2
Real estate & rental & leasing	809	3	4,093	5	1,951	5
Professional, scientific, & technical services	525	2	3,545	4	976	2
Management of companies & enterprises	0	0	169	0	265	1
Administrative & waste management services	505	2	2,627	3	1,365	3
Educational services	619	2	1,152	1	742	2
Health care & social assistance	2,972	10	10,049	12	3,861	10
Arts, entertainment, and recreation	322	1	3,297	4	476	1
Accommodation & food services	1,289	4	12,004	14	3,350	8
Other services, exc. public administration	1,159	4	3,912	4	1,854	5
Government and government enterprises	10,940	36	19,093	22	9,931	24

Source: U.S. Bureau of Economic Analysis (BEA) (2015)
(D) = undisclosed industry values

Table 3.15-4 Income Characteristics, Hopi and Navajo on Reservations, 2010

	Household Income		Households Reporting Income from the Following Sources (percent)[1]			Persons Below Poverty Level (percent)
	Less than $25,000 (percent)	Median	Earnings	Retirement Income	Public Assistance	
Hopi Reservation	34.8	$34,016	79.9	19.6	29.6	35
Navajo Nation (AZ only)	48.6	$26,401	64.0	15.7	14.7	38
State of Arizona	22.9	$50,448	78.2	18.9	9.8	15
U.S.	23.5	$51,914	79.7	17.5	10.0	14

[1] These columns may sum to more than 100 due to households receiving more than one form of income.

The BEA defines three major sources of personal income:

- Earnings, such as wages and salaries;
- Dividends, interest, and rent – current income derived from investments; and
- Personal current transfers – benefits received for which no current services are performed (e.g., retirement/Social Security, disability, veterans' benefits, etc.).

In 2013, earnings accounted for less than 50 percent of the income in Apache County and Navajo County, compared to the state average of 62 percent; Coconino County's earnings were comparable to the state average, which is more reflective of incomes in the cities of Sedona and Flagstaff (BEA 2014).

3.15.4 Economic Contributions Related to Kayenta Mine

PWCC's payroll expense in fiscal year 2014 was $60.8 million, including $34.6 million in wages and salaries and $26.2 million in retirement and benefits such as sick leave, holiday, and vacation compensation. The total equates to an average payroll and benefits cost of nearly $138,000 per employee (PWCC 2014b). PWCC's local operations also add local economic contributions via the current retirement benefits paid to former employees and future payments to current employees. Four hundred seventy-eight (478) individuals currently receive retirement payments based on service at the Kayenta and former Black Mesa coal mines and administrative operations. Of the 478 individuals currently receiving these retirement payments, 382 reside in Arizona, including 171 in Kayenta (PWCC 2015). PWCC contributes about $400,000 annually to Navajo Nation and Hopi Tribe scholarship funds. Through 2010, PWCC had contributed about $8.1 million to these scholarship funds.

PWCC paid an average of $40.6 million in royalties per year to the Navajo Nation and Hopi Tribes between 2011 and 2013. PWCC also makes annual coal bonus payments to the two tribes. These payments are established by contract and triggered and paid by any production within one year. Between 2005 and 2014, these bonus payments to the two tribes averaged $7.5 million per year. In some recent years, mining operations have been the single largest source of revenue in the Navajo Nation and Hopi tribal budgets. Funds received by the tribes are distributed broadly to a number of tribal agencies, Navajo chapters, and Hopi villages. Historically, coal revenues

fund the bulk of the Hopi government's annual operating budget and have funded the majority of more than 500 jobs provided by the Hopi Tribe. According to the Navajo Nation Division of Economic Development's *2009-2010 Comprehensive Economic Development Strategy – The Navajo Nation* report, of the fiscal year 2009 Navajo Nation General Fund budget of $150.5 million, total mining revenues contributed $54.9 million, or 36.5 percent (Navajo Nation 2009). According to March 2010 written comments made by the Hopi Tribe in response to the EPA's Advanced Notice of Proposed Rulemaking Regarding Best Available Retrofit Technology for Nitrogen Oxide Emissions at the Navajo Generating Station Docket Number EPA-R09-OAR-2009-0598, —[t]he Hopi Tribe derives almost all of its revenues directly or indirectly from coal mining activities. In 2009, the Hopi Tribe's coal-based revenues were $14 million, representing approximately 88 percent of the Tribe's annual governmental budget.

PWCC paid $25.3 million in other taxes and fees in 2013, including local property taxes paid to Navajo County and other local taxing jurisdictions and TPT/sales taxes.

Over the past five years, PWCC paid an average of $1.3 million in water royalties per year to the two tribes under lease agreements, based on an average annual use of 1,400 acre-feet. An increase in water fees, retroactive to 2015, is pending approval by two Tribal Councils and the Secretary of the Interior. PWCC payments for electrical power to the Navajo Tribal Utility Authority (NTUA) have averaged $9.9 million per year over the past three years.

PWCC compensates local area residents for acreage removed from customary grazing areas as a result of the mining activities. On average, these payments amount to about $487,000 distributed every five years to those residents whose grazing area has been reduced due to mining and reclamation activities (OSMRE 2011, Appendix F).

PWCC makes annual payments into the federal Abandoned Mine Land Reclamation and the Black Lung Disability Benefit programs[5]. PWCC's average annual payment into the Black Lung Disability Benefit Program is $4.56 million (Internal Revenue Service 2015). The Abandoned Mine Land fund was established in the SMCRA and most of the reclamation fees collected return to states and tribes in the form of grants to fund Abandoned Mine Land reclamation projects. PWCC's average annual payment into the Abandoned Mine Land Fund is $2.55 million (OSMRE 2015).

Mine employees support many young and elderly persons. The ratio of the dependent aged population to the working age population is higher overall for the Tribal Areas than the ratios for Apache, Coconino, and Navajo counties and these are significantly higher than the ratio for the state of Arizona (**Table 3.15-1**).

Residents around the Permit Area generally have greater prosperity than other residents of the Navajo and Hopi reservations. Incomes are highest for mine workers and for those employed in tourism or government. Typically, wages are low in other sectors, and those seeking work exceed the number of jobs available. A 2004 study of the area including the communities of Kayenta, Chilchinbito, and Oljato identified the mining operations as the driving force behind the local economy (ASU Center for Business Research 2004). Jobs that exist due to a mine worker's

[5] Payments into these programs are based on production at the Kayenta Mine and rates established by Congress.

household spending, or the spending of a business that supplies the mines, represent indirect jobs attributable to current mining operations.

Similarly, income and spending that support the increase in household spending and supplier spending attributable to the mining operation represent indirect economic impacts.

3.16 ENVIRONMENTAL JUSTICE

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, states that it is the responsibility of federal agencies to identify and address disproportionately high and adverse human health or environmental effects of its activities on minority populations and low-income populations. The Executive Order makes clear that its provisions apply fully to programs involving Native Americans (CEQ 1997).

The general purposes of the Executive Order are to 1) focus attention of federal agencies on the human health and environmental conditions in minority and low-income communities with the goal of achieving environmental health; 2) foster nondiscrimination in federal programs that substantially affect human health or environment; and 3) give minority communities and low-income communities greater opportunities for public participation in, and access to public information on, matters relating to human health and the environment.

One of two criteria can define an environmental justice population: 1) the number of minority and/or low-income persons within a defined area exceeds 50 percent of the population, or 2) the number of minority and/or low-income persons within a defined area exceeds the number of minority and low income persons in a larger community of which it is a part (e.g., state, county, or other division) (CEQ 1997). The study area for Environmental Justice includes the Hopi Reservation and the portion of the Navajo Nation in Arizona (**Figure 3.1-1**).

The Black Mesa Review Board was established within the Legislative Branch of the Navajo Nation pursuant to 2 Navajo Nation Code and § 901-920, Title 2, Chapter 3, Section 902, to advocate for fair and just compensation for Navajo families within the Navajo Nation Chapters whose boundaries overlap the leasehold and whose cultural, social, economic, and environmental interests are affected or impacted by the mining operations. The Board consists of a representative from the Navajo Nation, each affected Chapter, and an employee of PWCC. The Board is certified to exercise governance and decision making on behalf of the affected families in each Chapter.

Table 3.16-1 summarizes minority population characteristics for the study area against Coconino County, Navajo County, the state, and the U.S. In 2010, Native Americans and other racial and ethnic minorities comprised 97.9 percent of all residents on the Navajo Nation in Arizona and 97.5 percent of all residents on the Hopi Reservation; these percentages are much higher than the two counties, state, or U.S. The vast majority of these minority populations were Native Americans. Consequently, on the basis of race, the Navajo Nation and Hopi reservations qualify as environmental justice populations within the study area (**Figure 3.1-1**).

Table 3.16-1 Minority Populations

	Total Population	Percent White and Not Hispanic or Latino	Percent Minority	Percent American Indian
Navajo Nation (AZ)	101,835	2.1	97.9	97.1
Hopi Reservation	7,185	2.5	97.5	96.2
Apache County	71,518	20.4	79.6	74.5
Coconino County	134,421	55.2	44.8	28.9
Navajo County	107,449	43.9	56.1	44.9
State of Arizona	6,392,017	57.8	42.2	5.5
United States	308,745,538	63.7	36.3	1.7

Source: U.S. Census Bureau 2010

The Navajo Nation and Hopi reservations experience a far greater incidence of poverty compared to the two counties, state, or U.S. (**Table 3.16-2**). Consequently, on the basis of income, the Navajo Nation and Hopi reservations also qualify as environmental justice populations within the study area.

Table 3.16-2 Low Income Populations

	Per Capital Income (2013 $)	Income Below Poverty[1] (percent)
Navajo Nation (AZ)	10,840	41.2
Hopi Reservation	12,989	31.8
Coconino County	23,382	23.0
Navajo County	16,626	30.3
State of Arizona	25,358	17.9
United States	28,155	15.4

Sources: U.S. Census Bureau (2014a, 2014b)
[1] Based on 2009-2013 American Community Survey in Census (2014b).

3.17 HEALTH AND SAFETY

The direct safety study area is a radius approximately 50 km from the center of the Permit Area (**Figure 3.1-1**). Safety at the Kayenta Mine is managed by establishing appropriate policies and procedures and monitoring those procedures to verify that they are properly observed and executed. Work carried out in the presence of heavy equipment and machinery inherently bears a degree of risk. Mine operations safety standards include requirements for ground support systems, coal piles, electrical systems, combustible fluid storage, shops, equipment specifications and maintenance, explosives storage and handling, dust control, monitoring and reporting requirements, alarm systems, worker personal safety equipment, and restrictions for public access.

3.17.1 Safety Practices and Procedures

Safety practices at the Kayenta Mine are determined by review of the policies and procedures established by MSHA. In addition to complying with the regulations of MSHA, the Kayenta Mine operation is consistent with all federal, state, and tribal regulations related to mining operations.

3.17.2 Contaminants and Solid Waste

All mining operations are required to be in compliance with regulations promulgated under the RCRA, Federal Water Pollution Control Act (Clean Water Act), Safe Drinking Water Act, Toxic Substances Control Act, MSHA, Department of Transportation, and the CAA. In addition, the mining operations comply with all attendant federal and tribal rules and regulations relating to hazardous material reporting, transportation, management, and disposal. Wastes produced by current mining activities at the mine are handled according to the procedures described in the approved mine permit (PWCC 2005b). The procedures and requirements for handling hazardous and solid wastes comply with EPA-approved waste disposal plans. Potential sources of hazardous or solid waste include spilled, leaked, or dumped hazardous substances, petroleum products, and/or solid waste associated with mine operation or maintenance activities. Petroleum products, hazardous materials, and materials that could be classified as hazardous include greases, solvents, paints, flammable liquids, and other combustible materials. These types of wastes are recycled where practicable or disposed of by licensed contractors at an off-site EPA-permitted hazardous waste facility.

Several products are recycled at the mining operation area, including scrap metal, tires, batteries, computer equipment, fluorescent lamps (4-foot and 8-foot lengths), high-pressure sodium light bulbs, and mercury-vapor light bulbs. Used oil, parts washer fluid, spent solvent, grease, and antifreeze are recycled as appropriate.

3.17.3 Hazards

The main hazards associated with mining and the use of explosives are the handling of explosives by workers and the proximity to the blast site. Blasting operations at the mine are conducted according to federal law, applicable regulations, and the approved PAP. Under OSMRE's permitting requirements, a resident or owner of a dwelling or structure within 0.5 mile of any part of the Permit Area may request that a pre-blasting survey be conducted on their dwelling or structure. Upon receipt of this request, PWCC conducts the survey by analyzing the conditions of the dwelling or structure prior to blasting activities and documenting any pre-blasting damage and other physical factors that could be affected by the blasting.

Flyrock is rock that is ejected into the air or along the ground from a blast. Flyrock is controlled by the blasting design and by limiting access near the blast. The federal regulation in 30 CFR 816.67(c) prohibits flyrock from being cast more than one-half the distance to the nearest dwelling, beyond the area of control [required under 30 CFR 816.66(c)], or beyond the permit boundary. According to these regulations, no blasting is conducted within 0.5 mile of an occupied dwelling. Therefore, residents in or nearby the blasting area are evacuated prior to proceeding with any blasting actions.

Residents are notified well in advance of the blasting schedule, and notices are posted in public locations. Federal law and regulations both allow mining to within 300 feet of such a structure. The permit requirements are more stringent than the typical federal limits.

Along Navajo Route 41, PWCC assists with maintenance of the road surface and slopes and coordinates maintenance with the Navajo Nation Department of Transportation for repaving, seal coating the road or through their own roadway maintenance contract to maintain roadway shoulders and drainage. To ensure public safety along the mine roads, public traffic is excluded from active mine areas by security gates. All roads are signed and maintained by grading and dust suppression, and school buses and deliveries are escorted by PWCC security vehicles.

3.17.4 Human Health Baseline

Air quality is a health consideration which is considered in terms of NAAQS (**Sections 3.5** and **4.5**). NAAQS are determined based on the EPA's assessment of health-protective air quality levels. In addition to air quality analysis, human health risk assessments were conducted for both the Kayenta Mine (direct effects study area) (Flatirons Toxicology 2016) and the NGS (indirect effect study area) (Ramboll Environ 2015). The extent of the direct effects study area for human health was based on spatial distribution of residents, soil sampling locations, and preliminary estimates of TSP deposition patterns. The direct effects study area for human health extends up to a distance of approximately 50 km from the center of the Lease Area (**Figure 3.1-1**), and includes all residents within the Kayenta Permit Area and nearby residents comprising approximately 300 individuals and 78 households. The indirect effects study area for human health was based primarily on the extent of deposition modeling and includes the area up to 50 km from the NGS (**Figure 3.5-2**).

3.17.4.1 Renewal HHRA

A human health risk assessment (HHRA) (Flatirons Toxicology 2016) was prepared to present baseline human health data related to current and past operations at the Kayenta Mine. The baseline health risk included risks from natural conditions, accumulated mining activities, residential activities, other regional and global sources including the NGS, and unspecified sources as of July 2015. Also, an HHRA was prepared that presented the baseline conditions modeled for December 22, 2019 related to natural conditions and pollutants produced by past and current NGS operations and other local, regional, and global emission sources (Ramboll Environ 2015).

Quantitative evaluation of potential non-cancer human health risks involves mathematical comparison of exposures to either reference doses or reference concentrations to determine a hazard quotient (HQ). The HQs are summed to derive a hazard index (HI). If the sum of all the HQs (i.e., HI) is less than 1, then the exposures are acceptable for non-cancer health effects and no further evaluations are necessary. If the HI exceeds 1, then the individual HQs are arranged by target organ and evaluated further. If the HQs/HIs for the individual target organs are all less than 1, then the exposures are considered acceptable and no further quantitative evaluation is required (EPA 1989). To calculate potential cancer risks, exposures are multiplied by cancer slope factors (oral) or unit risk factors (inhalation) to estimate hypothetical probabilities of developing cancer. Cancer risks are estimated as the incremental probability of an individual developing cancer over a lifetime because of exposure over some defined exposure interval (Flatirons Toxicology 2016).

The basis for acceptable target cancer risks and hazard ratios for environmental sources has been developed by different federal regulatory agencies over the past several decades in different regulatory contexts. A common citation for the acceptable "cancer risk envelope" of 1 x 10-6 (1 in 1,000,000) to 1 x 10-4 (1 in 10,000) and a target HI of 1 for non-cancer adverse health effects is the National Contingency Plan (EPA 1992; Flatirons Toxicology 2016).

The estimate for the Kayenta Mine baseline risk case was highest for the child receptor and ranged from 0.9 (Resident Child) to 1.9 (Resident Farmer Child). Evaluation of target organs showed all individual HQs/HI were below the target level of 1. Chronic HI estimates for the adult receptor ranged from 0.1 (Resident Adult) to 0.5 (Resident Farmer Adult). The primary driver chemicals of potential concern (COPCs) for the Kayenta Mine baseline risk case were aluminum, arsenic, cobalt, iron, and manganese (Flatirons Toxicology 2016a).

Hypothetical cancer risk estimates for the Kayenta Mine baseline risk case varied between 4 in 1,000,000 (Resident Child) and 7 in 1,000,000 (Resident Farmer Child). The Kayenta Mine baseline cancer risk estimate for the adult receptor varied between 4 in 10,000,000 (Resident Adult) and 2 in 1,000,000 (Resident Farmer Adult). Arsenic accounted for virtually all of the Kayenta Mine baseline cancer risk estimates. Estimated blood levels of lead in children were below EPA recommended reference levels (Flatirons Toxicology 2016a).

3.17.4.2 NGS HHRA

For the NGS HHRA, the chronic noncancer HI estimate for the baseline risk case ranged from 0.02 (Off-Site Commercial Workers) to 1 (Recreational User, Child [primarily fish consumption]). The primary driver COPCs for the NGS baseline risk case were dioxans, furans, PAHs, and arsenic. Hypothetical cancer risk estimates for the NGS baseline risk case varied between 5 in 10,000,000 (Off-Site Commercial Workers) to 4 in 100,000 (Farm Family). The baseline risk for dioxins and furans for breastfeeding infants is 0.45 percent (Residents) to 3.1 percent (Farm Families) of the permissible maximums of these COPCs (EPA 2005). Estimated blood levels of lead in children were below EPA recommended reference levels (Ramboll Environ 2015).

3.17.4.3 Indoor Coal Burning

Kayenta Mine coal also is burned in Navajo homes for heating and cooking, and this practice would continue as long as residents have a household supply of coal available. After the mine ceases active mining in December 2019, no new coal would be mined but the existing local supply may continue for some time. The burning of coal indoors may contribute to respiratory diseases and other health issues. Key factors that influence exposure include the stove condition, venting, whether the coal is used for cooking or heating, and the type of coal. Gradient (2016) provided data that wood and coal burning within homes in Shiprock, New Mexico may contribute to poor air quality.

4.0 ENVIRONMENTAL CONSEQUENCES

4.1 INTRODUCTION

This chapter discusses the potential physical, biological, cultural, and socioeconomic direct and indirect effects[1] of Alternative 1 (Renewal) and Alternative 2 (Non-Renewal or No Action) as described in **Chapter 2**. Direct impacts are defined as those impacts that are caused by the action and occur at the same time and place. Indirect impacts are those that are caused by the action and occur later in time or are farther removed in distance, but are still reasonably foreseeable. For the purposes of this EA, indirect effects include the effect of Kayenta coal combustion at the NGS on geologic resources, air and climate, water resources, special status wildlife and fish, Indian trust assets, visual resources, and human health[2]. Impacts also may be short-term (also referred to as temporary) or long-term. Short-term impacts generally occur for a short period during a specific point in the mining process. Long-term impacts generally would last the life of the Renewal and beyond. Finally, impacts are described by their level of significance (i.e., major, moderate, minor, negligible, or no impact). An impact is considered to be major if it would result in a substantial change to the environment. An impact is considered moderate or minor if it would not result in a substantial environmental change but could still have some measurable effect. The determination of whether an impact is moderate or minor varies for each resource and the context of the specific action alternative. In contrast to no impact, a negligible impact is one that would occur but at the lowest limits of detection of an effect. The analysis applies quantitative thresholds when available, to determine the level of significance. Other issues have been analyzed qualitatively where necessary.

Impacts also vary in terms of significance. The basis for conclusions regarding significance are the criteria set forth by the CEQ (40 CFR 1508.27) and the professional judgment of the specialists doing the analyses. Impacts can be significant during mining but may be reduced to insignificant following completion of reclamation. The level of detail in the environmental impacts analysis corresponds to the context and intensity of the impacts anticipated for each resource.

Under Alternative 1, the OSMRE Western Region Director would approve the renewal of Permit AZ-0001E, which would authorize continued mining and reclamation in CRAs N-9, J-19, and J-21 and reclamation in CRA N-11 and other disturbed areas within the Permit Area as needed, and under the same provisions and reclamation plan as the current permit. Renewal of Permit AZ-0001E would not include any changes to those provisions or reclamation plan.

Active mining would only occur from July 5, 2015 through no later than December 22, 2019; beginning December 23, 2019, only reclamation would occur at the mine through the end of the Renewal period. Therefore, some impacts that would occur only during active mining are disclosed only for the period 2015 through 2019. The existing PAP, the eight standard permit conditions from 30 CFR 773.17, standard permit terms and specifications from the current permit, and one existing Special

[1] Cumulative impacts are discussed in **Chapter 5**.

[2] While OSMRE has no authority to regulate NGS operations, the effects of NGS coal combustion have been analyzed as "indirect effects" in this EA for geologic resources, air and climate, water resources, special status wildlife and fish, Indian trust assets, visual resources, and human health.

Condition pertaining to the monitoring plan for the Mexican spotted owl would be incorporated into the approved permit.

Under Alternative 2, OSMRE would not approve the renewal of Permit AZ-0001E for surface coal mining and/or reclamation in CRAs N-9, N-11, J-19, and J-21. Ongoing mining operations would cease. Facility removal and reclamation activities would proceed within the Permit Area according to the provisions in the current Kayenta Mine closure plan and SMCRA regulations. Reclamation activities would continue throughout the Permit Area until 2032, and would include two to three years of earthwork (grading and contouring) and facility removal, followed by seeding, monitoring the establishment of vegetation, then a phased bond release. It is anticipated that in 2032 reclamation and bond release would be complete and the leases from the tribes would end.

Table 4.1-1 summarizes and compares the potential environmental direct and indirect impacts (**Sections 4.2** through **4.17**) associated with the alternatives.

Table 4.1-1 Comparison of Direct and Indirect Impacts

Resource	Alternative 1	Alternative 2*
Geologic, Mineral, and Paleontological Resources	Impacts on geologic and paleontological resources would be negligible to minor. Paleontological resource impacts would be short-term and negligible to minor.	Impacts would be similar to those under Alternative 1, but only 16 mt tons of coal would be removed rather than 40 mt.
Soil Resources	Effects on soil productivity, erosion, and soil stability after reclamation for post-mine land uses (livestock grazing, wildlife habitat, and cultural plants) would be beneficial, long-term, and minor.	Impacts would be similar to those under Alternative 1, but only 472 acres of soil would be disturbed rather than 842 acres.
Landforms and Topography	Impacts to the local landforms and topography would be minor and short-term until reclamation restored these areas to their approved post-mining topographies. After reclamation has been completed, the impacts to landforms and topography would be negligible for the long term.	Impacts would be similar to those under Alternative 1, but only 472 acres of landforms and topography would be altered prior to reclamation rather than 842 acres.

Resource	Alternative 1	Alternative 2*
Air and Climate Resources	All criteria pollutant direct impacts would demonstrate compliance with all NAAQS (worst-case maximum 77.5% of 24-hr PM_{10} standard, negligible to minor impact). Indirect impacts from the NGS also would demonstrate compliance dissipating rapidly within 1 km (99% of 1-hr NO_2 standard). Direct GHG Emissions - Negligible long-term impact on Arizona (0.16%) and U.S. (0.0042%) total annual GHG emissions throughout all phases of the project. Indirect long-term GHG impact - Negligible on U.S. (0.82%) and global (0.04%) annual GHG emissions. This impact would occur until mining concludes at the end of 2019. Visible haze would not change from the current conditions, but would continue to December 2019. Exposure concentrations for COPCs in air would be extremely low to negligible. Only a minor impact would occur under Alternative 1. All criteria pollutants from the mine also would be negligible. The indirect impacts of all criteria pollutants from the NGS would be negligible to minor. The indirect effect of deposition of COPCs (including arsenic and mercury) from the NGS would be negligible, because deposition represents less than one percent of the baseline soil concentration.	Mining operations would cease upon OSMRE's decision to deny the Renewal, but emissions from the mine and the NGS will have resulted from July 6, 2015 to when OSMRE issued their decision to deny the Permit Renewal. Visible haze from the NGS would begin to dissipate following OSMRE's decision to deny the permit Renewal. Only those direct emissions that already have occurred from July 2015 to when OSMRE issued their decision to deny the Permit Renewal would be included in Alternative 2. This would include approximately 40% of emissions that would occur under Alternative 1. Similarly, if the Kayenta Mine ceases to operate, the NGS also would cease operations. Indirect emissions would be approximately 40% of Alternative 1.
Noise and Vibration	As noise and vibration levels would remain at or near current levels, the impacts would be negligible.	Impacts would be similar to those under Alternative 1, but the existing noise and vibration conditions would occur only until OSMRE issues their decision to deny the Permit Renewal.

Resource	Alternative 1	Alternative 2*
Water Resources	Any changes within the study area (i.e., Colorado River and San Juan Basins) as a whole would be short-term and minor for surface water. The short-term effects of surface water diversions, impoundments, and sediment ponds on surface water quantity would be minor within the Permit Area and negligible outside of the Permit Area. Impacts to groundwater quality related to the disposal of CCRs at the NGS is expected to be minor and localized. The PWCC NPDES permit requires all discharges from NPDES outfalls, including those associated with the Affected CRAs, to meet effluent limitations and applicable water quality standards for receiving streams. Therefore, discharges from existing and new ponds would have negligible impacts to surface water quality. The potential effects on the overall surface water quantity would be minor in volume of spring or seep water. The potential effects to groundwater would be minor. Impacts of pumping on groundwater discharge to streams would be negligible except for Begashibito Wash, where impacts would be minor. Impacts from CCRs would be locally minor and remediated immediately.	The impacts on local washes and channels from the sediment ponds or any existing seeps would be negligible to minor and the changes to surface water quantity or quality would be negligible to minor. The reduced pumping rate would allow recovery of water levels more quickly in the vicinity of the PWCC well field, and further reduce PWCC's contributions to drawdowns that would continue to occur as a result of community pumping. The potential impacts on groundwater would be negligible to minor, and would be less than described under Alternative 1.
Vegetation	Disturbed and reclaimed areas would be susceptible to invasion by noxious weeds and other invasive plant species, which would be a short-term and minor impact. The direct and indirect impacts to riparian vegetation from the various water impoundments would be negligible. The impacts to Navajo sedge and alcove bog-orchid also would be negligible. There would be negligible direct and indirect effects related to mine and NGS emissions and deposition, respectively, to vegetation within the applicable study areas.	Impacts would be similar to those under Alternative 1, but only 472 acres of vegetation would be disturbed rather than 842 acres.

Resource	Alternative 1	Alternative 2*
Wildlife and Fish	Impacts to wildlife would be short-term and minor given that the areas are currently being mined and the current impacts to wildlife would not change, but last another five years. Some habitat would be lost during the life of the Renewal but would be replaced and likely improved during reclamation. Impacts to terrestrial special status species would be short-term and minor. Indirect impacts from mercury and selenium to special status fish species would be negligible to minor given the possibility that mercury may remain airborne until 2050. The USFWS concurred with the BA in that Alternative 1 would not result in adverse impacts to federally listed species.	Impacts would be similar to those under Alternative 1, but only 472 acres of disturbance would occur rather than 842 acres, and the mining disturbance related to noise, vibration, and light would occur only until OSMRE issues their decision to deny the Permit Renewal. No additional impacts would occur to wildlife and fish species (including special status species) and therefore would be negligible.
Cultural Resources	Potential direct and indirect impacts to cultural resources, human remains, and sacred and ceremonial sites are anticipated to be long-term but minor. It is expected that continued implementation of the standard conditions and permit terms satisfactorily mitigate any such impacts.	Impacts would be similar to those under Alternative 1, but there would be potential disturbance to known and undiscovered sites on only 472 acres rather than 842 acres.
Indian Trust Assets	Although there would be a loss of Indian trust mineral assets as a result of mining activities, the impacts to these assets would be negligible. Combined mining activities in the Affected CRAs would disturb 842 acres of land used for livestock grazing and traditional uses, resulting in a localized moderate and short-term impact. The effects on surface water flow would be minor and the effects on surface water quality would be short-term and negligible. Water quality effects in the Wepo Formation, alluvial aquifers, and associated springs and seeps would be negligible to minor. Impacts to Indian trust water assets also would be negligible and Indian trust hunting and gathering assets would be negligible to minor.	Impacts would be similar to those under Alternative 1, but potential impacts to Indian Trust Assets would occur on only 472 acres rather than 842 acres, and only until OSMRE issues their decision to deny the Permit Renewal.

Resource	Alternative 1	Alternative 2*
Land Use and Recreation	There would be negligible effect on the grazing capacity in the study area. There would be a moderate, long-term, beneficial impact on grazing capacity after reclamation. Localized areas with poor water quality could affect the health of livestock until reclamation of these areas is completed (approximately six years); however, protective measures such as using fence enclosures, the seep management plan, and pond reclamation would reduce these effects to negligible levels.	Impacts would be similar to those under Alternative 1, but only 472 acres of potential rangeland with low forage availability and quality would be disturbed rather than 842 acres.
Visual Resources	With little visibility of continued mining operations by the moderately and highly sensitive viewers, the relatively short-term high visual contrasts of the mining operations are anticipated to result in minor effects on visual resources. However, after reclamation is completed according to the requirements of the permit closure plan and SMCRA regulations, impacts on visual resources would be reduced to negligible.	Impacts would be similar to those under Alternative 1, but changes to visual resources would occur on only 472 acres rather than 842 acres.
Transportation and Access	The potential effects on traffic volumes and the existing transportation network would be negligible.	Impacts would be similar to those under Alternative 1, but the current access and transportation conditions would occur until OSMRE issues their decision to deny the Permit Renewal.
Social and Economic Conditions	Mine employment and revenues to the Navajo Nation and Hopi Tribe would continue through July 2020. No additional demands on the existing infrastructure or services in the communities on or near the Permit Area would be anticipated. The social and economic contributions to the community would be a major, beneficial short-term impact.	Social and economic conditions impacts would be, major, adverse, and long-term.
Environmental Justice	The social and economic effects would have a major, beneficial short-term impact that would disproportionately affect environmental justice populations.	Social and economic effects would be a major, long-term adverse impact that would disproportionately affect environmental justice populations.

Resource	Alternative 1	Alternative 2*
Health and Safety	Neither the type nor quantity of any wastes generated and disposed of by the mine would change and impacts on public health and safety would be negligible. The direct and indirect health effects, as modeled by HHRAs for the Renewal and NGS operations, would be negligible.	Impacts would be similar to those under Alternative 1, but would occur only until OSMRE issues their decision to deny the Permit Renewal.

[1] Alternative 2 assumes that the mining operations in the Permit Area would cease upon issuance of OSMRE's decision to deny the Renewal.

4.2 GEOLOGIC, MINERAL, AND PALEONTOLOGICAL RESOURCES

4.2.1 Alternative 1: Renewal of Permit AZ-0001E

4.2.1.1 Geologic and Mineral Resources

Mining would remove about 250 feet of non-coal-bearing rock from the geologic column above and between the coal on approximately 842 acres in the Affected CRAs. Over the long-term, the mined areas would be backfilled with this unconsolidated material. This material would be fragmented prior to placement and would be graded to approximately the original topographic contours, considering the needs of minimizing erosion and supporting post-mining land uses. Unconsolidated backfill material would not be placed on steep slopes where geologic hazards such as landslides can develop. The loss of the consolidated stratigraphy would be a permanent impact. However, there are no unique or valuable geologic resources (beside coal) within the study area, and the impacts to geologic resources under Alternative 1 would be minor.

In accordance with SMCRA, coal-mining activities must be conducted in a manner that maximizes recovery of the coal resource and protects the coal resource that remains after mining. Approximately 40 mt of coal would be removed from the Wepo Formation under Alternative 1. Compared to the inferred total coal resource of 4.8 billion tons in the Wepo Formation, this would be a negligible effect.

Approximately 11.6 percent of the coal reserves in the Wepo Formation would be lost during mining activities due to normal overburden stripping. This impact to the coal resource is considered normal for these mining activities, given current mining technology and the stratigraphic nature of the coal being mined. Impacts on coal resource development with this recovery rate would be minor.

There would be no effect on coal resources in the Toreva Formation or Dakota Sandstone because these formations are greater than 250 feet bgs and therefore cannot be mined by surface-mining methods. Coal mining operations under Alternative 1 would not affect uranium or vanadium deposits located under the Wepo Formation. These mineral and coal deposits would remain available for future development.

Reclamation would continue on mined-out areas per SMCRA requirements and Permit AZ-0001E, which would be unlikely to impact geologic or mineral resources.

Indirect effects to geologic resources related to the disposal of CCRs at the NGS would be unlikely. Indirect effects to groundwater are described in **Section 4.7.1.2**.

4.2.1.2 Paleontological Resources

Paleontological resources (fossils) are non-renewable resources that cannot be used for scientific study if damaged, destroyed, or removed without proper scientific documentation. Coal mining activities and road construction for mine operations activities could damage undiscovered paleontological resources. These activities could improve access to fossil locations, which could increase theft and vandalism. However, operations in these areas also could uncover fossil resources that would otherwise remain unexposed and unavailable for scientific study. Because fossils are uncommon in the Mesaverde Formations in the Black Mesa area; these impacts would be short-term and minor to negligible.

If important or unusual paleontological resources are detected during mining activity, work in the area would cease and a qualified professional would evaluate the area. PWCC would work with regulatory officials for the recovery of important or unusual fossils prior to resuming mining operations (PAP).

4.2.2 Alternative 2: No Action

Under Alternative 2, no further mining would occur in the Permit Area following OSMRE's decision to deny the permit Renewal, but 21 mt of coal would be removed between July 6, 2015 and OSMRE's decision to deny the permit Renewal. There would be negligible to minor effects on geologic, mineral, and paleontological resources similar to those under Alternative 1. PWCC would initiate closure activities and complete final reclamation per SMCRA requirements and Permit AZ-0001E. The impacts to geologic and paleontological resources would cease.

4.2.3 Mitigation

No mitigation would be necessary for geologic, mineral, and paleontological resources.

4.3 SOIL RESOURCES

4.3.1 Alternative 1: Renewal of Permit AZ-0001E

Surface-mining activities would blend and homogenize soils and the original soil profile would be lost permanently. Surface disturbance of soils and vegetation on approximately 842 acres through mining operations and haul road construction could increase short-term erosion and soil movement from CRAs N-9, J-19, and J-21. However, numerous erosion controls, such as sedimentation structures and a Surface Stabilization Plan (PAP) are utilized at the mine to reduce the effects of surface disturbance. Temporary or permanent impoundments also could decrease off-site sedimentation and soil movement in localized areas. Surface-mining activities and road or support facilities construction would directly affect soil structure from surface disturbance that blends soil layers resulting in long-term loss of the original soil profile. This could reduce short-term soil productivity in these areas, which would be a short-term and minor effect because

reclamation activities would restore the topography and improve the productivity of the soil structure as explained below.

By salvaging topsoil and suitable subsoil from areas to be disturbed prior to mining, approximately 2.1 feet of soil material would be available to uniformly cover all reclamation areas. Soil reclamation under Alternative 1 would continue to be conducted as it currently is under the approved Minesoil Reconstruction Plan (PAP); topsoil (as defined in 30 CFR Part 701.5i) would be salvaged together with suitable subsoil and underlying unconsolidated material to provide a topsoil mixture suitable for reclamation. Salvaged material would be either redistributed immediately onto reclaimed areas or stockpiled for use as topsoil on future reclamation areas. Topsoil stockpiles would be protected from wind and water erosion by seeding the stockpiles and placing berms around the perimeter of the stockpile.

Slope reclamation operations generally include regrading, smoothing, and slope contouring to approximate the original topographic contours, considering the primary objectives of minimizing erosion and supporting the post-mining land uses of livestock grazing, wildlife habitat, and cultural plants. OSMRE guidelines for reclamation programs and projects identify soil and slope conditions considered acceptable or suitable during reclamation, including soil pH and acid-forming spoils, sodic zones, toxic substance occurrence in soil, percent and length of slope, and slope stability. Reclamation activities would reduce the loss of soil to erosion. The soil loss on restored land would be approximately three to nine tons/acre/year after 10 years, which is less than the seven to 22 tons/acre/year that can be expected on undisturbed slopes (PAP).

In the short-term, soil erosional stability would be maintained by an effective and permanent vegetative cover established during reclamation. Although the reclaimed land cannot be restored to pre-mining productive use immediately due to the long timeframe required for plant establishment in the arid climate, soil productivity would be maximized by reclamation procedures that create a suitable four-foot-deep plant root zone over the entire reclaimed area and establishing a diverse and permanent vegetation cover (**Section 4.8**). Soil reconstruction and revegetation would be undertaken to restore the land to productive use and, in the long-term, soil productivity should exceed pre-mining capability (PAP). Through incorporation of reclamation and environmental protection measures within the Affected CRAs, soil productivity and stability for post-mining activities would improve. Effects on soil productivity, erosion, and soil stability after reclamation for post-mine land uses (livestock grazing, wildlife habitat, and cultural plants) would be beneficial, long term, and minor.

Estimates of lead impacts under Alternative 1 in soil and air were *de minimis* (Flatirons Toxicology 2016).

4.3.2 Alternative 2: No Action

Under Alternative 2, mining operations would cease in the Permit Area upon OSMRE's decision to deny the Renewal. Soil on 472 acres in the Affected CRAs would be disturbed between July 6, 2015 and OSMRE's decision to deny the permit Renewal, which would be a minor effect similar to those under Alternative 1. PWCC would initiate closure activities and complete final reclamation per SMCRA requirements and Permit AZ-0001E; the effects on soils would be similar to those described for Alternative 1.

4.3.3 Mitigation

No mitigation would be necessary for soil resources.

4.4 LANDFORMS AND TOPOGRAPHY

4.4.1 Alternative 1: Renewal of Permit AZ-0001E

Under Alternative 1, impacts to the local topography would be minor and short-term until reclamation restored these areas to their approved post-mining topographies.

The impacts to topography would be greatest where mining would occur in the Affected CRAs, which would temporarily reduce the elevation where mining occurs. Areas where topsoil and overburden material are stored would temporarily increase the elevation in those areas. This change in the elevation from stockpiled material would be more visible from a distance (**Section 4.13**) and would be short-term and minor.

Per SMCRA requirements and Permit AZ-0001E, mined areas would be backfilled using overburden material. All areas disturbed by mining would be backfilled, if appropriate, then graded to their approved post-mining topographies. Surfaces would be recontoured to their approved conditions and surface drainage patterns would be established per the approved reclamation plan. After reclamation has been completed, the impacts to topography would be negligible in the long term.

4.4.2 Alternative 2: No Action

Under Alternative 2, mining operations would cease in the Permit Area upon OSMRE's decision to deny the Renewal. Topography would be affected on 472 acres between July 6, 2015 and OSMRE's decision to deny the permit Renewal, which would have short-term minor and long-term negligible effects similar to those under Alternative 1. PWCC would initiate closure activities and complete final reclamation per SMCRA requirements and Permit AZ-0001E.

4.4.3 Mitigation

No mitigation would be necessary for topography.

4.5 AIR AND CLIMATE RESOURCES

4.5.1 Alternative 1: Renewal of Permit AZ-0001E

4.5.1.1 Direct Mining Criteria Pollutant Impacts

Emission Factors Development

Emission factors found in *Compilation of Air Pollutant Emission Factors (AP-42)* (EPA 1995) were used to estimate emissions from activities at preparation areas such as the J-28 Preparation Area (**Table 4.5-1**). For activities associated with the pit areas and general mining operations, emission factors from the Wyoming Department of Environmental Quality (WDEQ) were utilized. WDEQ

factors do not exist for dozer activity or for coal and overburden drilling; therefore, AP-42 factors were used to estimate emissions from those activities.

In 1991, WDEQ funded a study by TRC Environmental Consultants (TRC 1991) to conduct a model validation analysis of four model/emission factor sets. The study was conducted for two groups of large surface coal mines in the Powder River Basin of northeast Wyoming.

Actual monitoring data were available from twenty-two monitoring sites. Data from those sites were compared against concentration predictions for the same past meteorological conditions and actual mining conditions. Validation studies were conducted for two models: the Industrial Source Complex (ISC) model and the Fugitive Dust Model (FDM). Emission estimates were made using two emission factor sets; those available from AP-42 and a set endorsed by the WDEQ (WDEQ 1979). The results of the study demonstrated that the most accurate, yet still conservative, predictions were provided by a combination of the WDEQ emission factors and FDM. The AP-42 and ISC combination performed the poorest of the four approaches. All short-term and annual average predicted concentrations compared poorly with measured (actual) 24-hour concentrations. Concentrations were over-predicted in comparison to actual measurements in some cases by a multiplication factor of 26. When maximum 24-hour emission rates were used in the models, over-predictions were as much as 50 times.

As a result of these validation studies, the WDEQ requires the use of a set of emission factors first evaluated in 1979 and they do not require coal mines to conduct formal dispersion modeling of 24-hours impacts. Instead they rely on monitoring to demonstrate compliance with NAAQS.

Operating Parameters

Annual operating parameters for years 2015 through 2019 are listed in **Table 4.5-1**. These parameters are shown separately for the three preparation areas, the overland conveyor, and the pits and general mining activities.

Table 4.5-1 Operating Parameters for the Kayenta Mine 2015-2019

	Mining Operation	Operation Parameter Units	Operating Parameters by Year				
			2015	2016	2017	2018	2019
J-28 Prep Area	Truck dumping at pile	tons	5,079,804	5,422,900	5,439,400	5,499,400	5,748,000
	Hopper loading	tons	5,079,804	5,422,900	5,439,400	5,499,400	5,748,000
	Transfer points	tons	5,079,804	5,422,900	5,439,400	5,499,400	5,748,000
	Primary crushing	tons	5,079,804	5,422,900	5,439,400	5,499,400	5,748,000
	Secondary crushing	tons	253,990	271,145	271,970	274,970	287,400
	Screening	tons	5,079,804	5,422,900	5,439,400	5,499,400	5,748,000
	Sample system transfer points	tons	91,436	97,612	97,909	98,989	103,464
	Sample system crushing	tons	4,023	4,295	4,308	4,356	4,552
	Wheeled dozers, meter[1]	hours	2,274	2,274	2,274	2,274	2,274
	Wheeled dozers, operation[2]	hours	1,625	1,625	1,625	1,625	1,625
	Coal pile wind erosion	acres	9.3	9.3	9.3	9.3	9.3

	Mining Operation	Operation Parameter Units	Operating Parameters by Year				
			2015	2016	2017	2018	2019
N-11 Prep Area	Truck dumping at pile	tons	1,969,423	1,995,500	2,256,400	2,424,000	2,163,200
	Hopper loading	tons	1,969,423	1,995,500	2,256,400	2,424,000	2,163,200
	Transfer points	tons	1,969,423	1,995,500	2,256,400	2,424,000	2,163,200
	Primary crushing	tons	1,969,423	1,995,500	2,256,400	2,424,000	2,163,200
	Screening	tons	1,969,423	1,995,500	2,256,400	2,424,000	2,163,200
	Sample system transfer points	tons	35,450	35,919	40,615	43,632	38,938
	Sample system crushing	tons	1,560	1,580	1,787	1,920	1,713
	Wheeled dozers, meter[1]	hours	1,009	1,009	1,009	1,009	1,009
	Wheeled dozers, operation[2]	hours	721	721	721	721	721
	Coal pile wind erosion	acres	5.1	5.1	5.1	5.1	5.1
N-8 Prep Area	Stacker/hopper loading	tons	7,049,227	7,418,400	7,695,800	7,923,400	7,911,200
	Transfer points	tons	7,049,227	7,418,400	7,695,800	7,923,400	7,911,200
	Secondary crushing	tons	353,307	371,810	385,713	397,121	396,509
	Screening	tons	7,049,227	7,418,400	7,695,800	7,923,400	7,911,200
	Sample system transfer points	tons	69,082	72,700	75,419	77,649	77,530
	Sample system crushing	tons	4,307	4,533	4,702	4,841	4,834
	Track dozers, meter[1]	hours	16,842	16,842	16,842	16,842	16,842
	Track dozers, operation[2]	hours	12,051	12,051	12,051	12,051	12,051
	Coal pile wind erosion	acres	20.9	20.9	20.9	20.9	20.9
Overland Conveyor	Transfer points 20/21E-23/24E	tons	5,079,804	5,422,900	5,439,400	5,499,400	5,748,000
	Transfer points 24/25E, 21A-22/23W	tons	7,049,227	7,418,400	7,695,800	7,923,400	7,911,200
Pits and General Mining Operations	Coal removal	tons	7,049,227	7,418,400	7,695,800	7,923,400	7,911,200
	OB removal (T/S)	tons	3,203,059	3,107,075	3,111,299	3,135,416	3,205,501
	OB removal (dragline)	cubic yards	45,968,753	44,591,240	44,651,860	44,997,967	46,003,799
	Scrapers	hours	9,632	9,632	9,632	9,632	9,632
	OB drilling	holes	45,877	45,877	45,877	45,877	45,877
	OB blasting	blasts	161	161	161	161	161
	Coal drilling	holes	24,082	24,082	24,082	24,082	24,082
	Coal blasting	blasts	149	149	149	149	149
	OB haul roads	VMT	46,603	45,206	45,268	45,619	46,639
	Coal haul roads	VMT	277,438	262,176	302,887	311,845	317,719
	Dozers on OB	hours	30,000	29,101	29,141	29,366	30,023
	Graders	hours	15,117	15,117	15,117	15,117	15,117
	Water trucks	VMT	88,603	88,603	88,603	88,603	88,603
	Wind erosion	acres	4,354	4,354	4,354	4,354	4,354

[1] Meter hours for dozers reflect when the dozers are both operating and idling, and are used for tailpipe emissions.
[2] Operation hours for dozers reflect when the dozers are operating on the coal piles, and are used for re-handling emissions.
VMT = vehicles miles traveled

4.5.1.2 Direct Emissions Calculations

Table 4.5-2 summarizes the annual emission estimates for PM_{10} and $PM_{2.5}$ for each coal preparation activity during the 2015 to 2019 period. For all direct emissions presented in this section, MMA (2016) provides the details of the emission calculations, including the operating parameters and emission factors used for each activity, plus the resultant PM_{10} and $PM_{2.5}$ emission estimates. Site-specific inputs (silt percentage, moisture percentage, and wind speed) were used when available. The emission factors, inputs, and control methods are consistent with previous emissions analyses performed for the Kayenta Mine.

Table 4.5-2 Annual Particulate Emissions, Coal Preparation 2015-2019

Prep Area	Mining Operation	Particulate Matter Emissions (tpy)									
		2015		2016		2017		2018		2019	
		PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
J-28	Truck dumping at pile	0.35	0.05	0.38	0.06	0.38	0.06	0.38	0.06	0.40	0.06
	Hopper loading	0.18	0.03	0.19	0.03	0.19	0.03	0.19	0.03	0.20	0.03
	Transfer points	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00
	Primary crushing - controlled	1.37	0.25	1.46	0.27	1.47	0.27	1.48	0.27	1.55	0.29
	Secondary crushing - controlled	0.07	0.01	0.07	0.01	0.07	0.01	0.07	0.01	0.08	0.01
	Screening - controlled	1.88	0.13	2.01	0.14	2.01	0.14	2.03	0.14	2.13	0.14
	Sample system transfer points	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sample system crushing - controlled	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Wheeled dozers	7.80	0.65	7.80	0.65	7.80	0.65	7.80	0.65	7.80	0.65
	Coal pile wind erosion	0.68	0.10	0.68	0.10	0.68	0.10	0.68	0.10	0.68	0.10
N-11	Truck dumping at pile	0.14	0.02	0.14	0.02	0.16	0.02	0.17	0.03	0.15	0.02
	Hopper loading	0.07	0.01	0.07	0.01	0.08	0.01	0.08	0.01	0.08	0.01
	Transfer points	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Primary crushing - controlled	0.53	0.10	0.54	0.10	0.61	0.11	0.65	0.12	0.58	0.11
	Screening - controlled	0.73	0.05	0.74	0.05	0.83	0.06	0.90	0.06	0.80	0.05
	Sample system transfer points	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sample system crushing - controlled	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Wheeled dozers	3.46	0.29	3.46	0.29	3.46	0.29	3.46	0.29	3.46	0.29
	Coal pile wind erosion	0.37	0.05	0.37	0.05	0.37	0.05	0.37	0.05	0.37	0.05
N-8	Stacker/hopper loading	0.39	0.06	0.41	0.06	0.43	0.06	0.44	0.07	0.44	0.07
	Transfer points	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00
	Secondary crushing - controlled	0.10	0.02	0.10	0.02	0.10	0.02	0.11	0.02	0.11	0.02
	Screening - controlled	2.61	0.18	2.74	0.19	2.85	0.19	2.93	0.20	2.93	0.20
	Sample system transfer points	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sample system crushing - controlled	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Track dozers	23.13	1.94	23.13	1.94	23.13	1.94	23.13	1.94	23.13	1.94
	Coal pile wind erosion	1.52	0.23	1.52	0.23	1.52	0.23	1.52	0.23	1.52	0.23
Overland Conveyor	Transfers 20/21E-23/24E	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00
	Transfers 24/25E, 21A-22/23W	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00

Prep Area	Mining Operation	Particulate Matter Emissions (tpy)									
		2015		2016		2017		2018		2019	
		PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
Rail	Transfer Point	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Load	Silo Vent	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Total Coal Preparation Emissions		**46.91**	**5.68**	**47.36**	**5.72**	**47.69**	**5.76**	**47.96**	**5.79**	**47.95**	**5.79**

Site-specific inputs include the moisture content of 13.1 percent for coal based on material samples taken at the mine. This value is not expected to change during the Renewal period, as the future coal reserves are in the same coal seams as those from which the samples were taken. The mean wind speed value of 7.6 mph is a five-year average from the mine's BM-MET9 site. The coal silt value of 8.6 percent for dozer operations is a typical value for this activity (AP-42, Section 11.9, Table 3), based on default parameters utilized in emission factor development.

Storage Pile Wind Erosion

The preparation facilities include several coal storage piles. Wind erosion estimates from these piles were calculated using the methodology contained in AP-42 Section 13.2.5, Industrial Wind Erosion. Emissions from piles are dependent on the frequency of surface disturbance and only occur when the fastest mile wind speed exceeds a certain threshold velocity on the different pile subareas.

The three piles at N-8 (K1, K2, and K3) and the two piles at J-28 (K5 and K6) have subareas that are disturbed daily while other subareas on these piles are disturbed every 12 days. The pile at N-11 (K8) has subareas disturbed either every two days or every 12 days. Following AP-42, the fastest mile wind speed data for each hour of the five-year period of 2006, 2008, 2011, 2012, and 2013 were used to calculate annual emissions from these piles.

Hourly emission rate files were used in the modeling to account for the different pile disturbance frequencies and the wind speeds encountered over the five-year period of meteorological data.

Silo Vent

Emissions from the conveyor transferring of coal to the silos are controlled with particulate filters at the silo bin vent. Because emission factors are not included in AP-42 for this type of source, PM emissions were estimated as if emanating from a baghouse system. This can be considered a conservative method as emissions from a baghouse system have been calculated to be greater than from the silo transfer points themselves.

Silo vent emissions are estimated with the calculation below:

Q (lb/hr) = L * F * (lb/7,000 grain) * (60 min/hr) = 0.34 lb/hr
Q (tons/yr) = 0.34 lb/hr * (8,760 hr/yr) * (2,000 tons/lb) = 1.50 tons/yr

where:

Q = $PM_{2.5}$ and PM_{10} emission rate
L = exit gas dust loading (typical value of 0.01 grain/actual ft^3)
F = exit gas flow rate (typical value of 4,000 actual ft^3/min)

This emission level of 1.5 tpy was assumed to be the same for PM_{10} and $PM_{2.5}$ and for all years.

Particulate Emissions for Mining Fugitives

Fugitive particulate emission sources associated with pit areas and general mining operations include excavation, haulage, and land reclamation activities. Emission estimates were developed for the fugitive dust sources by using applicable emission factors from WDEQ, AP-42, and the operating parameters listed in **Table 4.5-1**.

Table 4.5-3 summarizes the annual emission estimates for PM_{10} and $PM_{2.5}$ for each fugitive dust source during the 2015 to 2019 period.

Table 4.5-3 Annual Particulate Emissions, Mine Fugitive Dust 2015-2019

Mining Operation	Particulate Matter Emissions (tpy)									
	2015		2016		2017		2018		2019	
	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
Coal removal	2.2	0.2	2.3	0.2	2.4	0.2	2.5	0.2	2.5	0.2
OB removal (T/S)	7.2	0.7	7.0	0.7	7.0	0.7	7.1	0.7	7.2	0.7
OB removal (dragline)	206.9	20.7	200.7	20.1	200.9	20.1	202.5	20.2	207.0	20.7
Scrapers	19.4	1.9	19.4	1.9	19.4	1.9	19.4	1.9	19.4	1.9
OB drilling	0.9	0.1	0.9	0.1	0.9	0.1	0.9	0.1	0.9	0.1
OB blasting	0.9	0.1	0.9	0.1	0.9	0.1	0.9	0.1	0.9	0.1
Coal drilling	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0
Coal blasting	0.6	0.1	0.6	0.1	0.6	0.1	0.6	0.1	0.6	0.1
OB haul roads	6.3	0.6	6.1	0.6	6.1	0.6	6.2	0.6	6.3	0.6
Coal haul roads	67.0	6.7	63.3	6.3	73.1	7.3	75.3	7.5	76.7	7.7
Dozers on OB	11.3	6.2	11.0	6.0	11.0	6.0	11.1	6.1	11.3	6.2
Graders	30.4	3.0	30.4	3.0	30.4	3.0	30.4	3.0	30.4	3.0
Water trucks	5.3	0.5	5.3	0.5	5.3	0.5	5.3	0.5	5.3	0.5
Wind erosion	326.6	49.0	326.6	49.0	326.6	49.0	326.6	49.0	326.6	49.0
Total Mine-Related Fugitives	**685.0**	**89.9**	**674.5**	**88.7**	**684.7**	**89.7**	**688.7**	**90.2**	**695.2**	**90.9**

OB = overburden

Site-specific inputs (silt and moisture percentage, vehicle speeds, and number of wet days per year) were used in the emission calculations, where available. The silt and moisture values used for overburden dozer operations are typical values for this activity as shown in AP-42. The road silt value of 8.6 percent used to calculate haul truck emissions is typically used with the WDEQ emission factors. However, road samples analyzed from western surface coal mines show the silt content is typically less than this default, with a value of 4.3 percent presented in AP-42. Nevertheless, the 8.6 percent value was used as a very conservative estimate of road silt content at the mine.

The WDEQ emission factor equations were originally developed to calculate TSP emissions. To estimate PM_{10} emissions, these equations were multiplied by WDEQ's PM_{10}/TSP ratio of 0.30. However, there are no WDEQ ratios provided to determine $PM_{2.5}$ emissions from the TSP

equations. Therefore, the $PM_{2.5}$ ratios were derived from AP-42. Documentation for these ratios are provided in the AP-42 sections for unpaved roads (AP-42 Section 13.2.2), western surface coal mining (AP-42 Section 11.9), industrial wind erosion (AP-42 Section 13.2.5), and in the *Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors* (Midwest Research Institute 2006). Most sources have a $PM_{2.5}/PM_{10}$ ratio of 0.10 ($PM_{2.5}$/TSP ratio of 0.03), except wind erosion of disturbed areas, which has a $PM_{2.5}/PM_{10}$ ratio of 0.15 ($PM_{2.5}$/TSP ratio of 0.045).

PM emissions estimates generated for the coal preparation activities and the mine-related fugitives were summed for each year of the five-year period, and the year with the maximum emissions was determined. As summarized in **Table 4.5-4**, year 2019 has the highest emissions of the five years and was selected as one of the worst-case years for the modeling analysis. For year 2016, overburden removal occurs near the southern boundary, which results in the potential for higher particulate emissions and subsequently a greater impact near the Permit Area boundary. Therefore, 2016 was selected as the other worst-case year for the modeling analysis.

Table 4.5-4 Total Annual Particulate Emissions 2015-2019

Mining Category	Particulate Matter Emissions (tpy)									
	2015		2016		2017		2018		2019	
	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
Coal prep areas	47	6	47	6	48	6	48	6	48	6
Mine-related fugitives	685	90	675	89	685	90	689	90	695	91
Total	**732**	**96**	**722**	**95**	**733**	**96**	**737**	**96**	**743**	**97**

Heavy Equipment Emissions

$PM_{2.5}$, PM_{10}, NO_X, CO, and SO_2 emission inventories were developed for mining equipment exhaust for the worst-case years using equipment operating hours provided by PWCC and emission factors from EPA's NONROAD software. The NONROAD emissions model generates emission factors based on equipment fleet characteristics for a selected year. NONROAD does not provide $PM_{2.5}$ factors, so the PM_{10} estimates were conservatively assumed to also represent $PM_{2.5}$. **Table 4.5-5** summarizes the annual operating hours for each heavy equipment category along with emission estimates for these five pollutants and volatile organic compounds (VOC) for the selected worst-case years.

Scoria Operations Emissions

A scoria removal and processing operation, a small non-mining source that functions at the mine on an intermittent basis, also would generate PM and gaseous emissions. Operating parameters for scoria removal and processing are presented in **Table 4.5-6**. Although this source only functions in the summer every few years, emissions from the scoria operations were assumed to occur in each year during the 2015 to 2019 period to be conservative.

Table 4.5-5 Annual Heavy Equipment Hours and Tailpipe Emissions, Years 2016 and 2019

Equipment Type		2016 Equipment Hours and Annual Emissions (tpy)							2019 Equipment Hours and Annual Emissions (tpy)						
		Equip. Hours	PM_{10}	$PM_{2.5}$	NO_x	CO	SO_2	VOC	Equip. Hours	PM_{10}	$PM_{2.5}$	NO_x	CO	SO_2	VOC
Wheeled dozers at J-28	CAT 854; 907 hp	2,274	0.24	0.24	5.37	1.75	0.01	0.38	2,274	0.19	0.19	4.57	1.32	0.01	0.32
Wheeled dozers at N-11	CAT 854; 907 hp	1,009	0.11	0.11	2.38	0.78	0.00	0.17	1,009	0.08	0.08	2.03	0.59	0.00	0.14
Track dozers at N-8	CAT D11; 850 hp	16,842	1.66	1.66	38.30	12.11	0.04	2.70	16,842	1.19	1.19	31.91	8.76	0.04	2.24
Scrapers	CAT 657; 600 hp	9,632	0.36	0.36	6.01	2.41	0.01	0.46	9,632	0.25	0.25	3.95	1.62	0.01	0.42
Overburden drilling	CAT MD6540; 1,205 hp	7,142	1.23	1.23	28.38	7.62	0.02	2.14	7,142	1.00	1.00	24.97	6.03	0.02	1.81
Track dozers on overburden	CAT D11; 850 hp	29,101	2.87	2.87	66.08	20.90	0.07	4.66	30,023	2.12	2.12	56.80	15.59	0.07	3.99
Overburden haul trucks	CAT 793; 2,650 hp	22,603	3.97	3.97	102.92	34.54	0.14	8.28	23,319	2.42	2.42	92.25	21.15	0.13	7.12
Coal drilling	CAT MD6540; 1,205 hp	2,599	0.45	0.45	10.33	2.77	0.01	0.78	2,599	0.36	0.36	9.09	2.20	0.01	0.66
Coal haul trucks	CAT 793; 2,650 hp	32,772	5.75	5.75	149.22	50.07	0.20	12.01	39,715	4.12	4.12	157.10	36.02	0.23	12.12
Graders	CAT 24; 533 hp	15,117	0.45	0.45	7.30	2.93	0.01	0.57	15,117	0.30	0.30	4.72	1.92	0.01	0.52
Water trucks	CAT 793; 2,650 hp	11,814	2.07	2.07	53.79	18.05	0.07	4.33	11,814	1.23	1.23	46.73	10.72	0.07	3.61
Total Emissions		**--**	**19.16**	**19.16**	**470.08**	**153.94**	**0.60**	**36.48**	**--**	**13.27**	**13.27**	**434.12**	**105.92**	**0.60**	**32.94**

Table 4.5-6 Operating Parameters for Scoria Removal and Processing

Scoria Operation	Operation Parameter Units	Annual Operating Parameters	Maximum Daily Operating Parameters
Scoria removal	tons	110,000	1,692
Dozers	hours	520	8
Loaders	hours	520	8
Transfer to crusher	tons	110,000	1,692
Crushing	tons	110,000	1,692
Screening	tons	110,000	1,692
Stacker transfer	tons	110,000	1,692
Transfer to truck	tons	110,000	1,692
Truck travel (mine trucks)	VMT	4,000	60
Truck dumping to road	tons	60,000	1,692
graders	hours	520	8
Truck travel (county trucks)	VMT	6,500	100
Wind Erosion	acres	5	5

Note: Parameters are equivalent for all operating years.
VMT = vehicles miles traveled

PM emissions for scoria operations were estimated using the same methodology as the mine-related fugitives. **Table 4.5-7** summarizes the estimated annual emissions for PM_{10} and $PM_{2.5}$ for each fugitive dust source from the scoria operations.

Table 4.5-7 PM Annual Emissions, Scoria Operations

Scoria Operation	Annual Particulate Matter Emissions (tpy)	
	PM_{10}	$PM_{2.5}$
Scoria removal by loader	0.25	0.02
Dozer assisting removal	0.20	0.11
Loader on OB	0.20	0.11
Loader transfer to crusher	0.02	0.00
Crushing	0.13	0.13
Screening	0.48	0.48
Stacker transfer	0.02	0.00
Loader transfer to truck	0.02	0.00
Mine truck travel	0.54	0.05
Truck dumping to road	0.01	0.00
Grader	1.05	0.10
County truck travel	0.88	0.09
Wind erosion	0.38	0.06
Total Emissions	**4.15**	**1.16**

Note: Emissions are equivalent for all operating years.

Emission inventories for $PM_{2.5}$, PM_{10}, NO_X, CO, and SO_2 were calculated for equipment exhaust involved with the scoria operations using identical methodologies to those used for the mining heavy equipment exhaust. **Table 4.5-8** summarizes annual operating hours and emissions.

Table 4.5-8 Annual Tailpipe Emissions for Scoria Removal and Processing

Equipment Type		Operating Hours and Annual Emissions for 2016 (tpy)						
		Op. Hours	PM_{10}	$PM_{2.5}$	NO_X	CO	SO_2	VOC
Wheeled loader - scoria	CAT 992; 814 hp	520	0.06	0.06	1.23	0.40	0.00	0.09
Track dozer - scoria	CAT D11; 850 hp	520	0.05	0.05	1.18	0.37	0.00	0.08
Mine haul trucks - scoria	CAT 785; 1,450 hp	520	0.07	0.07	1.75	0.59	0.00	0.14
Grader - scoria	CAT 24; 533 hp	520	0.02	0.02	0.25	0.10	0.00	0.02
County haul trucks - scoria	CAT CT660; 475 hp	520	0.01	0.01	0.19	0.07	0.00	0.02
Generator - scoria	500 hp	520	0.02	0.02	0.40	0.12	0.00	0.03
Total Emissions		**--**	**0.22**	**0.22**	**5.00**	**1.65**	**0.01**	**0.38**
Equipment Type		**Operating Hours and Annual Emissions for 2019 (tpy)**						
		Op. Hours	**PM_{10}**	**$PM_{2.5}$**	**NO_X**	**CO**	**SO_2**	**VOC**
Wheeled loader - scoria	CAT 992; 814 hp	520	0.04	0.04	1.04	0.30	0.00	0.07
Track dozer - scoria	CAT D11; 850 hp	520	0.04	0.04	0.98	0.27	0.00	0.07
Mine haul trucks - scoria	CAT 785; 1,450 hp	520	0.04	0.04	1.52	0.35	0.00	0.12
Grader - scoria	CAT 24; 533 hp	520	0.01	0.01	0.16	0.07	0.00	0.02
County haul trucks - scoria	CAT CT660; 475 hp	520	0.00	0.00	0.09	0.03	0.00	0.02
Generator - scoria	500 hp	520	0.01	0.01	0.32	0.09	0.00	0.03
Total Emissions		**--**	**0.15**	**0.15**	**4.12**	**1.11**	**0.01**	**0.33**

Blasting Emissions

NO_X, CO, and SO_2 emission inventories were developed for coal and overburden blasting for the selected worst-case years. Blasting emissions were calculated from projected explosives (ANFO) usage provided by PWCC and emission factors presented in AP-42 Section 13.3, Explosives Detonation. **Table 4.5-9** summarizes annual ANFO usage and gaseous emissions for the worst-case years.

Table 4.5-9 Annual Blasting Emissions

Mine Operation	2016 Annual ANFO Usage (tons) and Annual Emissions (tpy)				2019 Annual ANFO Usage (tons) and Annual Emissions (tpy)			
	ANFO	NO_X	CO	SO_2	ANFO	NO_X	CO	SO_2
Overburden blasting	15,983	135.9	535.4	0.1	16,489	140.2	552.4	0.1
Coal blasting	779	6.6	26.1	0.0	831	7.1	27.8	0.0
Total Emissions	**--**	**142.5**	**561.5**	**0.1**	**--**	**147.2**	**580.2**	**0.1**

Criteria Pollutant Summary

Emissions estimates above are summarized for the categories: coal prep facilities, mining fugitives, scoria fugitives, blasting (ANFO), and equipment exhaust. **Table 4.5-10** shows annual emissions by pollutant for these categories for both worst-case years.

Table 4.5-10 Annual Criteria Pollutant Summary Worst-Case Emissions (tpy)

2016	PM_{10}	$PM_{2.5}$	NO_x	CO	SO_2
Coal prep facilities	47	6	--	--	--
Mining fugitives	675	89	--	--	--
Scoria fugitives	4	1	--	--	--
Blasting	--	--	142	562	0.1
Equip exhaust	19	19	475	156	0.6
Total	**745**	**115**	**617**	**718**	**0.7**
2019	**PM_{10}**	**$PM_{2.5}$**	**NO_x**	**CO**	**SO_2**
Coal prep facilities	48	6	--	--	--
Mining fugitives	695	91	--	--	--
Scoria fugitives	4	1	--	--	--
Blasting	--	--	147	580	0.1
Equip exhaust	13	13	438	107	0.6
Total	**760**	**111**	**585**	**687**	**0.7**

Direct GHG Emissions

Direct GHG emissions sources from onsite mining are in two main categories: the emissions (methane) released by the exposure of the coal seams to the atmosphere and the combustion emissions from mining equipment. The combustion emission component includes gaseous emissions and particulate emissions (black carbon).

Methane may be released from surface coal mining operations, including emissions from mining and coal handling. Kirchgessner et al. (2000) estimated methane content from coal mined from western surface coal mines at 0.17 pounds per ton of coal. Given the approximate coal mining of 7,900,000 tons of coal, the total methane released during mining, handling, storage, or processing is estimated to be 671.5 tpy. With methane's global warming potential of 25 this equates to 16,788 tons of CO_2e (15,230 metric tons CO_2e).

Fuel use for mining operations, including diesel-fired mining equipment, vehicle traffic, and hauling operations during the Renewal period is based on an estimated 7.66 million gallons of diesel fuel for the operating equipment at 7,900,000 tpy of coal production. That analysis uses diesel fuel emissions data from 40 CFR 98 Tables C-1 and C-2, and an assumed sulfur content of 15 parts per million (ppm) by volume along with the projected equipment SO_2 emissions for proposed mine operations.

Table 4.5-11 includes annual GHG emissions from coal mining (methane) and production of GHG emissions (equipment emissions) that would occur during the Renewal period. The range for configuration is provided for each operation, based strictly on the coal production. This level of annual production was calculated to meet the expected power generation levels at the NGS.

Table 4.5-11 Annual GHG Emissions for the Mine During the Renewal Period

Mine Operation	Proposed Total Coal Production (mtpy)	Methane Emissions CO_2e	Equipment Emissions CO_2e	Total Emissions CO_2e
		(Data in Metric Tons per Year)		
Alternative 1	7.9	15,230	78,415	93,645

HAP Emissions

An HHRA (Flatirons Toxicology 2016) was prepared to evaluate potential impacts under Alternative 1 on individuals who reside within or near the lease boundary. Baseline exposures from soil and food exposure pathways based on current soil concentrations were estimated for Resident, Resident Gardener, and Resident Farmer exposure scenarios.

Particulate deposition under Alternative 1 was negligible both in absolute terms and relative to existing baseline concentrations. Metal COPC soil concentrations under Alternative 1 were mostly less than 0.1 percent of existing baseline soil concentrations. PAH COPC soil concentrations were thousands to hundreds of millions of times lower than EPA Regional Residential Soil Screening Levels. Therefore, exposures from the soil and food exposure scenarios were not quantified. Exposure concentrations for COPCs in air were extremely low to negligible. Diesel PM was the risk driver for both cancer and non-cancer health effect endpoints for the Alternative 1 risk case. The primary exposure pathway for the Alternative 1 cases was air and the primary route of exposure was inhalation.

Table 4.5-12 lists the various air concentrations of specific pollutants from Alternative 1. Exposure concentrations for COPCs in air were extremely low to negligible based on the results of the Renewal HHRA (Flatirons Toxicology 2016) (**Section 4.17**).

Table 4.5-12 Air Concentrations for Specific Pollutants

Pollutants	Concentration ($\mu g/m^3$)
Arsenic	4.52E-06
Cadmium	4.12E-07
Lead	1.17E-05
Manganese	2.04E-04
Nickel	1.46E-05
Selenium	2.48E-06
Chrysene	1.74E-07

4.5.1.3 Impact Evaluation

Criteria pollutant impacts associated with Alternative 1 were evaluated based on ambient modeling (MMA 2016). Direct impacts related to HAPs are identified in **Section 4.5.1.2**, **Section 4.9.1.2**, and **Section 4.17.1**.

Ambient Air Quality Analysis

Table 4.5-13 shows the comparison of the maximum concentrations for each applicable NAAQS standard.

Table 4.5-13 Maximum Design Concentrations to NAAQS, 2016 or 2019

Pollutant	Averaging Time	Modeled Impact Concentration[1] (µg/m³)	Background Concentration (µg/m³)	Design (Total) Concentration[2] (µg/m³)	NAAQS (µg/m³)
PM_{10}	24-hr	82.48	33.70	116.18	150
$PM_{2.5}$	24-hr	9.69	13.00	22.69	35
$PM_{2.5}$	Annual	1.67	4.70	6.37	12
NO_2	1-hr	142.74	included	142.74	188
NO_2	Annual	13.15	5.64	18.79	100
CO	1-hr	185.54	1955.00	2140.54	40,000
CO	8-hr	4194.87	1495.00	5689.87	10,000
SO_2	1-hr	0.48	22.7	23.18	196
SO_2	3-hr	1.16	19.10	20.26	1,310
SO_2	24-hr	0.38	6.80	7.18	365
SO_2	Annual	0.02	4.90	4.92	80

[1] The higher of the 2016 or 2019 modeled results was chosen to be conservative. PM_{10} 24-Hour: Highest 6th-high over 5 years;
$PM_{2.5}$ 24-Hour: 5-year mean of the highest 8th high
$PM_{2.5}$ Annual: Maximum of the 5-year mean
NO_2 1-Hour: 5-year mean of 8th highest daily maximum
SO_2 1-Hour: 5-year mean of the 4th highest daily maximum
SO_2 3-Hour and 24-Hour; CO 1-Hour and 8-Hour: Highest 2nd-high over 5 years
NO_2 and SO_2 Annual: Maximum annual over 5 years
[2] Design concentrations is the sum of modeled impact concentration and background concentration

All modeling results demonstrate compliance under worst-case conditions (2016 operations closest to the ambient boundary and 2019 maximum particulate emissions). The majority of averaging period impacts are less than 70 percent of the NAAQS, demonstrating that for those criteria pollutants, there would be negligible effects under Alternative 1. The 1-hour NO_2 and 24-hour PM_{10} impacts would be 75.9 percent and 77.5 percent of the standards, respectively. The impact of Alternative 1 for those two averaging periods suggests that only a minor impact would result from Alternative 1.

Criteria Pollutant State and National Comparison

Per the 2011 National Emissions Inventory (NEI), the state of Arizona generated 178,231 tons of $PM_{2.5}$ and 406,993 tons of PM_{10}. National emissions were 6.1 mt of $PM_{2.5}$ and 20.7 mt of PM_{10}. The $PM_{2.5}$ emissions associated with the mine emissions contribute 0.06 percent and 0.002 percent of the state and national totals, respectively. Similarly, PM_{10} emissions from the mine contribute 0.19 percent and 0.004 percent when compared to the state and national totals, respectively. Gaseous pollutants from the mine when compared to the state or nation do not exceed 0.23 percent or 0.004 percent, respectively. Based on the percentage comparison, the potential impacts of all criteria pollutants from the mine would be negligible under Alternative 1.

GHG State and National Comparison

Similar to criteria pollutants, GHGs were compared to state and national totals. Arizona produced 57.08 mt of GHG as derived from the 2011 NEI data. Direct impact GHG emissions generated by the mine are approximately 0.167 percent of state totals, and 0.0042 percent of national total. The overall impact of these emissions during the Renewal period would be negligible.

PSD Evaluation

EPA's PSD program defines when an emissions increase that results from a change at a stationary source is "significant," and thereby warrants investigation into the extent of the ambient air quality impact caused by that emissions increase. By definition, a PM_{10} emissions increase of 15 tpy or more is "significant," an emissions increase of 10 tpy or more of direct $PM_{2.5}$ is "significant," and a NO_x emissions increase of 40 tpy or more is "significant." The worst-case particulate emissions are less than the projected emissions identified for the last permit renewal OSMRE (2011). A maximum of 745 tpy of PM_{10} and 115 tpy of $PM_{2.5}$ would occur under Alternative 1. Under the last renewal, it was estimated that 1,122 tpy and 156 tpy of PM_{10} and $PM_{2.5}$ would be emitted (OSMRE 2011). Thus, Alternative 1 would not result in a "significant" emissions increase of PM_{10} or $PM_{2.5}$ from the Kayenta Mine under the EPA's PSD methodology. The change in estimated NOx emissions under Alternative 1 would be an increase from 2011. The worst-case estimate under Alternative 1 would be 617 tpy, while in 2011 a maximum of 360 tpy was estimated. Thus, Alternative 1 would result in a "significant" emissions increase of NOx from the Kayenta Mine under the EPA's PSD methodology. Note that the estimated NOx emissions for Alternative 1 were modeled and demonstrated compliance with both the 1-hr and annual NO_2 NAAQS (**Table 4.5-13**). Therefore, although Alternative 1 would meet the PSD definition of "significant," there would still not be an adverse ambient air impact under Alternative 1.

4.5.1.4 Indirect Combustion Impacts Analysis

The Kayenta Mine has historically provided 100 percent of the coal produced to the NGS, and the NGS currently does not receive coal from any other mine. This would continue under Alternative 1. The maximum amount of coal expected to be supplied to the NGS during any one-year period is 8.1 mtpy. Note that while the maximum production rate of the mine between 2015 through 2019 would be 7.9 mt, previously mined coal outside the proposed Renewal period may also be burned at the NGS. Thus, all years assume a firing rate of 8.1 mtpy. This is representative of the maximum rate and will be assumed for all emission calculations discussed in this section.

Emissions were calculated for the current maximum contracted coal tonnage. These rates may vary significantly from year to year, but are useful for determining a general estimate of criteria pollutant emissions. The NGS facility consists of three pulverized coal-fired steam electric generating units, each of which are 750 megawatts (MW) with a net MW output of 2,250. Each unit is equipped with a SO_2 scrubber and hot-side electrostatic precipitators (ESP) controls. PM (i.e., fly ash) is removed from the flue-gas by ESP and SO_2 scrubbers. The forced oxidation wet SO_2 scrubbers also remove SO_2 emissions. NO_x emissions primarily are controlled in the combustion process by the use of low NO_x burners and separated overfire air. The scrubber control is downstream of the ESP. Based on those controls, the following emission factors were developed. In addition, the criteria pollutant emissions representing the maximum annual throughput from 2015 through 2019 are shown in **Table 4.5-14**.

Table 4.5-14 Coal-Fired Projected Emission Factors

Pollutant	Factor (lb/MMBtu)	Annual Projections (tpy)
PM_{10}	0.021	2,070
$PM_{2.5}$	0.015	1,487
VOC	0.002511	244.02

Pollutant	Factor (lb/MMBtu)	Annual Projections (tpy)
NO_x	0.21	20,409
CO	0.15	14,578
SO_2	0.10	9,719

Emissions of criteria pollutants from the NGS at the maximum firing rate would range from 0.01 percent (VOCs) to 12.64 percent (SO_2) of the Arizona total NEI emissions and from 0.0014 percent (VOCs) to 0.1513 percent (SO_2) of the national total emissions. The emissions would be insignificant relative to the national emissions totals and moderate emissions relative to the Arizona emissions total.

The NGS operates support equipment that produces air emissions. **Table 4.5-15** provides all criteria pollutant estimates for the facility.

Table 4.5-15 Support Equipment Criteria Pollutant Emissions (tpy)

Source	NOx	SO_2	PM_{10}	$PM_{2.5}$	CO	VOC
Oil-fired generating units (start-up)	12.09	0.14	0.00	0.00	2.52	0.10
Water cooling towers	--	--	0.86	0.02	--	--
Auxiliary boilers	0.48	0.14	0.02	0.00	0.10	0.00
Coal handling and storage (no coal pile)	--	--	0.21	0.03	--	--
Coal handling and storage	--	--	0.63	0.10	--	--
Limestone handling and storage	--	--	0.09	0.01	--	--
Limestone handling and storage (dust collectors)	--	--	1.47	0.40	--	--
Fly ash handling (no disposal)	--	--	7.82	1.18	--	--
Fly ash handling (with disposal)	--	--	0.24	0.04	--	--
Soda ash/lime handling	--	--	0.17	0.03	--	--
Fugitives – mobile	--	--	50.10	5.85	--	--
Fugitives – coal bulldozing	--	--	8.94	0.73	--	--
Fugitives – welding	--	--	0.10	0.10	--	--
Fugitives – abrasive blasting	--	--	0.44	0.04	--	--
Emergency generators	8.47	0.56	0.60	0.60	1.83	0.68
Fuel storage tanks	--	--	--	--	--	1.77
Diesel yard switcher locomotive	0.13	0.00	0.00	0.00	0.23	0.01
Nonroad equipment exhaust on roads	35.18	0.31	2.25	2.01	14.95	3.29
Onroad vehicles exhaust on roads	1.04	0.00	0.06	0.04	3.32	0.18
Nonroad equipment at landfills	1.00	0.02	0.08	0.07	0.49	0.08
Onroad vehicles at landfills	0.00	0.00	0.00	0.00	0.00	0.00
Wind erosion of coal, ash, and limestone piles	--	--	28.17	4.23	--	--

Note that all zero values are due to rounding. Minor emissions are released.

Ambient Air Quality Analysis

Results of AERMOD modeling for the NGS criteria air pollutants (Ramboll Environ 2016b) are provided in **Table 4.5-16**. The modeling analysis discussed below is based on proposed worst-case emissions associated with the NGS.

Table 4.5-16 NGS Worst-Case Modeling Results

Pollutant	Standard Primary or Secondary	Averaging Time	Modeled Impact* (µg/m³)	Background (µg/m³)	Total Impact*	Location of Max Impact**	% of NAAQS
SO_2	196	1-hr	141.1	22.5	163.6	8267, ESE	83
SO_2	1,310	3-hr	81.4	24.6	106.0	8375, SE	8
NO_2	188	1-hr	186.4	(1)	186.4	844.6, ESE	99
NO_2	100	Annual	14.4	6.0	20.4	807.8, ESE	20
CO	40,000	1-hr	746.5	3664.0	4410.5	850.6, ESE	11
CO	10,000	8-hr	154.6	2633.5	2788.1	822.8, ESE	28
PM_{10}	150	24-hr	94.4	44.5	138.9	826.8, ESE	93
$PM_{2.5}$	35	24-hr	11.9	20.8 (2)	32.7	826.8, ESE	94
$PM_{2.5}$	12	Annual	1.8	5.9 (3)	7.6	807.8, ESE	64
Pb	0.15	Quarterly	0.0007	0.0100	0.0107	808.6, ESE	7

[1]NO_2 1-HR was modeled in AERMOD with seasonal, hourly background values (Ramboll Environ 2016b [Figure 4-2]).
[2]$PM_{2.5}$ 24-HR background includes 1.0 µg/m³ secondary aerosol formation.
[3]$PM_{2.5}$ annual background includes 0.26 µg/m³ secondary aerosol formation.
*Maximum modeled impacts for National Ambient Air Quality Standards compliance based on the greater of the Pre-SCR and Post-SCR model-calculated results (see footnote 2 on page 4-27 regarding SCR).
**Simple direction and distance in meters from NGS middle stack.

The highest impacts tend to occur in the immediate vicinity of the NGS for all criteria pollutants except SO_2. The near-field maximum model results for all pollutants except SO_2 are dominated by impacts from surface level sources that operate within the NGS facility, within 800 meters to 850 meters from the site boundary. NO_X and $PM_{10}/PM_{2.5}$ impacts occur largely from heavy equipment exhaust and from fugitive emissions on the plant site, and not from the main boiler stack emissions. Impacts from SO_2 emissions are dominated by the main stack plumes, with maximum impacts occurring approximately 8.3 km to the southeast of the NGS.[3]

NAAQS Comparison

The NGS emissions would demonstrate compliance with all NAAQS (**Table 4.5-16**). The identification of the highest emissions, nearest to the ambient standards, for NGS can be extracted from **Table 4.5-16**. The maximum predicted 1-hour NO_2 maximum emissions at an individual receptor is located at the NGS boundary, at a level that would be just below the ambient air quality standard. The 1-hour NO_2 emissions would rapidly decline with distance from the NGS. Impacts on the 1-hour NO_2 levels would be less than half the standard (approximately the 100 µg/m^3 contour line) beyond about 2.5 km (1.6 miles) in any direction from the NGS (Ramboll Environ 2016b, Figure 5-2).

The background levels of $PM_{2.5}$ would tend to dominate the impacts, and those background levels would be below the ambient standard by about 50 percent (**Table 4.5-16**). The maximum impacts of the NGS on ambient concentrations of $PM_{2.5}$ also would be confined to receptors that are very near the NGS boundary. The 24-hour maximum $PM_{2.5}$ impact would occur at the NGS boundary, and the impacts would rapidly decline with distance from the NGS. Within 1 km from

[3] The PM_{10} and $PM_{2.5}$ model results are conservatively based on the post-SCR model results, which include added ammonium nitrate and sulfate emissions from the operation of the SCR. This was used as a conservative measure based on available data.

the NGS boundary, the maximum impact would be reduced from 32.7 μg/m^3 to about 24 μg/m^3, and impacts in all other directions would be well below the ambient standard.

These maximum impacts would be dominated by the surface level NO_X emissions from ground operations, such as vehicle emissions and emissions from fuel burning equipment associated with coal handling. The maximum impacts would occur near the NGS ambient air boundary. Fundamentally, the analysis demonstrates that indirect impacts of the NGS associated with Alternative 1, including options, would comply with the NAAQS for the criteria air pollutants (NO_2, SO_2, PM_{10}, $PM_{2.5}$, and CO). The maximum impacts would occur very near the NGS ambient air boundary, and those impacts would decrease substantially with distance from that boundary (Ramboll Environ 2016b). The results are a conservative estimate of actual impacts because the dispersion model calculations include conservative technical approaches that provide results that are likely over-estimated impacts.

Per the 2011 NEI, the state of Arizona generated 263,305 tons of NO_x. National emissions of NO_x were 14.4 mt. NO_x emissions associated with the NGS contribute 7.8 percent and 0.1425 percent of the state and the national totals, respectively. Other gaseous pollutants contributed to the NGS compared to the state or national totals do not exceed 12.64 percent or 0.1513 percent, respectively. Particulates do not exceed 0.84 percent of Arizona totals and 0.0247 percent of national totals. Based on the percentage comparison, the indirect impacts of all criteria pollutants from the NGS would be negligible to moderate depending on the pollutant. Emissions also were analyzed for ecological and human health risk (**Sections 4.9.1.2** and **4.17.1**, respectively) and the impacts were negligible.

Indirect Coal Combustion, GHG and Climate Change Impacts

In 2010, to assess GHG emissions on a facility, regional, and national level, the EPA introduced the Greenhouse Gas Reporting Program (GHGRP). The program collects GHG data from 41 source categories. GHGRP data includes direct emissions from large stationary sources, accounting for approximately half of total U.S. GHG emissions, and data from suppliers of materials that would result in GHG emissions when those materials are burned or released. Most industries began reporting for 2010 and 2011. The regulations that introduce the GHGRP also provided a standardized means to assess and calculate GHG emissions. These calculation methods were codified in 40 CFR Part 98. For the calculation of combustion emissions, the methods are included in subpart C of that regulation. These emissions calculations are an approved method for tabulating GHG pollutant emissions for the most common GHG pollutants. The emissions are not dependent on emissions location or combustion type and provide both speciated and CO_2e emissions. CO_2e is a quantity that describes, for a given mixture and amount of GHG, the amount of CO_2 that would have the same global warming potential (GWP), when measured over a specified timescale (generally, 100 years). CO_2e thus reflects the time-integrated radiative forcing of a quantity of emissions or rate of GHG emission—a flow into the atmosphere—rather than the instantaneous value of the radiative forcing of the stock (concentration) of GHGs in the atmosphere.

The CO_2e for a gas is obtained by multiplying the mass and the GWP of the gas. According to EPA, methane and nitrous oxide have GWPs, over a 100-year timespan, of 25 and 298, respectively. This means that emissions of one mmt of methane and nitrous oxide is equivalent to emissions of 25 and 298 mmt of CO_2, respectively.

In the U.S., total emissions of GHG in 2013 were estimated at 6,673 mmt of CO_2e (EPA 2015). The peak U.S. emission rate was 7,400 mmt in 2007; the data show a reduction of almost 10 percent from the peak year for the year 2013. Fossil fuel combustion accounted for 5,158 metric tons in 2013, or approximately 77 percent of the U.S. total GHG emissions for that year.

Regional Haze

Regional haze indirectly caused by the burning of Kayenta Mine coal at the NGS (**Section 3.5.7**) would be the same as the current conditions, but would continue until December 2019.

NGS GHG Emissions

GHG emissions under Alternative 1 primarily would be related to the combustion of coal at the NGS, and this is directly related to the level of power production. An estimate of GHG emissions from NGS operations also is provided, based on estimates of fuel use and oil combustion (**Table 4.5-17**). The estimates are based on an annual 88 percent capacity factor, and use the following assumed conversion factors (from 40 CFR 98 Tables C-1 and C-2, and Subpart A), and the heat rate data provided by the NGS:

- 93.28 kg CO_2 per million British Thermal Units (BTU) of coal combustion.
- 0.011 kg methane per million BTU of coal combustion, CO_2e weight of 25.
- 0.0016 kg nitrous oxide per million BTU of coal combustion, CO_2e weight of 298.
- Gross NGS heat rate of 11,194 BTU/kilowatt-hour, or 11.194 million BTU/MW-hour.

Table 4.5-17 NGS GHG Emissions (metric tons), Alternative 1

Source	3-Unit NGS
NGS generation (Megawatt, 88 percent capacity factor)	1980
Annual CO_2e Emissions (metric tons)	
NGS generation	18,257,000
NGS support operations	130,000
Total rounded	18,387,000
Annual CO_2 Emissions (metric tons)	
NGS generation	18,111,000
NGS support operations	129,000
Total rounded	18,240,000

Predicting the degree of impact that any single emitter of GHGs may have on global climate change, or on the changes to biotic and abiotic systems that accompany climate change, is not possible at this time. No tools or scientifically defensible analysis methods exist to describe the degree to which any observable changes can, or would be, attributable to Alternative 1. As such, the extent of impact that emissions resulting from continued mining may have on global climate change, as well as the accompanying changes to natural systems, cannot be accurately quantified (U.S. Global Change Research Program 2009).

To provide some additional context, the EPA has recently modeled global climate change impacts from a model source emitting 20 percent more GHGs than a 1,500-MW coal-fired steam electric

generating plant (approximately 14,132,586 metric tpy of CO_2, 273.6 metric tpy of nitrous oxide, and 136.8 metric tpy of methane). The model included an estimate of a hypothetical maximum mean global temperature value increase resulting from such a project. The results ranged from 0.00022 and 0.00035°C occurring after approximately 50 years of facility operation. The modeled changes are extremely small, and any downsizing of these results from the global scale would produce greater uncertainly in the predictions. The EPA concluded that even assuming such an increase in temperature could be downscaled to a particular location, it "would be too small to physically measure or detect" (Letter from Robert J. Meyers, Principal Deputy Assistant Administrator, Office of Air and Radiation re: "Endangered Species Act and GHG Emitting Activities [October 3, 2008]). Emissions under Alternative 1 would be a fraction of the EPA's modeled source and would be shorter in duration. Therefore, Alternative 1 would have no measurable impact on the climate and would be negligible.

Additionally, NGS would be compliant with the Clean Power Plan (currently under review, see **Section 3.5.7**) over the five-year Renewal period under Alternative 1. As such, NGS operations would be consistent with a federal program designed to reduce overall carbon emissions. Moreover, as explained in Chapter 1, OSMRE has limited discretion to deny the Renewal application or to limit the effects of NGS. There are no OSMRE-required environmental protection measures that address NGS emissions because OSMRE does not have the jurisdiction or authority to enforce them.

Although a single emitter of GHGs cannot be connected to the degree of impact that the emitter may have on global climate change, EPA (2015b) has predicted that Arizona will experience the following general trends related to climate change:

- The region will experience warmer temperatures with less snowfall.
- Temperatures are expected to increase more in winter than in summer, more at night than in the day, and more in the mountains than at lower elevations.
- Earlier snowmelt will result in earlier peak stream flows, weeks before the peak needs of ranchers, farmers, recreationalist, and others. In late summer, rivers, lakes, and reservoirs will be drier.
- More frequent, more severe, and possibly longer-lasting droughts will occur.
- Crop and livestock production patterns could shift northward; less soil moisture due to increased evaporation may increase irrigation needs.
- Drier conditions will reduce the range and health of ponderosa and lodge pole pine forests, and increase the susceptibility to fire.
- Grasslands and rangelands could expand into previously forested areas.
- Ecosystems and wildlife will be stressed.

Climate Change Impacts on the Renewal

Climate change is a natural process that has occurred throughout geologic time and is generally characterized by incremental changes in the wide range of complex factors that can affect the earth's climate over long periods of time. Variations in climate due to incremental changes, whether natural or contributed to by anthropogenic sources such as manmade GHGs, typically

occur in timeframes as short as many decades or as long as several millennia. The Renewal period is five years and the incremental natural and anthropogenic sources and processes that are predicted to lead to meaningful changes in global temperatures and weather patterns would continue during and beyond that period. However, definitive changes that would directly or indirectly impact mining during the Renewal period are not expected to occur in that relatively brief timeframe.

Some impacts from climate change on the Renewal that could occur over a longer timeframe would include both direct and indirect effects. Direct effects may include, for example, longer and more severe droughts in the Southwest U.S., depleting water levels in the N-Aquifer and reducing available water for mining, as well as for residential and agricultural use. Reclamation success may be harder to achieve for some vegetative species due to warmer temperatures and generally drier conditions. New reclamation techniques and changes in revegetation species may be required. Indirect effects may include as an example, increased demand for electricity for residential and commercial air conditioning as temperatures increase, which would necessitate increases in NGS electrical output and concurrent increases in coal production.

Social Cost of Carbon

The social cost of carbon (SCC) protocol was developed by a federal Interagency Working Group (IWG) to assist agencies in addressing Executive Order 12866, which required federal agencies to assess the cost and the benefits of intended regulations as part of their regulatory impact analyses. The SCC protocol was also developed for use in cost-benefit analyses of proposed regulations that could impact cumulative global emissions (Shelanski and Obstfeld 2015). However, a recent Executive Order entitled, "Promoting Energy Independence and Economic Growth," issued March 28, 2017, directed that the IWG be disbanded and that technical documents issued by the IWG be withdrawn as no longer representative of federal policy (Section 5 of the Executive Order). It further directed that when monetizing the value of changes in GHGs resulting from regulations, agencies shall follow the guidance contained in OMB Circular A-4 of September 17, 2003.

The SCC is meant to be a relative estimate of climate change damages used for comparison purposes and includes, but is not limited to, changes in net agricultural productivity, human health, and property damages from increased flood risk. The SCC is an estimate of the economic damages associated with an increase in carbon dioxide emissions typically expressed as a one mt increase in a single year. This dollar cost figure from this calculation represents the value of damages avoided for an associated carbon emissions reduction. SCC estimates produce a wide range of costs, with the greatest influence on costs caused by the discount rate. The discount rate is a measure to estimate the present value for costs/damages that may occur far out into the future. There is a lack of consensus on the appropriate discount rate, which leads to substantial variation in output. In other words, small differences in the discount rate can create large variations to the estimated SCC. Moreover, given current modeling and data limitations, it cannot include all damages or benefits. Also, the August 1, 2016 CEQ guidance does not mandate the inclusion of a monetary cost/benefit analysis be performed. It also states that if an analysis were to be conducted, there are limitations to and uncertainties with such an analysis that must be disclosed as well. That guidance was withdrawn April 4, 2017 (82 Fed. Reg. 16576). In all cases, a Federal agency should ensure that its consideration of the information and other factors relevant

to its decision is consistent with applicable statutory or other authorities, including requirements for the use of cost-benefit analysis.

Based on emission estimates for coal combustion, SCC calculations can quickly rise to large values; however, specific threshold levels for the determination of significance can vary depending on numerous project factors. OSMRE has elected not to specifically quantify the SCC. First, the GHG emissions associated with the Renewal are mostly from the indirect effects of coal combustion, and there is no consensus on the appropriate fraction of SCC tied to electricity generation that should be assigned to the coal producer under SCC calculations. In addition, NEPA does not require a cost-benefit analysis (40 CFR § 1502.23) or the presentation of the SCC cost estimates quantitatively in all cases, and that analysis was not undertaken here. Without a complete monetary cost-benefit analysis, which includes the social benefits of energy production to society as a whole and other potential positive benefits, inclusion solely of a SCC analysis would be unbalanced, potentially inaccurate, and not useful. GHG coal combustion emissions are quantified and contextualized against global and national GHG emissions above.

Consequently, any increased economic activity associated with Alternative 1 is simply an economic impact. Economic impact is distinct from "economic benefit" as defined in economic theory and methodology, and the socioeconomic impact analysis required under NEPA is distinct from cost-benefit analysis.

To summarize, this EA does not undertake an analysis of SCC because 1) it is not engaged in a rulemaking for which the protocol was originally developed; 2) the IWG, technical supporting documents, and associated guidance have been withdrawn; 3) NEPA does not require cost-benefit analysis and the agency did not undertake one here; and 4) because the full social benefits of coal-fired energy production have not been monetized, quantifying only the costs of GHG emissions would provide information that is both potentially inaccurate and not useful.

Ozone Impacts

Ozone can be found in the earth's atmosphere at both ground level and in the upper regions. Upper atmospheric ozone also is known as the ozone layer, and protects earth's surface from the sun's rays. Ground level ozone is the main component of smog and is considered a harmful pollutant.

Ground level ozone is not emitted directly into the air but is created by chemical reactions between NOx (nitrous oxide and NO_2) and VOCs in the presence of heat and sunlight (EPA 2015). The most significant chemical reaction driving the formation of ground level ozone is photolysis of NO_2; however, this process is reversed by the reaction of nitric oxide with ozone. Therefore, the formation of ozone due to NOx is dependent on the NO_2 to nitrous oxide ratio and, by itself, would result in very low levels of ozone formation. The net effect of the nitrogen cycle is neither to generate nor destroy ozone molecules. Moreover, for ozone to accumulate, an additional pathway is needed to convert nitrous oxide to NO_2; one that will not destroy ozone. The photochemical oxidation of VOCs, such as hydrocarbons and aldehydes, provides that pathway (CARB 2015). When VOCs are present, they form radicals that convert nitrous oxide to NO_2 and, thus, increase the formation of ozone.

The relative amounts of VOCs and NOx at a particular location, in addition to climatological conditions, will determine whether the NOx behaves as a net ozone generator or a net ozone inhibitor. When the VOC/NOx ratio in the ambient air is low, NOx tends to inhibit ozone formation. In such cases, the amount of VOCs tends to limit the amount of ozone formed, and the ozone formation is called "VOC-limited". When the VOC/NOx ratio is high, NOx tends to generate ozone. In such cases, the amount of NOx tends to limit the amount of ozone formed, and ozone formation is called "NOx -limited" (CARB 2015).

Precursors of ozone, including NOx and VOCs, are generated by both direct and indirect sources. The vast majority of precursor emissions are derived from coal combustion and to a lesser degree, onsite blasting. Based on the combustion at the NGS maximum coal firing rate (8.1 mtpy) conservative estimates of ozone precursors are included in **Table 4.5-18**.

Table 4.5-18 Predicted Ozone Precursor Emissions Rates

Emissions Method	Coal Combustion Rate (tpy)	NO_2 (tpy)	VOC (tpy)
NGS firing rate	8,100,000	20,468	250
Blasting	N/A	617	--

Although ozone precursor emissions from the combustion of coal and direct onsite blasting can be significant, current rates of coal combustion from regional generating facilities and other sources of ozone precursors have not resulted in ambient ozone concentrations that have exceeded the NAAQS.

Regional Ozone Compliance

Several ozone monitors throughout the states of Arizona and Utah were evaluated for NAAQS compliance and subsequent attainment/nonattainment designation. Data from seven regional monitors were gathered to examine ozone concentrations surrounding the NGS and the Kayenta Mine: Flagstaff, Arizona; Grand Canyon, Arizona; Petrified Forest, Arizona; Escalante National Monument, Utah; Canyonlands National Park, Utah; Hurricane, Utah; and Zion National Park, Utah. **Table 4.5-19** demonstrates the 4th highest of the eight-hour daily maximums beginning in 2011 through 2014. Note that the NAAQS standard was 75 ppb during 2011 through 2014 and lowered to 70 ppb in 2015. The concentrations recorded at the ozone monitoring stations represent both past and present NGS full operations.

Table 4.5-19 Ozone Monitoring Results from 2011 Through 2014

Parameter	Site Location	2011	2012	2013 (3-yr avg)	2014 (3-yr avg)	Standard
Ozone 4th highest 8-hour daily maximum (data in ppb)	Flagstaff, AZ	68	72	69 (69)	73 (71)	70 ppb (current) 75 ppb during 2011 to 2014
	Grand Canyon, AZ	74	73	69 (72)	69 (70)	
	Petrified Forest, AZ	69	73	69 (70)	68 (70)	
	Escalante National Monument, UT	--	68	67 (67)	60 (65)	
	Canyonlands National Park, UT	69	72	66 (69)	67 (68)	
	Hurricane, UT	68	59	69 (65)	70 (66)	
	Zion National Park, UT	72	75	70 (72)	69 (71)	
	Average	70.0	70.3	68.4	68.0 (68.7)	

Source for all air quality data except for Page: http://www.epa.gov/airdata/ad_rep_mon.html

Ozone standards are based on the 4th highest value averaged over a three-year period for the eight-hour averaging period. For all monitor locations at the time of measurement, the ambient concentration values indicate that the region is in compliance with the ozone NAAQS, suggesting that proposed rates of coal combustion emissions would not produce exceedances of the NAAQS. This includes average regional compliance with the 2015 revised ozone NAAQS.

Although all sites demonstrated compliance with the standard (75 ppb) during the time referenced in **Table 4.5-19**, some sites would have exceeded the new ozone NAAQS (70 ppb). These include: Grand Canyon and Zion NP in 2013 as well as Flagstaff and Zion in 2014. A No Action Alternative (both Kayenta Mine and NGS shutdown beyond 2020) modeling analysis was conducted, which demonstrated full compliance with the ozone NAAQS (Ramboll Environ 2016d). The highest impact was at Canyonlands, NP at 69.8 ppb.

Toxics Impacts

Dispersion and deposition of trace metals from the NGS stacks include mercury, selenium, and arsenic. Other HAPs from the NGS stacks were modeled and determined not to have any adverse impacts to the environment (Ramboll Environ 2016c). The NGS contribution to the regional deposition pattern including cumulative sources varies by metal. The deposition and fate of mercury has been studied in detail within a region that includes Lake Powell (EPRI 2016). The NGS contributes a maximum of 2.2 percent (12.7 micrograms per square meter) of annual deposition of mercury from all U.S. sources (approximately 577 micrograms per square meter). At this location, approximately 16 percent of the deposition is from China, approximately 81 percent from the rest of the world, and less than 1 percent from other regional sources within 300 km. A similar pattern was observed at a receptor point in Lake Powell, where the NGS would contribute less than one percent of the deposition.

For arsenic and selenium, the NGS is the primary regional air emission source for both metals, with deposition rates declining sharply over a 50-km distance from the NGS, with low level concentrations across the Northeast Colorado River Region that includes Lake Powell and the San Juan River watershed.

The deposition rates for arsenic, mercury, and selenium can be compared to the baseline concentration in soils, using the 95th percentile upper confidence limit for soil (MMA 2016 [Table 7-1]) and the maximum deposition rate (MMA 2016 [Table 7-3]), and calculating the comparative deposition to the concentration, using a 7.6-centimeter soil depth and 1.5 grams per cubic centimeter density of soil. For this comparison, and for five years of operation at the maximum level, arsenic and mercury deposition would add less than one percent to the baseline soil concentration (MMA 2016). Deposition of selenium would add about 4.6 percent to the baseline soil levels. Similar to the depictions of PM_{10} impacts, (MMA 2016 [Figures 6-1 and 6-4]), the highest deposition rates would occur near the Affected CRAs and would be half the maximum deposition rates at all but a few receptors off the mine lease area.

The indirect effect of deposition of COPCs from the NGS would be negligible under Alternative 1 as arsenic and mercury deposition represent less than one percent of the baseline soil concentration. Selenium deposition would reach 4.6 percent of the baseline soil concentrations after 5 years of operation, but the selenium deposition would occur over a very limited area (MMA 2016). Selenium deposition would have negligible impacts on wildlife via vegetation

consumption (**Section 4.9**). Further discussion regarding water and human health impacts from HAP emissions is provided in **Sections 4.7** and **4.17**.

4.5.2 Alternative 2: No Action

Alternative 2 assumes that the mining operations would cease in the Permit Area upon the OSMRE's decision to deny the Renewal. Therefore, only those direct emissions that have already occurred from July 2015 to August 2017 would be included in Alternative 2 (**Table 4.5-20**). Reclamation would result in some air quality emissions derived from grading and dozers, but by comparison the total amount of direct emissions from reclamation would be negligible. This would include approximately 40 percent of the total particulate emissions that would occur under Alternative 1. During the administrative delay period, Alternatives 1 and 2 would have similar effects regarding NAAQS compliance on a short-term standard basis. However, comparison to longer-term standards would show a reduction due to the cessation of mining.

Table 4.5-20 Direct Mining July 2015 - August 2017 Emissions

2015	PM_{10}	$PM_{2.5}$	NO_x	CO	SO_2	VOC
Coal prep facilities	47	6	--	--	--	--
Mining fugitives	685	90	--	--	--	--
Scoria fugitives	4	1	--	--	--	--
Blasting	--	--	134	532	0.1	--
Equip exhaust	18	18	449	148	0.6	36.76
Total	**754**	**115**	**583**	**680**	**0.7**	**36.76**
2016	**PM_{10}**	**$PM_{2.5}$**	**NO_x**	**CO**	**SO_2**	**VOC**
Coal prep facilities	47	6	--	--	--	--
Mining fugitives	675	89	--	--	--	--
Scoria fugitives	4	1	--	--	--	--
Blasting	--	--	142	562	0.1	--
Equip exhaust	19	19	475	156	0.6	36.86
Total	**745**	**115**	**617**	**718**	**0.7**	**36.86**
Jan – Aug 2017	**PM_{10}**	**$PM_{2.5}$**	**NO_x**	**CO**	**SO_2**	**VOC**
Coal prep facilities	31	4	--	--	--	--
Mining fugitives	450	59	--	--	--	--
Scoria fugitives	2.7	0.7	--	--	--	--
Blasting	--	--	95	375	0.07	--
Equip exhaust	12.7	12.7	317	104	0.4	24.57
Total	**496**	**77**	**412**	**479**	**0.5**	**24.57**

Indirect emissions discussed for Alternative 1 (**Section 4.5.1.4**) were derived from 2019 operations (**Table 4.5-21**). For conservative purposes, 2015 and 2016 emissions are based on the same firing rate (8.1 mt) as 2019. It also is assumed that the NGS would operate for approximately 67 percent of 2017, thus annual emissions are reduced by 33 percent. The 2015 and 2016 indirect emissions would be equivalent to those outlined in **Section 4.5.1.4**. The emissions would be insignificant relative to the national emissions totals and moderate emissions relative to the Arizona emissions total. Regional haze indirectly caused from burning Kayenta Mine coal at the NGS would cease being generated and would begin to dissipate following OSMRE's decision to deny the permit Renewal.

Table 4.5-21 Indirect 2015 - August 2017 Emissions

2015	PM_{10}	$PM_{2.5}$	NO_x	CO	SO_2	VOC
Coal-fired units	2,070	1,487	20,409	14,578	9.719	244
All other equipment	102.3	15.5	58.4	23.3	1.2	6.11
Total	**2,172**	**1503**	**20,467**	**14,601**	**9,720**	**250**
2016	**PM_{10}**	**$PM_{2.5}$**	**NO_x**	**CO**	**SO_2**	**VOC**
Coal-fired units	2,070	1,487	20,409	14,578	9,719	244
All other equipment	102.3	15.5	58.4	23.3	1.2	6.11
Total	**2,172**	**1503**	**20,467**	**14,601**	**9,720**	**250**
Jan – Aug 2017	**PM_{10}**	**$PM_{2.5}$**	**NO_x**	**CO**	**SO_2**	**VOC**
Coal-fired units	1,380	991	13,606	9,719	6,480	163
All other equipment	68.2	10.3	38.9	15.5	0.8	4.1
Total	**1,448**	**1,002**	**13,645**	**9,734**	**6,480**	**167**

4.5.3 Mitigation

There would not be any mitigation necessary for air and climate resources.

4.6 NOISE AND VIBRATION

4.6.1 Alternative 1: Renewal of Permit AZ-0001E

Blasting activities would be conducted in accordance with administrative regulations contained in 30 CFR 816.61 established to minimize adverse impacts resulting from noise and vibration; these regulations stipulate the use of blast design features that are considered protective under airblast, flyrock, and ground-vibration standards in 30 CFR 816.67. Sensitive noise receptors, including the 114 residents who live within the Permit Area and the six residences within the 0.5-mile range of warning signals for blasting during mining operations in the Affected CRAs (**Section 3.12**), would continue to experience noise from mining activities. The number of warning and all-clear signals produced at blasting sites by an audible-speaker warning device of 100 watts or greater—audible at 0.5 mile—would remain at current frequency as overall coal production per year is not anticipated to increase.

Noise from a point source, such as mining equipment, decreases approximately 6 dBA for each doubling of the distance to a sensitive noise receptor. For example, the loudest single noise source at the Kayenta Mine (the rock drill) would be 95 dBA at 50 feet and would decrease to 89 dBA at 100 feet (OSHA 1999). The closest receptor is a residence located 1,156 feet from the Affected CRAs (specifically, to the southeast of J-21). There would be approximately 68 dBA of point source noise at this residence during the Renewal period, which would be the same as the current levels.

In addition to the distance of the sensitive noise receptors from the Affected CRAs, mining activities occur below grade; the walls of the pit and spoil piles could absorb and attenuate some of the noise from mining activities. The current noise reduction measures associated with activities at mining sites include maintenance of equipment exhaust systems and engine sound controls to manufactures' specifications and limiting blasting to daylight hours. Although blasting

activities would continue to result in periodic intense sound levels, sensitive noise receptors are located at a distance where the noise intensity would be typically within standards established in 30 CFR 816.67.

Vibration impacts were determined by using the Blasting Guidance Manual (Rosenthal and Morlock 1987), which was developed to prevent injury and damage to public and private property outside the Permit Area. OSMRE requires that airblast levels be limited to a maximum of 134 dB (peak) (PAP). Ground vibrations cannot exceed peak particle velocity of 1.25 inches per second at a distance of 300 feet or 0.75 inches per second at 5,000 feet (Rosenthal and Morlock 1987). The nearest occupied residences are located approximately one mile from J-21. Temporary effects from vibration and airblast levels within standards established in 30 CFR 816.67 are not considered capable of producing injury or property damage, but could cause annoyance depending on the distance to the receptor (Mohamed 2010). Vibration impacts are not expected to change from current levels and would not exceed 134 dB.

Because noise and vibration levels would remain at or near standards established in 30 CFR 816.67, Rosenthal and Morlock (1987) and the PAP, the impacts would be negligible under Alternative 1.

4.6.2 Alternative 2: No Action

Under Alternative 2, mining operations would cease in the Permit Area upon OSMRE's decision to deny the Renewal. The existing noise and vibration conditions would continue until OSMRE's decision to deny the permit Renewal, which would be a negligible effect similar to under Alternative 1. PWCC would initiate closure activities and complete final reclamation per SMCRA requirements and Permit AZ-0001E. The effects related to noise and vibration would be reduced to those related to backfilling, grading, etc., during reclamation activities (maximum of 77 dBA at 300 feet). This would be a negligible effect. There would be no further effects related to blasting. After reclamation is concluded, there would be no effects related to noise and vibration.

4.6.3 Mitigation

There would not be any mitigation necessary for noise and vibration.

4.7 WATER RESOURCES

Coal mining and other related surface activities have the potential to impact the flow and quality of surface water and the shallow groundwater system (Alluvial and Wepo aquifers), as well as the deeper N- and D-Aquifers used for water supply. Impacts to surface water and shallow aquifers are measured by changes in water flows and water quality and generally are limited to an area within a few miles of the mining operations. The study area for direct effects from mine operations on surface water resources and shallow aquifers that interact with surface water includes the Permit Area and the study area for indirect effects includes those portions of the Black Mesa Basin underlain by the confined and unconfined areas of the N-Aquifer (**Figure 3.7-1**). Impacts to groundwater levels and water quality due to pumping of the N- and D-Aquifers for mining-related water supplies are the result of changes in the water levels (potentiometric surface) in the aquifers. These changes can occur over relatively large areas, especially in the confined portions of the aquifer systems. Impacts to groundwater are measured in terms of

changes in water levels in the N- and D-Aquifers, changes in water quality in the aquifers, and changes in spring flow and spring water quality for springs that derive their water from these aquifers.

Potential indirect effects on water resources from mining also can occur from the combustion of the coal at the NGS, as well as from the disposal of CCRs at the NGS. The potential indirect effects of coal combustion include the deposition of airborne combustion products directly into streams and ponds, as well as their transport to those surface waters during precipitation runoff. The study area for the potential indirect effects of coal combustion on aquatic species includes the Colorado River and San Juan River basins and those effects are discussed in detail in **Section 4.9**. The potential indirect effects of CCRs on water resources includes potential infiltration of combustion products into aquifers, potential release by surface runoff flow during precipitation into surface waters, or release into the atmosphere during wind events and subsequent deposition into surface waters. The study area for the potential indirect effects of the disposal of CCRs at the NGS on water resources includes a 0.5-mile radius around the NGS (**Figure 3.7-1**).

4.7.1 Alternative 1: Renewal of Permit AZ-0001E

4.7.1.1 Impacts on Surface Water

Changes in surface water quality were evaluated by considering impounded water quality, seep discharges to surface water, NPDES discharges, and the potential for increased suspended sediment loads in runoff. Potential impacts of surface water quality changes on biological resources are discussed in **Section 4.9**. Changes in surface water flow were evaluated by considering modifications to the contributing drainage basin, surface runoff characteristics and surface water conveyance including sediment control and channel restoration. The restoration of channel geometry, morphology, or location resulting from the destruction and reconstruction of drainage channels and the use of sediment control structures to manage discharge of surface water from the mine areas would not alter surface flows into regional drainages outside of the study area because the surface area covered by impoundments is minor compared to the overall surface area within the Permit boundaries affected by runoff. Any changes within the study area would be short-term and minor under Alternative 1 for the reasons discussed in the following sections.

Surface Water Quality

Eight additional sediment impoundments are planned for construction during the Renewal period, and 51 sediment impoundments would remain permanently after mining and reclamation. The water quality of proposed permanent impoundments would be expected to reflect the quality of runoff from reclaimed areas after reclamation activities have been completed and vegetation restored, which may take upwards of 15 years. OSMRE requires PWCC to monitor water quality in proposed permanent impoundments in order to determine whether the impounded water is suitable on a long-term basis to support livestock grazing and wildlife habitat at final bond release (PWCC 2005b). If the data indicate a proposed permanent impoundment does not meet the performance standards of 30 CFR 816.49(b), or does not meet applicable tribal water quality standards, OSMRE may require PWCC to reclaim the impoundment. Therefore, the impact of the permanent impoundments on surface water quality would be minor because of the need to

meet OSMRE and tribal water quality standards and short-term because OSMRE would require impoundments that do not meet water quality standards to be reclaimed.

The release of constituents to surface water could occur by formation of seeps downstream of existing or recently constructed sediment ponds. If seeps form, some degradation of surface water quality may occur locally within the Permit Area. However, the impact on overall surface water quality likely would not be measurable because the volume of seep water released into the ephemeral streams would be considerably less than storm water runoff and therefore would be expected to be diluted by the storm water runoff volume (PWCC 2005b). Any released seep water also would encounter alkaline soils, causing the pH in the water to rise and any metals present to either precipitate or be absorbed in the soils. At proposed sediment ponds, PWCC would be required to use design and construction methods that minimize seep formation by identifying geochemically inert materials for constructing the embankments, compacting the embankments based on engineering design standards, and siting embankments at locations with low permeability geologic units to the extent practicable. The PWCC NPDES permit requires all discharges from NPDES outfalls, including those associated with the Affected CRAs, to meet effluent limitations and applicable water quality standards for receiving streams. NPDES discharges are typically much less than instream flows. In 2015, pond overflow discharges were generally less than 0.5 acre-feet/day while average stream flow during the rainy season (time of pond overflows) range from 27 to 65 acre-feet/day (PWCC 2015). Seep water quality (**Table 3.7-4**) shows exceedances at some seeps of livestock watering and agricultural irrigation standards for pH, aluminum, nitrate, and occasionally selenium. One seep showed exceedances of TDS and sulfate for aquatic and wildlife standards. These constituents would be expected to be mitigated by alkaline soils and diluted by storm water runoff, leading to stream impacts that would not be measurable outside the Permit Area. Therefore, discharges from existing and new ponds would have negligible impacts to surface water quality.

Surface Water Quantity

Sediment ponds are designed to treat the volume of runoff generated by a 10-year, 24-hour precipitation event. The required capacity of ponds also includes an additional amount of storage volume for handling sediment accumulation. Ponds proposed for construction during the Renewal period that would serve as NPDES outfalls would be subject to the requirements of a modified Seepage Management Plan in the NPDES permit. Of these eight proposed new ponds, ponds J21-L, J21-M, and J21-N in Dinnebito Wash would be added to the list of outfalls in the NPDES permit (PWCC 2016). Future ponds where seeps develop also would be evaluated in accordance with the Seepage Management Plan. The minor short-term and localized impacts of seeps associated with existing sediment ponds and seeps that could occur beneath new sediment structures on surface water quality is not expected to be significant because of the restrictions of the PWCC NPDES permit and the requirements in the Seepage Management Plan. Potential impacts of proposed new and existing ponds on surface water quality therefore would be negligible.

Erosion rates are typically high on areas disturbed by mining and could increase the amount of suspended sediment in storm water runoff. The potential increase in suspended sediment load from the mined areas would be minimized using engineering controls such as sedimentation ponds and/or other sediment control structures. Design and operation of sedimentation ponds

would result in lower sediment loads than are generated by the natural flow regimes of the various washes and channels within and adjacent to the PWCC lease area. Erosion of the sides and channel bottom of washes downstream of sediment ponds would be expected for a short distance as the wash adjusts to lower contributions of sediment from the upstream watershed. Sediment control structures are designed in anticipation of this behavior, and allow the water (using grade-control structures, gabion aprons, and bank stabilizers) to discharge with minimal erosion. In all cases, rates of erosion or deposition of sediment would reach a balance with natural rates in receiving streams over relatively short distances (i.e., several hundred yards), well before the washes exit the PWCC lease area. In addition, performance standards are monitored and corrected by PWCC as they are observed, confirmed by regular OSMRE and tribal inspection, and monitored by BIA to ensure compliance with lease terms and conditions. Therefore, the effects of erosion and sediment loads from control structures under Alternative 1 would be negligible, short-term, and limited to short distances in receiving streams within the Permit Area.

The diversion and reconstruction of natural streamflow would be designed to preserve geomorphic and fluvial stability and prevent uncontrolled erosion or sedimentation. Where this is not possible, engineered durable structures, such as rip-rap grade-control structures, would be designed and constructed in the channel to prevent uncontrolled erosion or sedimentation. Like the pond discharges, these channels and structures are regularly inspected and maintained by PWCC and are routinely inspected by OSMRE and tribal inspectors to ensure the channels and structures are in good condition and operating as designed.

PWCC would ensure, per the approved permit, that any effects of the mine's drainage system on the natural stream patterns in the affected environment would be confined to the Permit Area. Reclaimed watersheds would be constructed using similar ranges of naturally occurring geomorphic features such as drainage density, hillslope lengths and slopes, and channel gradients. These constructed features would be similar to natural variability of the unmined watersheds within and adjacent to the PWCC lease area. The impact of mine operations on the landform geometry, morphology, stream channel systems including drainage patterns, and channel characteristics would be minor and long term.

Within the Permit Area, the use of sediment ponds results in some surface water being lost, either through infiltration into the subsurface, evaporation from the surface of the pond, or use by livestock and wildlife. This loss of potential surface flow represents a potential reduction of surface water quantity a short distance below the Permit Area during the Renewal period, relative to the reaches of the regional drainage system outside of the Permit Area. Decrease of runoff also would occur where existing streams in the Permit Area are diverted from their channels to allow surface mine excavations and reclamation to proceed.

By 2019, drainage control structures in Dinnebito Wash Basin are estimated to impound about 42.3 af of runoff, or about 1.4 percent of the total runoff in the basin; drainage control structures in Moenkopi Wash are estimated to impound about 591.5 af of runoff by 2019, or about 6.9 percent of total runoff in the basin (PWCC 2016). Estimates comparing the change in potential runoff controlled by ponds reflect the potential volumetric loss on downstream water quantities beyond the Permit Area for the Renewal period. These estimates indicate there would be a net reduction of 13.6 af (about 0.14 percent) of runoff contained by ponds within the Moenkopi drainage, and a net increase of 1.8 af of runoff (about 0.06 percent) contained by ponds within

the Dinnebito drainage (PWCC 2016). The estimates within the Moenkopi drainage account for plans to reclaim 21 ponds and construct four new ponds (N9-J, N9-J1, N9-J2, and N9-J3). The Dinnebito drainage estimates account for plans to reclaim one pond and construct four new ponds (J21-L, J21-M, J21-N, and J21-N1). Overall, the impacts to downstream water quantity beyond the Permit Area during the Renewal period would be negligible, resulting in less than a one percent increase in potential runoff loss in the Dinnebito Wash Basin, and less than a one percent decrease in potential runoff loss in the Moenkopi Wash Basin as of December 22, 2019.

After mining, about 4.9 percent of total runoff in the entire Dinnebito basin and 2.8 percent of total runoff in the entire Moenkopi basin would be impounded permanently. The permanent impoundments are estimated to result in a reduction of flow at the lower end of Dinnebito and Moenkopi Washes of about 1.0 and 4.6 percent, respectively, of the average annual runoff (PWCC 2016). The volume of water retained or detained by the permanent impoundments would be a small proportion of average annual runoff in the affected watersheds. Therefore, the effect of permanent impoundments left in the post-mining landscape under Alternative 1 would be negligible.

The analysis described above assumes no transmission loss of flow between the PWCC lease area and the downstream USGS streamflow gage near the village of Moenkopi. Historic measurements indicate that loss through infiltration is very high in Moenkopi Wash, with rates of about one-inch per hour (PWCC 2005b). Using a 644-acre-foot volume (equal to the total impounded volume for 1983 to 1984), the analysis indicated surface flow from the PWCC lease area could travel about 45 miles downstream before it was completely absorbed by the wash bed material. This is short of the 70 miles to the first location of surface water use downstream at the town of Moenkopi, where most irrigation operations are located. This estimate is supported by measurements from a storm event on July 27, 1998, where 206.7 af of water were gauged at the permit boundary with Moenkopi Wash, and only 14 af were measured at the USGS gage near Moenkopi from July 27 to 29, 1998.

Based on these observations and other comparisons of flow records (PWCC 2005b), it appears that about 50 percent of runoff events in excess of 1,000 cfs, and up to 100 percent of smaller runoff events can be lost naturally through infiltration in the wash. The change in streamflow, resulting from the added mine operations, would not be detectable 70 miles downstream. The short-term effects of surface water diversions, impoundments, and sediment ponds on surface water quantity would be minor within the Permit Area and negligible outside of the Permit Area.

4.7.1.2 Impacts on Groundwater

Potential impacts to groundwater would include: 1) impacts to shallow aquifers from locally incepted water perched in the Wepo Formation coal seams; 2) impacts to wells and water supply from pumping of water in the N- and D-Aquifers; and 3) impacts to groundwater quality from potential changes in the infiltration of surface water, or spoils leaching and migration of leached constituents to shallow groundwater aquifers.

Impacts to Shallow Aquifers and Surface Water

Pit Inflows

Wepo well 52 (WEP052) shows a shallowing water level trend since 2010 of 4.7 feet, and declining TDS (288 mg/L in 2015). Flows into the N9 pit have not been observed since 2010, and no pumping of groundwater inflows was needed through 2015. No measurable groundwater inflow is expected in the N9 pit during the Renewal period. Wepo well 69 (WEP069) was installed upgradient of the N9 pit in 2012, and water levels have risen more than four feet since monitoring began (PWCC 2016).

No significant groundwater inflow has been observed in the J19 and J21 pits through 2015. Only minimal and localized inflows were noted in the J19 pit and pumping was not warranted. Annual groundwater inflows to the J19 pit would be expected to range between 0.9 and 2.06 million gallons (2.76 to 6.32 af) between 2015 and 2020. This compares to annual pit inflows from 1994 to 2014 of 1.1 to 3.07 million gallons (3.38 to 9.42 af) (PWCC 2016). Similar to the J19 pit, only minimal inflows were noted in the J21 pit over a period of 20 years and flow into the J21 pit during the permit period would be expected to be similar. Potential impacts to mine pit inflows and water quality are expected to be similar or less than present and thus constitute a negligible impact.

Shallow Groundwater Resources

In the event springs or other water sources are mined out in the Affected CRAs during the Renewal period, PWCC would be required to provide alternative water supplies to replace the lost water source. Upon completion of backfilling, regrading, topsoiling, and revegetation, the replaced spoil in areas that were previously saturated could resaturate and create a localized change in the potentiometric surface within the Wepo Formation adjacent to the reclaimed mine pit. Based on estimates of the pre-mining hydraulic properties of the Wepo Formation, porosities and hydraulic conductivities within the regraded spoils would be higher, and recharge capacities should be similar or somewhat greater than pre-mining capacities. However, this does not mean that water levels in the Wepo Formation would return to original levels. It is likely that there would be some minimal impact on local groundwater levels in the Wepo Formation and adjacent alluvial aquifers during mining. After reclamation is complete, the hydrologic balance within the shallow aquifers would approach a new equilibrium. Therefore, changes in Wepo water levels due to intercepting Wepo Formation water would be long-term but limited to the local vicinity of the mine pit, resulting in minor impacts on the use of the shallow groundwater system within the Permit Area. Potential impacts to shallow aquifer water levels and water quantity would be expected to be minor but long-term and limited to the Permit Area.

Recharge to Shallow Aquifers

Surface water flow events recharge the alluvial aquifers associated with the stream channels. Reduced flows in washes could decrease the amount of recharge; however, the impoundment of runoff water and subsequent seepage of sediment pond water into the banks and substrate of the ponds could locally enhance recharge. The primary effect is likely to be a local redistribution of where recharge occurs, and the length of time the effect would occur depending on whether sediment ponds are temporary or permanent. It is expected that any reduction in recharge would

be immeasurable and there would be negligible impact on the quantity of recharge to the alluvial aquifers from mining activity.

Shallow Groundwater Quality

Acid reactions in the spoil water could occur, but are unlikely to be widespread. There are sufficient carbonate minerals in the overburden materials to neutralize most acidic water that could be produced by the oxidation of sulfides. All but one of the overburden core samples taken on the PWCC lease area and Permit Area had excess neutralization potential (PWCC 2005b). These cores also indicate that there are no high concentrations of metals in the overburden. The alkalinity imparted by the dissolution of carbonate minerals slows the dissolution of sulfide minerals, preventing the release of metals. If acidic water is produced and encounters the alkaline overburden, the pH would rise and metals that are present would tend to precipitate in or absorb into the soils. This evaluation is supported by the analysis of groundwater in the Wepo and alluvial aquifer monitoring wells. Water from these wells is near neutral in pH, and concentrations of metals in groundwater at these wells generally do not exceed livestock watering standards (PWCC 2005b).

Although there are specific procedures to minimize and mitigate acid-forming materials, the presence of carbonate minerals in the Wepo Formation overburden and interburden is sufficient to neutralize any acidic waters formed, but some local pockets of acidic water could form. Areas where this occurs could result in the release of trace elements present in the sulfide minerals. These chemical reactions could result in some minor to moderate water-quality impacts on local wells, increasing TDS and trace element concentrations in groundwater to a level that decreases their usability. However, the impact of acidic drainage on groundwater quality likely would not be widespread, and contained to the mine pit and adjacent area, and would not migrate outside the Permit Area. The overall potential effects from acid-forming materials on groundwater would be expected to be minor and limited to the Permit Area.

Surface mining activities could degrade shallow groundwater quality if surface water infiltrates into the subsurface. Controlled surface water would infiltrate to the shallow subsurface in impoundments, sediment ponds, or diversions potentially increasing the concentrations of some soluble ions (calcium, magnesium, sodium, sulfate, and bicarbonate) and TDS. The potential for formation of acidic seepage and trace metal migration is minimal because of the high carbonate content of the soils. The magnitude of the impact on groundwater quality would be limited to the immediate pond and pit areas due to low transmissivity and groundwater gradients in the shallow aquifers (PWCC 2005b). The potential effects to groundwater would be expected to be minor, limited to the Permit Area, and potentially long-term.

Surface Water Quality

Similarly, spoil water also could discharge to the surface water as springs or seeps. Some degradation of surface water quality could result, particularly near the springs. As noted above, discharges from springs with low pH water could be neutralized by the alkaline soils. Since streams are ephemeral and generally flow only after precipitation events, the much larger stream flows tend to dilute poor-quality spring or seep water discharges. Streamflow events are generally not suitable for use by livestock because of the high sediment load, high velocities, and short durations, resulting in little potential for livestock to be exposed to poor-quality spoil water that could be released into the stream. The potential effects on the overall surface-water quality

would be expected to be minor, limited to the Permit Area, and relatively short-lived because of dilution by runoff water.

Indirect Effects on Groundwater Quality; Coal Combustion Impacts

Kayenta Mine coal combusted at the NGS generates CCRs that are disposed of in a regulated landfill at the NGS. The disposal of CCRs at the NGS is regulated under Subtitle D of RCRA. The NGS is required to retain stormwater runoff, control dust, and monitor groundwater at the site, and must demonstrate to the public through posting of inspections by qualified professional engineers that the regulatory requirements are being adhered to. A deep well groundwater monitoring system is currently 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. Annual groundwater monitoring and triggers for corrective actions will be developed and implemented per the schedule and requirements set out in the CCR rule. Due to these protections, the impacts to groundwater quality related to the disposal of CCRs at the NGS under Alternative 1would be expected to be minor and localized and remediated if required.

Impacts on Water Supply

Unconsolidated aquifer systems have the potential for subsidence due to compression of fine-grained layers during groundwater withdrawal. In addition, the removal of cavity-filling material and dissolution of limestone in some limestone aquifers can foster sinkhole development. These effects are not a concern in this evaluation, because the primary water-bearing units of the N- and D-Aquifers are not composed of unconsolidated sediments or limestone that would be subject to subsidence effects.

There is a potential for the local water supply to be affected by continued pumping of water from the N- and D-Aquifers during the Renewal period. The impact of groundwater withdrawal is commonly assessed by a measured or projected lowering of the water levels in the pumping wells and in wells located within the cone of depression created by the pumping well(s). Effects from lowering the water level in the N- and D-Aquifers were evaluated for potential increases in the cost of pumping by private wells to access groundwater, reduction in the saturated thickness or transmissivity in unconfined or confined aquifers, changes in stream base flow or spring flow, and the flow of groundwater towards the well field.

The potential impact of continued pumping of groundwater from the N- and D-Aquifers by the mine during the Renewal period was evaluated by simulating future water level changes in both aquifers within and adjacent to the Permit Area for the Renewal period and beyond for 13 years through the reclamation period (Tetra Tech 2016). The assessment developed by Tetra Tech (2016) was based on the groundwater modeling developed in 2010 to evaluate the effects of mining use on groundwater levels through 2025 and then beyond for the reclamation period that would end in 2038. This groundwater model was used in the 2011 EA for the Kayenta Mine Permit Renewal (2010 – 2015) (OSMRE 2011b).

The current assessment of groundwater level impacts due to water use by the Kayenta Mine during the Renewal period addresses the effects of pumping substantially less groundwater than was assumed in the 2010 modeling for the 2011 EA. The present assessment uses the same groundwater model employed for the 2010 modeling (Tetra Tech 2016). The 2010 groundwater

model used a three-dimensional numerical model for the N- and D-Aquifers developed by PWCC (1999) for the Black Mesa Basin. This model was calibrated through 1996 and then validated using 2009 data before use in the 2011 EA. Details of the model validation are presented in Tetra Tech (2016).

2011 EA Model Simulation Results

The groundwater model simulations used to assess impacts to water supply in the 2011 EA assumed more groundwater use (pumping) by the mine than will be used in the 2015 through 2020 Renewal period. These modeling scenarios thus present a conservative estimate of the potential impact of groundwater use by the mine during the Renewal period. For this reason, these modeling results will be summarized in this section and then a comparison of groundwater use between the 2011 EA and this EA will be presented to discuss the expected reduction in impacts due to less water use from 2015 to 2020 than was assumed in the 2011 EA.

For the 2011 EA, the modeled water use by the mine from 2010 through 2025 was 1,236 af/yr. From 2026 to 2028, the water used was reduced to 505 af/yr due to commencement of reclamation and from 2029 to 2038 the water use was 444 af/yr. Simulated water level impacts for pumping by PWCC and municipal pumping for the time period from 2010 to 2038 are presented in **Appendix F**, Figure 7 for 2015, **Appendix F**, Figure 8 for 2025, and **Appendix F**, Figure 9 for 2038. All predicted water level changes are relative to water levels in 2010 (Tetra Tech 2016).

For 2015 (**Appendix F**, Figure 7), the simulated water levels for PWCC and community pumping combined show groundwater level recovery near the PWCC lease area would be around 20 feet compared to 2010 due to a reduction in water used compared to previous years. Community pumping near Tuba City and Second Mesa shows drawdown of up to 10 feet in the N-Aquifer. For PWCC pumping only for 2015, there would be no significant drawdown near the community areas. For 2025 (**Appendix F**, Figure 8), groundwater recovery in the PWCC lease area would be around 30 feet compared to 2010 and drawdown in the areas of community pumping would be up to 30 feet in the Second Mesa-Hotevilla area due to continued use of water by the communities. By 2038 (**Appendix F**, Figure 9), groundwater recovery in the PWCC lease area would be 50 feet or more, while drawdown in the areas of community pumping in the southeastern part of the Black Mesa would be in the range of 10 to 50 feet.

The modeled impact of groundwater pumping in the N- and D-Aquifers on groundwater discharge to streams is summarized in **Table 4.7-1**. The streams most impacted by all groundwater pumping would be Laguna Creek, Pasture Canyon, Jeddito Wash, Polacca Wash, Moenkopi Wash, and Begashibito Wash. PWCC pumping would have less than 0.1 percent total impact on all washes in 2015, except for Begashibito Wash, where the PWCC pumping would account for the majority (89 percent) of the reduction of 3.8 af/yr in groundwater discharge to the wash. In 2025 and 2038, the same drainages would be affected by a reduction in groundwater discharge, with Begashibito Wash showing the greatest reduction in discharge and PWCC accounting for 87 percent of the 12.1 af/yr reduction in 2025 and 82 percent of the 23.1 af/yr reduction in 2038. The reduction in discharge to Begashibito Wash is around one percent of the total flow in the wash.

Table 4.7-1 Predicted Decrease in Wash Discharge, Black Mesa Complex

Pumping	2010 (af/yr)		2015 (af/yr)		Change Due to Pumping (af/yr)			Percent Total	Percent Total
	All	Non-PWCC	All	Non-PWCC	All	Non-PWCC	PWCC	All	PWCC
2015									
Chinle Wash	498.8	498.8	498.8	498.8	0.0	0.0	0.0	0.00	0.00
Laguna Creek	2,440.6	2,450.6	2,418.3	2,427.8	22.2	22.9	-0.6	0.91	-0.03
Pasture Canyon	377.6	377.6	363.1	363.1	14.5	14.5	0.0	3.84	0.000
Moenkopi Wash	4,279.6	4,302.1	4,277.0	4,301.4	2.7	0.7	1.9	0.06	0.05
Dinnebito Wash	514.8	515.3	514.6	515.2	0.2	0.1	0.1	0.04	0.02
Oraibi Wash	455.4	456.0	454.4	455.2	1.0	0.8	0.2	0.21	0.04
Polacca Wash	429.8	431.0	427.3	428.9	2.4	2.2	0.3	0.57	0.06
Jeddito Wash	2,011.4	2,015.6	2,007.3	2,012.9	4.1	2.7	1.4	0.20	0.07
Begashibito Wash	2,166.0	2,177.0	2,162.2	2,176.6	3.8	0.4	3.4	0.18	0.16
Pumping	**2010 (af/yr)**		**2025 (af/yr)**		**Change Due to Pumping (af/yr)**			**Percent Total**	**Percent Total**
	All	**Non-PWCC**	**All**	**Non-PWCC**	**All**	**Non-PWCC**	**PWCC**	**All**	**PWCC**
2025									
Chinle Wash	498.8	498.8	498.8	498.8	0.0	0.0	0.0	0.01	0.00
Laguna Creek	2,440.6	2,450.6	2,385.8	2,395.1	54.8	55.5	-0.8	2.24	-0.03
Pasture Canyon	377.6	377.6	332.8	332.8	44.8	44.8	0.0	11.86	0.000
Moenkopi Wash	4,279.6	4,302.1	4,274.9	4,299.6	4.7	2.4	2.3	0.11	0.05
Dinnebito Wash	514.8	515.3	514.2	515.0	0.6	0.3	0.3	0.13	0.07
Oraibi Wash	455.4	456.0	452.6	453.9	2.7	2.1	0.6	0.60	0.14
Polacca Wash	429.8	431.0	422.9	424.8	6.9	6.2	0.7	1.60	0.15
Jeddito Wash	2,011.4	2,015.6	1,990.0	2,007.4	12.4	8.2	4.2	0.62	0.21
Begashibito Wash	2,166.0	2,177.0	2,153.9	2,175.4	12.1	1.6	10.5	0.56	0.49
Pumping	**2010 (af/yr)**		**2038 (af/yr)**		**Change Due to Pumping (af/yr)**			**Percent Total**	**Percent Total**
	All	**Non-PWCC**	**All**	**Non-PWCC**	**All**	**Non-PWCC**	**PWCC**	**All**	**PWCC**
2038									
Chinle Wash	498.8	498.8	498.7	498.7	0.1	0.1	0.0	0.02	0.00
Laguna Creek	2,440.6	2,450.6	2,336.7	2,347.6	103.8	103.1	0.8	4.26	0.03
Pasture Canyon	377.6	377.6	294.4	294.4	83.2	83.2	0.0	22.02	0.000
Moenkopi Wash	4,279.6	4,302.1	4,273.0	4,296.8	6.6	5.2	1.4	0.16	0.03
Dinnebito Wash	514.8	515.3	513.6	514.6	1.2	0.7	0.6	0.24	0.11
Oraibi Wash	455.4	456.0	450.1	451.6	5.3	4.4	1.0	1.17	0.21
Polacca Wash	429.8	431.0	418.0	419.4	11.7	11.6	0.1	2.73	0.03
Jeddito Wash	2,011.4	2,015.6	1,987.1	1,998.0	24.3	17.6	6.6	1.21	0.33
Begashibito Wash	2,166.0	2,177.0	2,142.9	2,172.9	23.1	4.1	19.0	1.07	0.88

Source: Tetra Tech 2016

Comparison of 2011 EA and 2016 EA Pumping Scenarios

Table 4.7-2 and **Appendix F**, Figure 10 compares the groundwater pumping by PWCC for the 2011 EA with the estimated groundwater use for the Renewal period used in this EA. **Appendix F**, Figure 10 displays this difference graphically.

Table 4.7-2 Groundwater Pumping Comparison

Period	Pumping Schedule 2011 EA	Pumping Schedule 2016 EA
2015 through 2019	1236 af/yr	1200 af/yr
2020 through 2022	1236 af/yr	500 af/yr
2023 through 2025	1236 af/yr	100 af/yr
2025 through 2028	505 af/yr	100 af/yr
2028 through 2038	444 af/yr	100 af/yr

Water Level Impacts

The amount of groundwater pumping by PWCC expected for the Renewal period is similar to that used in the 2011 EA for the same time period. As shown in **Appendix F**, Figure 10, the amount of pumping expected early in the 2015 to 2020 Renewal period would be lower under this EA than that which was modeled under the 2011 EA, and would decline quickly and would be slightly less than the pumping rate used in the 2011 EA for the remainder of the Renewal period. Thus, water level recovery between the end of 2010 and the end of 2015 in the Permit Area should be comparable to that modeled in the 2011 EA and shown in **Appendix F**, Figure 7. Drawdown in the community pumping areas may be the same, or slightly less than shown in **Appendix F**, Figure 7 due to slightly more groundwater recovery in the Permit Area and possibly less community water use than was modeled in the 2011 EA (Tetra Tech 2016).

The significant difference between modeled groundwater use in the 2011 EA and the expected groundwater use in this EA is for the time period from 2020 to 2032, the period of mine cessation and reclamation. As shown in **Appendix F**, Figure 10, expected groundwater pumping by PWCC from 2020 to 2032 would be significantly lower than that modeled in the 2011 EA for the same time period. This would allow for more rapid groundwater recovery in the Permit Area than was modeled in the 2011 EA (**Appendix F**, Figures 8 and 9), so that expected groundwater recovery values for the Permit Area should be greater under this Renewal than were shown for the 2011 EA. Community groundwater use may be the same or slightly less than modeled for the 2011 EA, so that drawdown in the community areas may be less than shown in **Appendix F**, Figure 8, and Figure 9. Also, more rapid recovery of groundwater in the Permit Area than simulated for the 2011 EA would serve to reduce the drawdown in the community pumping areas on a temporary basis. Eventually, after recovery in the Permit Area is mostly complete, community pumping would result in increasing drawdown in the areas affected by community pumping.

Surface Water Flow Impacts

Reduced groundwater use by PWCC from 2020 to 2032 under the current pumping scenarios compared to groundwater pumping modeled in the 2011 EA would result in less reduction of groundwater discharge to streams (**Table 4.7.1**). Begashibito Wash would continue to show the most impact from groundwater pumping, but the reduction in total flow would be less than one percent. Because of the distance to the areas of groundwater discharge to streams from the

Permit Area and because many of the streams are in the unconfined part of the N-Aquifer, it is expected that it would take decades before the reduction in groundwater discharge to streams is apparent under the Renewal (Tetra Tech 2016).

Effects of D-Aquifer Leakage on N-Aquifer Water Quality

Reduced groundwater use and thus reduced pumping of the N-Aquifer in the current Renewal pumping scenarios would result in less drawdown in the N-Aquifer than simulated for the 2011 EA, and thus less impact on water quality in the N-Aquifer from leakage from the D-Aquifer through the Carmel Formation (Tetra Tech 2016). Also, NAV well screen intervals are cased off from the D-Aquifer, thus further limiting any interaction between the two aquifers. Active NAV wells are sampled annually and idled NAV wells are sampled for water quality degradation from the D-Aquifer every five years. This impact on the quality of the N aquifer from D aquifer leakage would be negligible to minor.

Overall, impacts of pumping on the N-Aquifer would be expected to be moderate and beneficial under Alternative 1 due to the recovery of groundwater levels resulting from less pumping during the Renewal period. In areas distant from the Permit Area, drawdown would continue to increase, but at a slower rate than modeled for the 2011 EA. Eventually, drawdown would cease and recovery of groundwater levels would begin in the more distant areas. Impacts of pumping on groundwater discharge to streams would be negligible. Changes in the total sulfate concentration in the N-Aquifer due to pumping of the aquifer by PWCC and the potential the pumping creates for increased flow between the N- and D-Aquifers through the Carmel Formation were minimal, with N-Aquifer wells showing less than 0.5 percent change in sulfate concentration (Tetra Tech 2016).

4.7.1.3 Material Damage Considerations

OSMRE evaluates the potential for material damage due to proposed mining activities and sets material damage criterion when necessary (OSMRE 2011b). This section summarizes the potential for material damage to water resources developed in the 2011 Cumulative Hydrologic Impact Assessment (CHIA) (OSMRE 2011a) (**Appendix D**) and presented in OSMRE's 2011 EA (OSMRE 2011b). OSMRE revised the 2011 CHIA in 2016, but that revised CHIA applies to the proposed 25-year operations extension of the NGS-KMC post-December 22, 2019 (analysis of this proposal currently suspended), a separate action not related to this EA.

Surface Water Quantity Material Damage

The surface water quantity monitoring program and the PAP have provided sufficient information for assessing surface water quantity impacts on existing and foreseeable agricultural irrigation, livestock, and aquatic and wildlife habitat water uses. OSMRE has determined that the operation has been designed to minimize surface water quantity impacts within the Permit Area and prevent material damage outside the Permit Area and adjacent areas by limiting the surface area impacted by surface water impoundments (OSMRE 2011b). The 2011 EA, identifies a level of moderate impact if the watershed area controlled by impoundments is between 30 to 50 percent of the total drainage area, and major impacts if the area impacted by impoundments is greater than 50 percent (OSMRE 2011b). OSMRE (OSMRE 2011b) defines the surface water quantity material damage at 50 percent of Moenkopi or Dinnebito cumulative impact area (CIA) managed by impoundments (OSMRE 2011b). Mine operations will be regulated to ensure impacts are

minimized and this level of material damage is not reached. The watershed area in the Moenkopi and Dinnebito CIAs impacted by impoundments is below 30 percent. Therefore, there is no material damage to surface water quantity.

Surface Water Quality Material Damage

PWCC's hydrologic balance protection plan includes an approach to handle earth materials and surface water runoff in a manner that minimizes the formation of acidic or toxic drainage, and prevents additional contributions of suspended solids and other water pollutants from entering streamflow outside the permit area to the extent possible. As such, all areas disturbed by the mining operation drain to a series of sediment settling and containment ponds or dams that are designed to contain at least the 10-year, 24-hour runoff event plus an additional amount of sediment storage. Infrequent pond discharges from flow events exceeding the pond capacity are monitored for effluent compliance concentrations and reported in accordance with the requirements of NPDES permit number NN0022179.

The surface water monitoring program has provided sufficient information for OSMRE to make the impact assessment. After assessing the potential surface water quality impact of the mining operation on existing and foreseeable uses of Secondary Human Contact, Partial Body Contact, Agricultural Livestock Watering, Agricultural Water Supply, Aquatic and Wildlife Habitat (acute and chronic), and Fish Consumption water uses, OSMRE has determined that the operation has been designed to minimize surface water quality impacts within the Permit Area and prevent material damage outside the Permit Area and adjacent areas (OSMRE 2011b). Therefore, there is no material damage to surface water quality within or adjacent to the Permit Area.

Alluvial Quantity Material Damage

The available quantity of alluvial water stored in the alluvial aquifer system varies depending on location within the alluvial channel and the quantity of water infiltrated in response to storm flow events. Additionally, developing alluvial water for agricultural livestock use is maintenance intensive due to the sediment transported during storm flow events. Although the reliability of using the alluvial system for agricultural livestock water supply development is low and maintenance prohibitive, surface water impoundment structures from the mining operations locally enhance alluvial water quantity, and the operations will not compromise foreseeable use of alluvial water quantity. Therefore, OSMRE has not established a material damage criterion related to alluvial water quantity, but has required continued alluvial water quantity monitoring (OSMRE 2011b).

Alluvial Quality Material Damage

Evaluation of alluvial water quality indicates that the quality is subject to seasonal variability and a large amount of variability from location to location. Agricultural livestock watering use was considered for material damage evaluation; however, historical alluvial use locations within the alluvial CHIA CIA have all been abandoned and no attempts to develop alluvial water have been initiated over the past 40 years within the CIA. Accessibility to potable public water standpipes and retention of surface water impoundments for livestock watering make development of the saturated alluvium for livestock watering a challenging and maintenance-intensive alternative. Comparison of upstream water quality with downstream water quality related to water quality

standards (WQS) and major cations and anions, indicates that the mining operations are not compromising the agricultural livestock supply water outside the Permit Area. Alluvial water quality will continue to be monitored and evaluated against available livestock water quality standards. Similar to the surface water quality assessment protocol, if monitoring demonstrates that WQS have been exceeded, OSMRE will evaluate if the exceedances are the result of a mining related impact and take appropriate action to correct the exceedances (OSMRE 2011b).

Wepo Formation Quantity Material Damage

OSMRE has determined that the mining operations at the Kayenta Mine will not adversely impact existing or potential users of the Wepo Formation water outside the Permit Area due to the areal discontinuity of the saturated Wepo Formation (OSMRE 2011b). Additionally, eight Wepo springs are monitored within the Kayenta Mine Permit Area and adjacent areas. OSMRE has determined that the existing Wepo monitoring program is in compliance with 30 CFR 816.41, and that PWCC shall continue the existing monitoring program for Wepo wells and Wepo springs (OSMRE 2011b). If the mining operation results in sustained spring flow depletion at these eight springs or well yield depletion at the eight wells, PWCC shall mitigate as required in 30 CFR 780.21. Therefore, OSMRE has not established a material damage criterion specific to protection of Wepo water (OSMRE 2011b).

Wepo Formation Quality Material Damage

The impact of mining at the Kayenta Mine on Wepo Formation water quality outside of the Permit Area has been negligible with respect to livestock uses (OSMRE 2011b) Historically, there has been only isolated use of water from the Wepo Formation for livestock, and generally the water quality prevents the Wepo Formation from being a widespread water source within the Permit Area and adjacent areas. Although spoil water could conceivably migrate into the Wepo Formation along the periphery of backfilled mine pits, the hydraulic gradient is toward the spoil from the Wepo Formation. Combined with the low hydraulic conductivity and the discontinuous nature of Wepo Formation, there is no indication that water from the spoil is migrating or would migrate to any great extent into the Wepo Formation. Spoil water quality for major cations, anions, and TDS are elevated compared to background concentrations; however, the potential for degraded water quality migration outside the mine pit area is limited. If water quality migration outside the mine pit area occurred, the alluvial water quality monitoring program in the receiving alluvial channels will identify the migration of associated impacts. Therefore, OSMRE has not established a material damage criterion specific to mining impacts on Wepo Formation water quality. OSMRE regularly evaluates monitoring data to ensure impacts to the Wepo Aquifer are minimized to the mine pit areas (OSMRE 2011b).

D-Aquifer Quantity Material Damage

The simulated water level at windmill well 4T-402 would decrease by approximately 10 percent. Although an obstruction in the well prohibits water level confirmation, the operation of the windmill has not been compromised during the 40-plus year operation of the PWCC wellfield. Although a 10 percent reduction in water level elevation was simulated at location 4T-402, no additional operation cost has occurred since the location is wind powered. If the water availability is compromised, PWCC is responsible for water replacement in accordance with 30 CFR 816.41(h). Therefore, OSMRE has not established a material damage criterion for the

D-Aquifer quantity due to the absence of potential impact on domestic supply water, livestock supply water, or agricultural supply water (OSMRE 2011b).

D-Aquifer Quality Material Damage

The overall D-Aquifer system water quality is poor compared to the N-Aquifer system. The natural hydrologic impact potential is for poorer quality D-Aquifer water to migrate downward to the N-Aquifer system (Truini and Longsworth 2003). Therefore, since no hydrologic mechanism is present for PWCC operations to impact D-Aquifer quality, OSMRE has not established a material damage monitoring criteria (OSMRE 2011b).

N-Aquifer Quantity Material Damage

PWCC pumping of the confined N-Aquifer system has reduced the water pressure within the N-Aquifer system. The reduction in water pressure does not limit the ability of the communities to utilize the N-Aquifer water resource for existing and foreseeable domestic water supply. However, a regional N-Aquifer monitoring network with reliance on the BM-wells, and local water level monitoring at the PWCC wellfield continue to verify impact predictions in the PWCC groundwater model, and validate simulated predictions against measured data. OSMRE has protected the N-Aquifer water resource by establishing a material damage limit of greater than 50 percent increase in pumping costs (OSMRE 2011b). Additionally, N-Aquifer baseflow was assessed with the calibrated and validated PWCC groundwater model. OSMRE has protected the N-Aquifer baseflow by establishing a material damage limit of greater than 30 percent reduction in simulated baseflow (OSMRE 2011b).

OSMRE has found that PWCC has adequately demonstrated the lack of measurable impact to N-Aquifer spring flow for the N-Aquifer springs of concern attributed to PWCC pumping. One low-flow spring, Burro Spring, exists at the confined/unconfined boundary, and will continue to be monitored. Therefore, OSMRE has not established a material damage criterion for potential impacts to the reduction of N-Aquifer spring discharge. Regional N-Aquifer monitoring with reliance on the BM-wells, and a local water level monitoring at the PWCC wellfield will continue to be evaluated to verify impact predictions in the PWCC groundwater model (OSMRE 2011b).

N-Aquifer Quality Material Damage

OSMRE will assess N-Aquifer water quality impacts based on water quality at the PWCC wellfield, since the highest N-Aquifer water quality impact potential is in the vicinity of the wellfield based on drawdown. OSMRE will continue to evaluate TDS, chloride, and sulfate water quality concentrations against the standards for domestic water supply. A level of material damage will be considered when a PWCC NAV well no longer meets the TDS, chloride, and sulfate domestic water supply use standards (OSMRE 2011b). Based on the 2011 CHIA (**Appendix D)**, PWCC pumping of the N-Aquifer had not caused material damage to the quality of N-Aquifer water. PWCC mining rates and water usage would be similar to those in 2011 during the Renewal period. PWCC's operation of the Kayenta Mine has been designed to prevent material damage to the quality of the N-Aquifer water. Water quality of the PWCC wellfield will continue to be assessed on a quarterly basis by OSMRE to ensure that the N-Aquifer continues to meet applicable water quality standards (OSMRE 2011a, 2011b).

4.7.2 Alternative 2: No Action

4.7.2.1 Impacts on Surface Water

Under Alternative 2, surface water runoff controls (i.e., sedimentation ponds) existing as of OSMRE's decision to deny the permit Renewal, would remain in place until reclamation activities are completed and vegetation becomes established. No additional ponds would be built. Similar to Alternative 1, PWCC would remove 32 ponds but on a more accelerated schedule. During the 13-year reclamation period, PWCC would continue to operate under the terms and conditions of the NPDES permit, including compliance with the Seepage Management Plan and request modifications of the permit to allow removal of eligible temporary ponds under Western Alkaline Coal Mining regulations (40 CFR 434). The impacts on local washes and channels from the sediment ponds or any existing seeps would be negligible to minor.

Potential impacts to streamflow after reclamation would be reduced as a result of reclaiming all temporary sediment ponds within the 3-year reclamation period. Two proposed permanent sediment ponds would not be built and left in the post-mining landscape, reducing the overall effects on surface water quantity or quality within the Permit Area, lease area, or within the entire basins of both Moenkopi and Dinnebito Washes.

These changes to surface water quantity or quality would be negligible to minor.

4.7.2.2 Impacts on Groundwater

Groundwater quantity and quality impacts to the shallow aquifers as a result of mining at the Kayenta Mine to date have been negligible. Since mining would cease in the Affected CRAs, and backfilling and grading would occur within the next several years, the potential for additional impacts on groundwater to occur would be further reduced. 30 CFR 780.21 requires PWCC to develop a hydrologic reclamation plan that will ensure the relevant requirements for protecting the hydrologic balance will be met. The PAP summarizes all methods and plans PWCC would use during mining and reclamation for the five-year Renewal term, and through bond release to minimize disturbances to the hydrologic balance as required and specifically listed at 30 CFR 816.41 through 816.43. The potential impacts on groundwater would be negligible to minor, and could be less than described under Alternative 1.

Impacts on Water Supply

Withdrawals from the N-Aquifer would be reduced from an average rate of 1,200 af/yr to about 500 af/yr to support reclamation activities for a three-year period, and further reduced to 100 af/yr for a 10-year period thereafter. Reclamation would begin about three years sooner under Alternative 2 than under Alternative 1. The reduced pumping rate would allow recovery of water levels more quickly in the vicinity of the PWCC well field, and further reduce PWCC's contributions to drawdowns that would continue to occur as a result of community pumping. These predicted regional-scale reductions in stream base flows, which are too small to be measured, would be even less. The potential for leakage from the D-Aquifer into the N-Aquifer has been estimated to be negligible for the Renewal period, and would be even lower than those described under Alternative 1 as the pumping rate would be appreciably reduced to 500 af/yr for three years, and further reduced to 100 af/yr for a 10-year reclamation period beginning about three years earlier than under Alternative 1. In addition, reclamation of wells NAV 5 in 2015 and

NAV 4 in 2016, and the cementing off of screened casing adjacent to the Entrada Formation in NAV 7 in 2016 further reduced the potential for D-Aquifer water entering the N-Aquifer.

4.8 VEGETATION

4.8.1 Alternative 1: Renewal of Permit AZ-0001E

Developing the N-9, J-19, and J-21 CRAs under Alternative 1 would have the direct impact of removing 842 acres (approximately 0.1 percent or less) of the existing piñon/juniper woodland, saltbush and greasewood, and sagebrush shrubland vegetation types in the Lease Area (**Section 3.8**). However, reclamation would replace the areas mined under Alternative 1 with an all-purpose rangeland composed primarily of native species. The reclamation vegetation would be dominated by grasses and shrubs and scattered groupings of trees and cultural plants. Long term, this would increase the amount of reclaimed vegetation in the study area by about six percent. No mixed conifer or tamarisk riparian shrubland would be removed under Alternative 1. The effect of converting the existing vegetation communities to the reclaimed vegetation community is long-term but negligible because the mined and reclaimed areas would affect less than one percent of the total available acres of plant communities in the study area. Also, reclaimed sites would transition to a stable vegetation community, and the use of native species could provide additional seed sources of native populations of these species in adjacent areas (Peters et al. 2006, Schuman 2002).

Existing plans for reclamation in Permit AZ-0001E that would reduce mining-related surface disturbance to vegetation include establishment of grasses, forbs, and shrubs. Plant species used for revegetation would be mostly native, but some non-native grasses and forbs would be used to aid in the post-mine land uses. On reclamation areas, four feet of soil and suitable plant growth media would be placed. These areas would be seeded with approved seed mixtures that are stipulated to be free of noxious weeds. Seeded areas would be mulched with native grass hay. Habitat islands for wildlife and cultural plants would be established in the reclamation areas in which small, periodic clusters of exposed rock are installed, and clusters of piñon, juniper, forbs, and shrubs are planted. Shrubs and woodland vegetation also would be established around ponds, drainage bottoms, and hill slopes. Reclaimed sites would be monitored twice a year for 10 years to evaluate the adequacy of revegetation and the presence of weed species. As under existing Permit AZ-0001E, revegetation success standards identified in the PAP (Table 8, Chapter 23, Volume 11) would be used to determine the adequacy of revegetation prior to bond release; these success standards would allow the post-mining land uses of grazing, wildlife habitat, and cultural plant use. Prescriptions for reseeding, grazing management, or weed control would be made based on the results of statistical sampling or monitoring observations in reclaimed areas.

Cultural plant sites (i.e., plants important to American Indian cultural traditions) would be established on select sites within reclamation areas. These would be developed in areas with a mesic aspect and on coarse-textured skeletal soils and rocky substrates similar to native areas supporting piñon-juniper woodland and historic cultural collection sites. These sites, combined with native shrubland and piñon-juniper planting areas, would comprise approximately five percent of reclaimed lands.

Disturbed and reclaimed areas would be susceptible to invasion by noxious weeds and other invasive plant species, which would be a short-term impact. Livestock grazing and reclamation activities to regrade, spread topsoil, and reseed areas disturbed by mining activities could increase the potential for establishment of noxious weeds and invasive plants (Bryson and Carter 2004, Pyke 1999). Most of the weeds that are present in the Permit Area are annual weeds, which compete poorly with established reclamation vegetation. Within the Permit Area, seed and mulch are specified to be free of noxious weeds. PWCC routinely controls diffuse knapweed by applying herbicides along roadsides. Prescriptions for reseeding, grazing, mowing, or chemical control are made based on the results from statistical sampling of plots in reclaimed areas. Additionally, PWCC maintains a twice per year vegetation monitoring and weed program for 10 years after reseeding areas. This program identifies the measures to control noxious weeds that could establish in the Permit Area. With ongoing reclamation and mitigation efforts, potential establishment of invasive plant species or noxious weeds would be temporary and highly localized. Therefore, this impact would be minor.

Settling ponds, impoundments, and other erosion control measures would prevent sediment loads in disturbed area runoff from adding to the naturally occurring sediment loads that could be deposited along areas of riparian vegetation within or downstream of the Dinnebito, Moenkopi Wash, and Coal Mine Wash drainages. Impoundments developed in association with the Affected CRAs and reclamation sites could augment the small number of riparian areas present at impoundments in previously mined areas in the Permit Area. The impacts to riparian vegetation from the various water impoundments would be negligible.

According to an ERA that included the Renewal (Ramboll Environ 2016a,b), there is a negligible risk of mining operations emissions and deposition affecting vegetation in the direct effects study area; therefore, there would be negligible direct effects related to mine emissions and deposition to vegetation within the direct effects study area. According to an ERA that evaluated the operation of the NGS over 25 years (Ramboll Environ 2016a,b), there is a negligible risk of NGS operations emissions and deposition affecting vegetation in the indirect effects study area; therefore, there would be negligible indirect effects related to NGS emissions and deposition to vegetation within the indirect effects study area.

Water withdrawals for mining activities are not likely to affect riparian vegetation in areas downstream as groundwater and surface water quantity and quality would not change under Alternative 1. Monitoring of the N-Aquifer during withdrawal has not shown impacts on surface water that would affect riparian vegetation downstream of the Permit Area. The results of modeling water withdrawal from the N-Aquifer under Alternative 1 indicate minimal effects on streamflow outside of the Permit Area (**Section 4.7**). Accordingly, the indirect impacts to riparian vegetation from water withdrawal from the N-Aquifer for mining activities would be negligible.

4.8.1.1 Special Status Plants

Brady Pincushion Cactus

Known records for Brady pincushion cactus are restricted to specific geology on the rims of Marble Canyon. Alternative 1-related impacts in this area are limited to those resulting from emission effects and not surface disturbance. Impacts to the Brady pincushion cactus resulting from emissions under Alternative 1 were analyzed in the NGS Near-field ERA (Ramboll Environ

2016a). The results of the ERA indicated that the Renewal would result in HQs of 0.05 for exposure to maximum COPCs concentrations; which indicates a potential but negligible ecological risk to the species.

Fiskeisen Plains Cactus

Impacts to the species under Alternative 1 may include emissions and deposition effects; however, results of the ERAs for the Renewal do not indicate a risk to this species from these effects (Ramboll Environ 2016a, 2016b). For more information regarding this assessment and conclusion, see Brady pincushion cactus above.

Welsh's Milkweed

Welsh's milkweed is known to occur within the NGS Near-field area (Ramboll Environ 2016a) but not within the Permit Area. Because of the proximity of species records to the NGS, Welsh's milkweed was analyzed for potential Alternative 1 emissions and deposition effects. The results of the NGS Near-field ERA indicated that no impacts would occur to the species as a result of emissions under Alternative 1 (HQ less than 1) (Ramboll Environ 2016a).

Navajo Sedge

There is no potential habitat for the Navajo sedge in the Permit Area. However, habitat outside the Permit Area could be affected by drawdown of the N-Aquifer, which could potentially decrease water flow in seeps and springs. The only known populations of Navajo sedge that could be affected under Alternative 1 include the Tsegi Canyon population, about 12 miles north of CRA N-9, and the population where Moenkopi Wash and Ho No Geh Canyon overlap the unconfined portion of the N-Aquifer. Both of these populations occur outside of the mine permit boundary. Alternative 1 is not predicted to decrease flows in seeps and springs associated with the N-Aquifer since there is not anticipated to be a significant drop in flows to washes (less than one percent) (**Section 4.7.1.2**). Additionally, a previous analysis (OSMRE 2011) determined that potential drawdown in the N-Aquifer would not impact this species and the revised groundwater pumping for the Renewal would reduce the amount of water than what was previously analyzed. Therefore, the impacts on the species and its habitat would be negligible.

Alcove bog-orchid

There is no potential habitat for the alcove bog-orchid in the Permit Area. However, habitat outside the Permit Area could be affected by drawdown of the N-Aquifer, which potentially could decrease water flow in seeps and springs. The only known population of alcove bog-orchid that could be affected under Alternative 1 is the Tsegi Canyon population, which is associated with seeps and springs originating from the unconfined portion of the N-Aquifer; therefore, it is unaffected by groundwater pumping under Alternative 1 since there is not anticipated to be a significant drop in flows to washes in the N-Aquifer (**Section 4.7.1.2**). Additionally, a previous analysis (OSMRE 2011) determined that potential drawdown in the N-Aquifer would not impact this species and the revised groundwater pumping for the Renewal would reduce the amount of water than what was previously analyzed. Therefore, the impacts on the species and its habitat would be negligible.

Rydberg's Thistle

Impacts to the Rydberg's thistle would be similar to the impacts to Navajo sedge. While no specific habitat would be impacted under Alternative 1, the indirect effects to this species may occur from the drawdown of water. These impacts are anticipated to be negligible as the use of water for mining activities would not affect the groundwater level (**Section 4.7**).

Parish's Alkali Grass

Parish's alkali grass has a broad distribution, and there is no known suitable habitat for the species in any of the areas that would be disturbed during mining activities. The potential effects on the species under Alternative 1 would be from drawdown of the N-Aquifer due to pumping, which potentially could affect habitat by decreasing water flow in seeps and springs. Effects on the species from decreased flow in springs and seeps could include decreased winter germination. Additionally, habitat for the species may be affected by changes in the seasonal variability in flows, which could provide suitable habitat for the species.

Parish's alkali grass is not currently found in the Permit Area, and there is no known suitable habitat for the species in any of the areas that would be disturbed during Renewal period mining activities. The potential effects on the species under Alternative 1 would come from drawdown of the N-Aquifer due to pumping, which potentially could affect habitat by decreasing water flow in seeps and springs. The estimated drawdown is very small and is not predicted to affect suitable Parish's alkali grass habitat.

Development of CRAs N-9, J-19, and J-21 would not impact suitable habitat for the species because all known populations of Parish's alkali grass are outside of the Permit Area, and no populations have been located during surveys in study area (ESCO 2003). However, sediment control activities could increase the amount of habitat for Parish's alkali grass if areas with seeps develop with alkali crusts. Coal mining during the Renewal period would have no anticipated impacts to Parish's alkali grass and Alternative 1 would not affect the continued existence of the Parish's alkali grass.

Alcove Death Camass

Impacts to this species would be the same as those listed for other species occurring in similar habitats (i.e., Alcove bog-orchid, Rydberg's thistle, and Navajo sedge).

4.8.2 Alternative 2: No Action

Under Alternative 2, mining operations would cease in the Permit Area upon OSMRE's decision to deny the Renewal. Vegetation on 472 acres in the Affected CRAs would be removed between July 6, 2015 and OSMRE's decision to deny the permit Renewal. There would be negligible to minor effects similar to under Alternative 1. PWCC would initiate closure activities and complete final reclamation, including revegetation, per SMCRA requirements and Permit AZ-0001E.

Noxious weeds and invasive plant species could be introduced during reclamation and livestock grazing during reclamation activities (and beyond). Initiating reclamation for all areas disturbed by mining activity, roads, and support facilities could increase the number of vehicles entering and exiting areas within the Permit Area. This could indirectly increase the potential for noxious

weed and invasive plants establishment in the short term in comparison to Alternative 1. However, monitoring requirements would be the same as Alternative 1, and the long-term potential for noxious weed and invasive plants establishment within the Permit Area would not differ substantially from Alternative 1.

Under Alternative 2, reclamation of all mined areas and temporary impoundments would occur within three years. As a result, disturbed areas upstream of these impoundments would have been reclaimed and reseeded for at least two years, effectively minimizing sediment loads in runoff from recently reclaimed areas adding to the naturally occurring sediment loads that could be deposited along downstream riparian areas. Reclamation would restore continuity of re-constructed drainages in reclaimed areas with natural drainage patterns, and the removal of temporary impoundments would result in a short-term change in vegetation species present in localized areas. Alternative 2 would reduce the number of proposed permanent ponds within the study area that could alter the vegetation species present in localized areas relative to Alternative 1. In comparison, the effects would be negligible.

4.8.3 Mitigation

There would not be any mitigation necessary for vegetation.

4.9 WILDLIFE AND FISH

This section describes the analysis of effects on wildlife and fish resources that may be impacted by the alternatives, including the potential direct impacts from noise and light generated from the mining activities in the Affected CRAs as well as the indirect impacts from the combustion of Kayenta Mine coal at the NGS.

As part of the analysis, ERAs were developed that examined the baseline conditions (**Section 3.9**) and the potential impacts from the operation of the NGS over the life of the project (Ramboll Environ 2016a, 2016b). The ERAs looked at several contaminants (e.g., mercury, selenium, etc.) that would be released and, in conjunction with the baseline levels of those contaminants, made a determination as to the potential level of impact Alternative 1 would have based on the biology of either the specific species, or a surrogate.

The two ERAs developed for this project include the NGS Near-field and the Colorado River (in two segments).

- NGS Near-Field: The NGS Near-field study area was defined by the maximum deposition rate of selenium from the NGS stacks. Selenium was chosen to represent all potential HAPs because it showed the highest rate of deposition among the contaminants evaluated. The results indicated the deposition area to be within a 9.9-mile (16-km) radius of the source and confirmed the applicability of using AERMOD (versus more long-range models) to model emissions-dispersion and deposition from NGS (Ramboll Environ 2016a). The 9.9-mile (16-km) radius was conservatively rounded upward to a 12.4-mile (20-km) radius, which is defined as the NGS Near-field study area.
- Colorado River: Analysis of the Colorado River Regions was conducted to address potential risks to aquatic and aquatic-oriented wildlife in the Colorado River upstream

and downstream of Lake Powell, in areas that were not specifically evaluated in the NGS Near-field ERA. The Colorado River study area, for which one ERA was prepared with separate results provided for the Northeast and the Southwest Colorado River regions, falls outside of the 12.4-mile (20-km) NGS Near-field study area and the San Juan River study area (Ramboll Environ 2016b). They are briefly described as follows:

- **Northeast Colorado River Region.** This includes the portion of Lake Powell beyond the 12.4-mile (20-km) NGS Near-field study area and the Colorado River northeast of Lake Powell upstream to the confluence of the Colorado and Green rivers (approximately 170 miles [274 km] upstream of the Glen Canyon Dam).
- **Southwest Colorado River Region.** This includes the lower Colorado River downstream of the 12.4-mile (20-km) NGS Near-field study area, from Lees Ferry to the confluence of the Colorado and Little Colorado rivers (approximately 62 miles [100 km] downstream of the Glen Canyon Dam).

In addition to the ERAs developed for Alternative 1, this analysis also relies on an analysis for the San Juan River. EPRI conducted a watershed-scale assessment of trace metal deposition and dynamics within the San Juan River Watershed resultant from emission of arsenic, mercury, and selenium from three regional power plants (NGS, San Juan Generating Station, and Four Corners Power Plant). Atmospheric modeling of arsenic, mercury, and selenium was conducted using a suite of regional air quality models (Weather Research and Forecasting, Community Multiscale Air Quality-Advanced Plume Treatment, Community Multiscale Air Quality, Goddard Earth Observing System Chemistry) and the output was incorporated into a watershed biogeochemical cycling and aquatic biota bioaccumulation model to estimate concentrations in surface water (arsenic and selenium) and fish tissue (mercury). Modeling estimates include contributions of local, regional, and global sources in the San Juan River basin extending down to the San Juan arm of Lake Powell.

The modeling objective was to estimate annual deposition of arsenic, mercury, and selenium for the Watershed Analysis Risk Management Framework model during the time period of 1990–2074. The modelling accounted for historical contributions to deposition and media concentrations, and "delayed" or latent contribution to fish tissue bioaccumulation (for an additional 30 years) after a theoretical shut down of the NGS in 2044 (**Section 1.2**). To these ends, atmospheric deposition was simulated for multiple potential scenarios of emissions from local coal fired power plants as well as regional (U.S.) and global sources of mercury beyond of the bounds of the San Juan River basin. Four air dispersion and deposition modeling simulations were conducted:

- Baseline scenario – representing historical emissions and deposition to approximate "current" conditions.
- Regional (U.S) scenario – post 2019 operation of NGS, post-2013 operation for the Four Corners Power Plant and post-USEPA Mercury and Air Toxics Standard rule for other coal-fired power plants in the U.S.
- 2050 Case Low – a lower bound estimate of future China emissions.
- 2050 Case High – a higher bound estimate of future China emissions. Only the higher ground estimates were used for the San Juan ERA.

4.9.1 Alternative 1: Renewal of Permit AZ-0001E

4.9.1.1 General Fish and Wildlife

Continued mining in the Affected CRAs generally would not remove any additional habitat of significant size as these areas have previously been disturbed. There is a potential for up to 842 acres to be disturbed during the Renewal period. Any wildlife remaining in the Affected CRAs likely would be displaced into surrounding, unimpaired, or reclaimed habitat, which would be a minor, short-term effect until reclamation replaced most wildlife habitat. However, if any disturbance occurred in habitat consisting of rock outcrops, bluffs, or similar rocky terrain, those areas would be permanently removed. During reclamation, those areas would be restored to a more gentle and rolling topography. Several species, most notably rodents, foxes, sharp-shinned hawks, Cooper's hawks, and other migratory birds would be most impacted by the additional loss of habitat. This impact would be long-term and minor given the amount of suitable habitat that is present surrounding the Affected CRAs and Permit Area.

During reclamation, the mined out areas would be replaced primarily with native grasses, forbs, shrubs, and concentrated planting areas with some culturally important plants and trees within the reclamation area as described by the reclamation plan. The reclaimed areas would provide habitat for species adapted to habitat edges, early successional environments, and grassland habitats. Species that are highly adaptable would have the potential to use the reclaimed areas in greater abundance than before the disturbance. These include, deer, elk, deer mice, Ord's kangaroo rats, Gunnison's prairie dogs, Navajo mountain vole, black-tailed jackrabbits, desert cottontails, red foxes, coyotes, some species of bats, eastern fence lizards, prairie falcons, and red-tailed hawks. Over the long term, the breeding potential for raptors would increase as trees develop in portions of the reclamation that are planted with culturally important tree species. The post-reclamation improvement to wildlife habitat would be a long-term beneficial impact to wildlife.

Daily noise associated with mining activity in the Permit Area and along associated mining roads would cause a direct impact to wildlife, mostly to raptors, owls, and migratory birds, which being mobile are more likely to forage in the Affected CRAs. Noise from vehicles would be ongoing and localized around the periphery of mining pits, mine facilities, and hauls roads and would cause wildlife to flush or alter their normal behavior patterns within 50 to 100 feet of the source (Barber et al. 2010). Noise from blasting would be more intermittent, but would impact a much larger area (several miles). Impacts from noise would extend beyond the point of origin but would be attenuated by topography, vegetation cover, and distance. Some migratory birds and wildlife may flush or increase alert responses within two miles of the Affected CRAs. However, blasting and road noise have occurred within the Permit Area for many years so wildlife has likely adapted to a certain extent to the noises from mining activity (PWCC 2001). The effect of noise on wildlife under Alternative 1 would be short-term and minor.

PWCC would continue to conduct annual wildlife monitoring and special status species studies within the Permit Area through final reclamation and bond release as part of its permitting stipulations from OSMRE. These stipulations are part of the 2010 Permit Application Package prepared from OSMRE, SMCRA, the SMCRA amendments, and the ESA. The surveys would include: mine-front raptor surveys for northern goshawks and Cooper's hawks, red-tailed hawk nest monitoring, Gunnison's prairie dog colony monitoring, monitoring for wildlife species

utilizing reclaimed areas, Mexican spotted owl surveys, and special interest reconnaissance surveys for species listed by the Navajo Nation and USFWS. As part of reclamation, monitoring would continue to be conducted in revegetated areas and prescriptive measures would be applied to help encourage development of desired vegetation and discourage the establishment of noxious weeds and invasive species. The results of these long-term surveys would be submitted to OSMRE.

Direct and indirect affects to migratory birds and their habitats would be significantly reduced or avoided by conservation practices such as: avoiding disturbance in known high quality habitats (especially concentrated nesting areas); limiting disturbances to the minimum necessary; planning disturbances to avoid habitats that are unique, rare, or in limited supply; avoiding new disturbances in large intact unfragmented habitat blocks; or planning activities seasonally to minimize disturbance or disruption to nesting and breeding periods based on species potentially affected.

Seasonal disturbance timing limitations would be taken where practicable that are adjusted to match the habitat types and likely species of concern for mining activities during the Renewal period that could impact nesting periods.

Any disturbances during the nesting season in potential or suitable habitats would have pre-disturbance clearance surveys conducted within seven days prior to the disturbance to detect any newly arriving nesting birds.

If active nests with eggs or young are located within a projected disturbance area, disturbance restrictive buffers around those nests would be implemented or activities delayed until all young have fledged. Buffer distances for bird species would be developed in coordination with OSMRE and the USFWS.

Vegetation reclamation plans would continue to include the establishment of all-purpose rangeland for grazing of livestock and big game species. Along with benefiting these species, the reclamation also would benefit other wildlife species that may use the reclaimed areas as either forage or habitat. The standard rangeland seed mixture is comprised of grasses, forbs, and shrubs and includes 15 native plant species and six introduced plant species.

Key shrubland and woodland wildlife habitat areas would be established at cultural plant sites, concentrated shrub and tree planting sites, and rock habitat features interspersed as patches within the broader reclamation areas. These patches would include trees, forbs, and shrubs and an understory of native grasses that would not out-compete the woody species. These areas would be planted with seedlings, container-grown specimens, and a light rate seed mix with culturally-important plant species. PWCC also would create rock piles about every 100 acres to provide habitat for rock-dwelling species in reclamation areas.

Direct impacts from habitat loss and mining-related noise during the Renewal period would be short-term and minor on wildlife, within and surrounding the Affected CRAs. Also, extensive areas of wildlife habitat would be unaffected by mining noises outside the Kayenta Mine Permit Area and the larger region. These minor direct impacts would not be considered significant.

Indirect impacts under Alternative 1 potentially would occur from the combustion of Kayenta Mine coal at the NGS. In the Near-field and Colorado River ERAs, it was determined that the baseline conditions do not pose an unacceptable threat to terrestrial wildlife or their habitats. The ERAs also looked at a scenario with the maximum output of the NGS combined with the baseline and the potential impacts to terrestrial wildlife. It determined that the maximum output from the NGS over the Renewal period would not pose unacceptable risks to wildlife species or their habitat from constituents of primary concern (e.g., mercury, selenium, and other pollutants) (Ramboll Environ 2016a, 2016b).

No direct impacts to fisheries are anticipated under Alternative 1. A discussion of impacts to endangered fish species is provided in **Section 4.9.1.2**. Similar to indirect impacts to terrestrial wildlife, the Near-field and Colorado River ERAs examined the potential indirect impacts to non-special status fisheries near the NGS and in the Colorado River. The ERAs determined that Alternative 1 would not pose unacceptable risks to aquatic species or their habitat from constituents of primary concern (e.g., mercury, selenium, and other pollutants) (Ramboll Environ 2016a, 2016b).

4.9.1.2 Special Status Species

Direct impacts to special status species would result primarily from the presence of noise and light generated by mining activities in the Affected CRAs while indirect impacts may occur from the combustion of coal at the NGS. ERAs developed for Alternative 1 cover both the Near-field area surrounding the NGS (Ramboll Environ 2016a) and sections of the Colorado River above and below Lake Powell (Ramboll Environ 2016b). These ERAs evaluated the operation of the NGS and when added to the baseline, determined whether impacts to terrestrial and aquatic species or their habitats would occur. The determinations made in these ERAs are included in the individual species assessments below.

California Condor

There are no unique foraging opportunities or suitable roosting/nesting features (e.g., tall cliffs or canyons) within the vicinity of the Affected CRAs that would attract condors to the area. As the Renewal is over a short duration, and because the California condor is highly unlikely to occur in the study area and habitat is lacking, Alternative 1 would have negligible impacts to this species.

The ERAs (Ramboll Environ 2016a, 2016b) examined the potential for adverse impacts to the California condor and determined that little mercury or other contaminates would accumulate in large carrion, the primary source of the condor's diet, as a result of operation of the NGS during the Renewal period. There would be negligible risk to condors from the operation of the NGS. Further, since condors are accidental or occasional visitors in this area, the potential exposure to impacts is lessened.

Mexican Spotted Owl

The effects analysis for the Mexican spotted owl is based on its distribution and the location of suitable habitat within the study area, which are not uniformly dispersed. Suitable habitat in the study area is located on the northern end of Black Mesa and this species has been known to occur in the vicinity of the Kayenta Mine. The stands of mixed conifer forest that support Mexican spotted owls are all north and east of the permit boundary.

Coal mining in the Affected CRAs would not remove suitable habitat for the Mexican spotted owl. Vegetation in the Affected CRAs includes primarily piñon-juniper woodland with limited amounts of sagebrush shrubland and saltbush and greasewood shrublands. All suitable habitat (mixed-conifer forests) and protected activity centers for the species are located in canyons north of the boundary of the Permit Area. No suitable, occupied habitat occurs in the vicinity of the Affected CRAs, and no Mexican spotted owls have been detected at any of the CRAs in the past (PWCC 2001). The closest stands of suitable habitat in mixed-conifer forest are 9 miles to 10 miles (14.5 km to 16.1 km) north of CRA J-19 and 11 miles to 12.5 miles (17.7 km to 20.1 km) north of CRA J-21. Mixed conifer habitat occurs north and east of CRA N-9 at much closer distances that range between 2.0 miles and 4.8 miles (3.2 km and 7.7 km) at the closest point. Although habitat for the Mexican spotted owl would not be removed, noise from mining activities and light pollution coming from dragline lights during the night could influence occupied habitat.

The loudest noises from typical mining activities at the mine would come from rock drills and blasting. Surface blasting is conducted an average of twice daily during weekdays, between sunrise and sunset. Other mining activities occur throughout the day and night all days of the week. OSMRE requires that air-blast levels be limited to a maximum of 134 dB (peak) at the source, and a typical rock drill creates about 95 dB of noise measured at 50 feet (15.2 m) from the source (MMA 2000; EPA 1971).

The noise coming from rock drills at CRA N-9 would measure about 48.5 dB in habitat 2.0 miles (3.2 km) away and 40.9 dB in habitat 4.8 miles (7.7 km) away. Blasting noise would measure about 33.5 dB at 2.0 miles (3.2 km) and 25.9 dB at 4.8 miles (7.7 km). Rock drills (the loudest source of mining noise) operating in CRA J-19 would register at about 34.5 dB in the closest habitat about 9 miles (14.5 km) away, and rock drills operating in CRA J-21 would register about 33.1 dB in the closest habitat about 11 miles (17.7 km) away[4]. Mining noises would attenuate further, where vegetation, canyons, and hillsides opposite the noise source shields Mexican spotted owl habitat. Weather conditions would affect the amount of noise reaching these habitat areas – either slightly dampening or amplifying the sound. In addition, multiple sound sources can have an additive or cancelling effect and raise or lower the actual decibel level of mining-related noises in the closest Mexican spotted owl habitat. However, the loudest mining noises detectable in Mexican spotted owl habitat would be similar to the ambient noise in an average quiet residence at night (about 30 dB) and could range up to about that of an average office environment (about 50 dB).

The USFWS (2003) has established thresholds for noise exposure to Mexican spotted owls. The agency estimated the sound-only injury threshold for Mexican spotted owls at approximately 92 dBA at nest sites. Disturbance thresholds were estimated at 70 dBA and detectability thresholds were estimated at 44 dBA (USFWS 2003). Rock drills and other heavy machinery operating above 90.5 dB in CRA N-9 would produce the only detectable sound in the closest habitat about 2.0 miles (3.2 km) away and likely would fall below detectable levels beyond about 3.4 miles (5.5 km). Mining-related noises coming from CRAs N-9, J-19, or J-21 would never reach disturbance or injury thresholds according to these USFWS standards. Therefore, Mexican spotted owls would not be exposed to noises that could induce stress, alter behavior, or suppress breeding in the action area.

[4] Estimated using the inverse square law ($I = P/4\pi r2$).

Dragline excavators operate around the clock at the Kayenta Mine. At night, the work area is illuminated with lights mounted to the machinery and aimed toward the mining surface. Rather than shining directly into Mexican spotted owl habitat, mining lights would produce a visible glare and skyglow outside of active mining areas. At the time of this analysis, no data were available regarding the specifications on lights or illumination requirements at the mine. Assuming that safety regulations (30 CFR § 77.207) result in illumination of the mining area similar to direct sunlight, the amount of light at the mine could be as high as 130,000 lux (lumens/m^2) (Elion 1979). Also, conservatively assuming that about half the light is reflected and half is absorbed by the dark surfaces of the mining pit, about 65,000 lux could be emitted from an active CRA. The average albedo (reflectance) of the earth is about 30 percent (National Aeronautics and Space Administration 2014).

Mining in CRA N-9 would result in 0.006 lux in the closest habitat 2.0 miles (3.2 km) away and 0.001 lux in habitat 4.8 miles (7.7 km) away. Light coming from CRA J-19 would result in about 0.00031 lux in the closest Mexican spotted owl habitat about 9 miles (14.5 km) away, and light from CRA J-21 would result in about 0.00021 lux in the closest habitat about 11 miles (17.7 km) away. Ambient light on a moonless night is about 0.002 lux, and mining lights likely drop to this ambient level at about 3.5 miles (5.6 km)[5]. Therefore, mining-related light would be obscured by the ambient level of light, with the exception of that coming from CRA N-9.

The terrain would shade most of the Mexican spotted owl habitat from any mining-sourced light emanating from the Affected CRAs, with only some of the canyon rims being within the line of sight of the mine. In addition, the upper tree canopy likely would further block light and reduce the possible impact from mining lights.

Studies of light pollution on the Mexican spotted owl were not available. Under conditions that greatly change the natural light levels in Mexican spotted owl habitat, it is possible that this species could respond by changing normal behaviors as has been observed in other bird species. A study of the effects of light pollution on song bird behavior indicated that artificial light in an urban environment had substantial effects on the timing of reproductive behavior and on individual mating patterns (Kempenaers et al. 2010). In addition, rodents, the primary prey of Mexican spotted owls, could change activity patterns under the influence of artificial night lighting. Observations of many rodent species indicate that individuals reduce activity or stay under canopy cover to reduce predation risks in response to higher ambient light (O'Farrell 1974; Vickery and Bider 1981; Getz 2009), but Mexican spotted owls may be more successful at catching prey under higher ambient light, as is suggested by observations of other owl species (Daly et al. 1992). However, the potential amount of light coming from the Affected CRAs described previously would not be enough to affect the natural behaviors of Mexican spotted owls or prey species.

Between 1994 and 2000, mining activity was closer to occupied habitat than under Alternative 1, and Mexican spotted owls continued to inhabit and successfully reproduce during that period (PWCC 2001). Therefore, the effects of light and noise from Alternative 1 would be less than in the past, and the species would continue to occupy habitats and successfully reproduce while CRA N-9 is mined. The amount of night lighting would not change from the current conditions,

[5] Estimated using the inverse square law ($I = P/4\pi r2$).

and would persist for a short time under Alternative 1. Therefore, night lighting under Alternative 1 would be a negligible to minor impact to Mexican spotted owls.

The Near-Field ERA developed for Alternative 1 (Ramboll Environ 2016a) did not include a specific analysis regarding the indirect impacts from operation of the NGS on the Mexican spotted owl as there is little to no suitable habitat for this species in the Near-field area (20-km radius of the NGS). However, the Near-field ERA did conclude that the operation at the NGS over the life of the project would have negligible impacts on owl species (Ramboll Environ 2016a).

Southwestern Willow Flycatcher

Willow flycatchers have been observed infrequently during migration in a limited number of places in the Permit Area and in riparian areas farther away near the confluence of Moenkopi Wash and Dinnebito Wash (LaRue 1994). However, no suitable habitat occurs near the Affected CRAs, and no riparian habitat would be removed under Alternative 1. Groundwater monitoring of the N-Aquifer has demonstrated that water withdrawal has not had significant impacts on riparian areas downstream of the Permit Area, which includes stopover habitat for migrating southwestern willow flycatchers (LaRue 1994). Because 1) habitat for the southwestern willow flycatcher is limited on Black Mesa, 2) the species' occurrence would be rare and transient in the Permit Area, 3) southwestern willow flycatchers would not use the Affected CRAs, and 4) habitat would not be removed under Alternative 1 and groundwater pumping and surface impoundments would have negligible effects on habitat, the effects on the southwestern willow flycatcher would be negligible.

The ERAs examined the potential for this species to be impacted from continued operations at the NGS. The ERAs determined that there was negligible potential for mercury or other contaminates to affect the flycatcher via prey pathways because the flycatcher feeds primarily on terrestrial insects and not aquatic insects. Therefore, indirect impacts to the flycatcher would be negligible (Ramboll Environ 2016a, 2016b). Additionally, the ERAs determined that indirect impacts to southwestern willow flycatcher critical habitat would also be negligible.

Yellow-billed Cuckoo

Direct impacts to the yellow billed cuckoo would be similar to those described for the southwestern willow flycatcher. No riparian habitat would be removed under Alternative 1 and the water withdrawal from the N-Aquifer is not anticipated to adversely impact yellow-billed cuckoo habitat. Therefore, direct impacts from Alternative 1 would be negligible.

The ERAs examined the potential for this species to be impacted from continued operations at the NGS. The ERAs determined that there was negligible potential for mercury or other contaminates to affect the yellow-billed cuckoo via prey pathways as because the cuckoo feeds primarily on terrestrial insects and not aquatic insects (Ramboll Environ 2016a, 2016b) Therefore, indirect impacts from the NGS to the yellow-billed cuckoo would be negligible. Additionally, the ERAs determined that indirect impacts to yellow-billed cuckoo critical habitat would also be negligible.

Sora

The sora is not anticipated to occur within the Affected CRAs due to a lack of habitat. As such, there would be no direct impacts to this species from Alternative I. Indirect impacts would be limited to the potential for deposition of mercury or selenium into its habitat. The ERAs determined that there was negligible potential for mercury or other contaminates to affect the sora (Ramboll Environ 2016a, 2016b) Therefore, indirect impacts from the NGS to the sora would be negligible.

Bald Eagle

The bald eagle is a rare winter migrant to the Affected CRAs and is therefore unlikely to be directly impacted by Alternative I. Some individuals that use the area may be displaced. However, this impact would be minor given the unlikely chance for bald eagles to occur. No nesting habitat would be lost. Similar to other raptors, the ERAs determined that there was a negligible risk to the bald eagle from continued operations at the NGS as mercury or other contaminates are not anticipated to accumulate in the eagle's primary food source. Therefore, potential risk to this species is anticipated to be negligible (Ramboll Environ 2016a and 2016b).

Black-footed Ferret

Wildlife monitoring for prairie dogs has not identified any colonies in the Affected CRAs, and evidence of black-footed ferret use has not been observed during monitoring studies for the species elsewhere within the Permit Area (EMI 2016). In addition, suitable habitats in prairie dog towns southwest of the Permit Area are too small to support a local population of black-footed ferrets. As habitat for black-footed ferrets is lacking, and because no ferrets occur in the Permit Area, there would be no or negligible impacts to black-footed ferrets from mining activities under Alternative 1.

Golden Eagle

The golden eagle uses the Permit Area infrequently and occasionally forages near the Affected CRAs (EMI 2016). Blasting could arouse or flush individual eagles in the Permit Area or arouse individuals at perch sites; however, blasting noise would be attenuated by the square of the distance from the source and from obstructions such as topography and vegetation (Mohamed 2010). Additionally, noise from mine operations and blasting is not predicted to change from 2010 levels, and no increase in the severity of the potential impact is anticipated on golden eagles. The effects on golden eagles from noise would be minor because the sources of noise would be intermittent, single events, which are similar to noises that were occurring while golden eagles were observed using the Permit Area.

Similar to the California condor, the ERAs determined that there was a negligible risk to the golden eagle from continued operations at the NGS as mercury or other contaminates are not anticipated to accumulate in the eagle's primary food source. Therefore, potential risk to this species is anticipated to be negligible (Ramboll Environ 2016a and 2016b).

Ferruginous Hawk

Potential foraging habitat for this species occurs in revegetated areas and in prairie dog colonies that could develop in these areas. Alternative 1 could result in the indirect impact of providing additional foraging habitat after reclamation by creating areas with little tree canopy cover and greater foraging opportunities. However, blasting could arouse or flush individual ferruginous hawks that happen to use the Permit Area during foraging. Blasting noise would be attenuated by the square of the distance from the source and from obstructions such as topography and vegetation (Mohamed 2010). As noise from mine operations and blasting is not predicted to change from previous levels when ferruginous hawks were observed in the vicinity, and because reclamation could develop additional habitat for the ferruginous hawk; there would be no increase in the severity of the potential impacts anticipated on ferruginous hawks under Alternative 1. The impacts to the ferruginous hawk would be minor. As mercury is not a known threat to this species, there would be no indirect impacts from coal combustion at the NGS to ferruginous hawks.

Northern Goshawk

Potential foraging habitat for the species occurs in CRA N-9 (BIOME 2003), which would be lost with development of this area. Piñon-juniper woodlands are infrequently utilized as post-fledgling foraging habitat by dispersing juveniles (Weins et al. 2006). Monitoring for northern goshawks is conducted annually as part of the advancing mine front surveys and would continue in advance of mining CRA N-9. To date, no northern goshawks have been detected in the two-mile survey area around the northern part of the Permit Area. As the habitat removed for mine development likely is of limited quality for goshawks and because the species has not been recorded within or near the Permit Area, the effects of mining in the Affected CRAs on the northern goshawk would be minor. As mercury and other contaminants associated with the combustion of coal are not a known threat to this species, there would be no impacts from coal combustion.

Peregrine Falcon

Peregrine falcons occasionally forage in the Permit Area, and individual falcons could occur periodically in CRA N-9 and other places with piñon-juniper woodland (BIOME 2003). Development of CRA N-9 would remove potential foraging habitat for the species in this CRA, but a utilitarian foraging habitat would be replaced by the reclamation vegetation and permanent impoundments, which could have greater abundance of prey for any peregrine falcons that forage in the Permit Area. Blasting could arouse or flush individuals in the Permit Area or arouse individuals during foraging; however, noise from mine operations and blasting is not predicted to change from current levels (OSMRE 2011), and no increase in the severity of this potential impact is anticipated on peregrine falcons. Potential effects on peregrine falcons would be minor because the removal of potential foraging habitat for the peregrine falcon is 0.1 percent or less in comparison to the total available habitat on Black Mesa and foraging opportunities would return or be improved after reclamation. In addition, noise would be associated with intermittent, single events, which is similar to noise that was occurring when peregrine falcons were previously observed in the Permit Area. The effects of mining in the Permit Area on the peregrine falcon would be minor. As mercury and other contaminants associated with the combustion of coal are not a known threat to this species, there would be no impact from coal combustion.

Northern Saw-whet Owl, Northern Pygmy Owl, and Flammulated Owl

These three species potentially could inhabit mixed-conifer forests north and northeast of CRA N-9. Habitat could be impacted by noise from blasting and mining activities, and from light pollution coming from dragline lights at CRA N-9 at night. The mining noise could arouse individual owls, the additional light could increase foraging efficiency but decrease prey availability, or both noise and light could affect behavior of individual owls (Barber et al. 2010; Kempenaers et al. 2010; O'Farrell 1974; Vickery and Bider 1981; Getz 2009). However, noise and light would attenuate by the square of the distance from the source and from obstructions such as topography and vegetation (Mohamed 2010), and given the distance between the mining areas and the habitat of these owl species, it is not anticipated that noise or light would affect the biology of these species (see impact analysis for the Mexican spotted owl). Thus, impacts on the northern saw-whet owl, northern pygmy owl, and flammulated owl would be negligible to minor, as Alternative 1 likely would not affect the behavior or ecology of these species. Additionally, as mercury and other contaminants associated with the combustion of coal are not a known threat to these species, coal combustion would have no impact.

Burrowing Owl

Development of the Affected CRAs would not impact potential habitat for the species. On the other hand, reclamation activities could increase the amount of habitat for Gunnison's prairie dog, which could create more potential habitat for burrowing owls. However, all prairie dog towns are outside of the Permit Area, and no burrowing owls have been seen on Black Mesa. Coal mining under Alternative 1 would have no anticipated impacts to the burrowing owl. Additionally, mercury is not known to be a threat to this species so coal combustion at the NGS would not impact burrowing owls.

Mogollon (Mexican or Navajo Mountain) Vole

Development of the Affected CRAs could remove habitat for the species in piñon-juniper woodlands and big sagebrush shrublands under Alternative 1. Mining activities also could result in the death of some individuals. Reclamation vegetation and habitats planted in these areas would suitably replace the lost habitats. The results of previous studies by LaRue and SWCA have shown relatively large populations of Navajo mountain voles in reclaimed areas (PWCC 1992). As reclamation could add additional habitat and reduce the loss of habitat from mining in the Affected CRAs the effects of Alternative 1 would be minor on the Navajo mountain vole. Additionally, mercury is not known to be a threat to this species so there would be no impact from coal combustion at the NGS.

Townsend's Big-eared Bat

Development of the Affected CRAs could remove foraging habitat for the species under Alternative 1, but reclamation vegetation in these areas may suitably replace the lost foraging opportunities. As reclamation may eventually add habitat, which would offset any loss of habitat under Alternative 1, the effects of mining would be minor on Townsend's big-eared bat. Additionally, mercury is not a known threat to this species so there would be no impact from coal combustion at the NGS.

Endangered Fish Species

Under Alternative 1, there would be no direct impacts to bonytail, Colorado pikeminnow, humpback chub, or razorback sucker as none of these species occur within the Permit Area and the Renewal would not affect habitat for these species. Indirect impacts may occur from the combustion of coal at the NGS and are described below.

As part of the Section 7 requirements under the ESA, a BA of Alternative 1 was developed (OSMRE 2017). During that process, ERAs for the Colorado River and a 20-km buffer around the NGS (Near-field) were developed that specifically looked at the potential impacts to these species (Ramboll Environ 2016a, 2016b). The ERAs evaluated the baseline conditions (as of July 2014) and the potential deposition related impacts from operations from NGS activities during the Renewal period. Specifically, the ERA examined the potential effects from mercury and selenium deposition from coal combustion on these species. Additionally, the analysis also relied on the analysis of the San Juan River that included three coal fired power plants (including the NGS) (EPRI 2016). The USFWS responded to the BA with a Concurrence Letter on September 19, 2017 (USFWS 2017) (**Appendix G**).

Combustion of coal releases mercury into the atmosphere, which may be deposited into habitat for the endangered fish directly, or onto adjacent land and subsequently washed into the river. Mercury is a concern primarily to longer-lived fish species (e.g., Colorado pikeminnow) because it bioaccumulates within the tissue of individuals. Therefore, the longer an individual lives and absorbs mercury, the higher the levels within their tissues over time. Mercury can affect an individual's central nervous system, alter their behaviors (e.g., reduced predator avoidance), and disrupt the endocrine system resulting in reduced reproductive success (Lusk 2010). While the specific effects of mercury and other heavy metals on pikeminnow are known, the role these contaminants play on suppressing populations of the endangered fish are not well understood (USFWS 2011b).

In addition to mercury, impacts to the endangered fish from increases in selenium from the combustion of coal at the NGS could occur. Selenium, a trace element, is a natural component of coal and soils in the area and can be released to the environment by the irrigation of selenium-rich soils and the burning of coal in power plants with subsequent emissions to air and deposition to land and surface water. Contributions from anthropogenic sources have increased with the increases of world population, energy demand, and expansion of irrigated agriculture. Selenium, abundant in western soils, enters surface waters through erosion, leaching, and runoff. While required in the diet of fish at very low concentrations (0.1 μg/g) (Sharma and Singh 1984), excess dietary selenium causes elevated selenium concentrations to be deposited into developing eggs, particularly the yolk (Buhl and Hamilton 2000). If concentrations in the egg are sufficiently high, developing proteins and enzymes become dysfunctional or result in oxidative stress, conditions that may lead to embryo mortality, deformed embryos, or embryos that may be at higher risk for mortality.

The Near-field ERA (Ramboll Environ 2016a) area was developed using the EPA's recommended AERMOD model to simulate selenium emissions from the three NGS units. Selenium was selected because it showed the highest deposition among the contaminants in a screening analysis. The results of the AERMOD analysis demonstrated that the deposition areas for the ERA (i.e., where selenium deposition exceeds 10 percent of the selenium ecological soil screening level)

was 16 km around the NGS. This was rounded up to 20 km to provide a conservative analysis. The Colorado River ERA (Ramboll Environ 2016b) looked at areas upstream (eastern portion of Lake Powell up to the confluence of the Colorado and Green Rivers approximately 274 km upstream of the Glen Canyon Dam), and downstream (Lee's Ferry to the confluence of the Colorado and Little Colorado Rivers approximately 100 km downstream of the Glen Canyon Dam. The extent of the Colorado River Study Area was selected to capture potentially sensitive ecological areas along the Colorado River directly upstream and downstream of Lake Powell to ascertain whether NGS emissions could potentially impact sensitive species adjacent to the NGS.

Based on the Near-field ERA analysis (Ramboll Environ 2016a), Alternative 1 would add approximately 0.000000000717 mg/L of methyl mercury, and 0.00000202 mg/L of selenium to the surface water (total, refined) in the analysis area. The Near-field ERA determined that this would not have a significant impact to the baseline levels of mercury or selenium that are currently present and would therefore, not impact any of the endangered fish species present.

None of the endangered fish species are anticipated to occur within the Near-field ERA study area, so no estimates of impacts from Alternative 1 on populations are available.

The ERA conducted for the Colorado River (Ramboll Environ 2016b) determined that Alternative 1 would result in the deposition of approximately 0.000000000239 mg/l of methyl mercury and 0.000000531 mg/L of selenium (both total, refined) deposited in the northeast portion of the ERA study area. The southwest portion of the Colorado River study area would have 0.000000000417 mg/L of methyl mercury and 0.000000199 mg/L of selenium deposited as a result of Alternative 1. Given the relatively small amounts of the mercury and selenium that would be added to the Colorado River as a result of Alternative 1, the impacts to the endangered fish species and/or their critical habitat is anticipated to be negligible.

Within the Colorado River portion of the study area the USFWS (Smith 2017) provided estimates of the anticipated impacts to the humpback chub and razorback sucker in the downstream portions as a result of Alternative 1 (McGregor 2016). In that analysis, the USFWS determined that there would be no injury effects to either species from selenium increases. **Table 4.9-1** shows the estimated impacts to the humpback chub and razorback sucker from mercury. Given that the anticipated injury to the razorback sucker and humpback chub would be too small to meaningfully measure, detect, or evaluate, Alternative 1 would have negligible impacts to these species (Smith 2017).

Table 4.9-1 Colorado River Mercury Injury Effects, Alternative 1 (2015-2020)

Species	Eggs/ Embryos Lost	Larvae Lost	Adult Reproduc-tion Injury	Juveniles (<400 mm) Lost	Adults (>400 mm) Lost	Subadult Behavioral Injury	Adult Behavioral Injury
Razorback Sucker	4.5	0.1	0.1	0.1	0.1	0.1	0.1
Humpback Chub	32.5	0.4	0.1	0.1	0.1	0.1	0.1

[1] The end date includes any potential time that emitted mercury may remain airborne before deposition and potential movement through terrestrial and aquatic ecosystems in the indirect effects study area.

In addition to the potential impacts to the area surrounding the NGS (i.e., Near-field) and the Colorado River, impacts also may occur to these species in the San Juan River. An analysis was developed for this portion of habitat for three coal fired power plants that included the NGS (EPRI 2016). It determined that ongoing operation of the NGS at levels the same as described under Alternative 1 would contribute little selenium, mercury, or arsenic to the San Juan River. The analysis showed that the maximum contribution of selenium concentration in surface water from the NGS was 0.44 percent and the maximum contribution of mercury in fish tissue was 0.035 percent. The report determined that the uncertainty in the future emissions of mercury from China is much greater than the total mercury emissions from the NGS (EPRI 2016). While mercury would be deposited at similar low rates as shown in the Near-field analysis and the Colorado River ERAs (Ramboll Environ 2016a, 2016b), selenium impacts to the San Juan River are slightly higher.

The analysis performed by the USFWS (Smith 2017) determined the potential impacts to the Colorado pikeminnow and razorback sucker as shown in **Tables 4.9-2** and **4.9-3**. For the Colorado pikeminnow and the razorback sucker, all of the potential impacts are would be too small to meaningfully measure, detect, or evaluate; therefore, the impacts would be negligible (Smith 2017).

Table 4.9-2 San Juan River Mercury Injury Effects, Alternative 1 (2015-2020)

Species	Eggs/ Embryos Lost	Larvae Lost	Adult Reproduction Injury	Juveniles (<400 mm) Lost	Adults (>400 mm) Lost	Subadult Behavioral Injury	Adult Behavioral Injury
Colorado Pike-minnow	59.3	1.2	0.1	0.1	0.1	0.1	0.1
Razorback Sucker	451.0	7.2	0.1	0.5	0.2	0.1	0.1

Table 4.9-3 San Juan River Selenium Injury Effects, Alternative 1 (2015-2020)

Species	Eggs/ Embryos Lost	Larvae Lost	Adult Reproduction Injury	Juveniles (<400 mm) Lost	Adults (>400 mm) Lost	Subadult Behavioral Injury	Adult Behavioral Injury
Colorado Pike-minnow	4,111.8	7.6	NA	NA	0.1	NA	NA
Razorback Sucker	48,515.4	30.1	NA	NA	0.7	NA	NA

In addition to impacts to individuals, impacts from Alternative 1 to the listed critical habitats for the endangered fish species are considered. For the bonytail, critical habitat occurs in the Upper Colorado River. The ERA for this area determined that the baseline refined concentration of

mercury was measured at 0.034 µg/L. This does not exceed the National Ambient Water Quality Criteria. For selenium, the maximum concentration was measured at 6.5 µg/L and the refined concentration was measured at 2.54 µg/L. The ERA determined that Alternative 1 would result in an additional 7.02 E-8 µg/L of methylmercury. Therefore, the USFWS determined that Alternative 1 would result in very small contributions to baseline concentrations of mercury and selenium in bonytail critical habitat, which would have a negligible impact on its critical habitat (Smith 2017).

For the portion of the Colorado pikeminnow critical habitat that occurs in the Colorado River, impacts would be the same as described above for the bonytail, and therefore would be negligible. In the San Juan River portion of the Colorado pikeminnow, the USFWS (Smith 2017) determined that Alternative 1 would result in an additional 0.0000008 µg/L of total mercury and 0.000000114 µg/L of refined mercury, both of which were determined to be negligible. For the effects of selenium on critical habitat in the San Juan River, the maximum dissolved selenium baseline concentration (12.0 ug/L) was greater than the Navajo Nation Water Quality Standard for total selenium (2 µg/L) (NNEPA 2008). The maximum dissolved (filtered) surface water due to the proposed action also exceeds the water quality criteria for lotic systems (3.1 µg/L, dissolved) per EPA Selenium Ambient Water Quality Criteria (EPA 2016). However, there were no exceedances for selenium based on the refined (1.23 ug/L) or average (1.13 ug/L) surface water concentrations. Therefore, the addition of selenium to the environment from the proposed action would result in a negligible effect to the water quality element of critical habitat for the Colorado pikeminnow. Overall, Alternative 1 would have a negligible impact on Colorado pikeminnow critical habitat (Smith 2017).

Impacts from Alternative 1 on humpback chub critical habitat would be similar to those for the bonytail, and therefore would be negligible (Smith 2017).

Impacts from Alternative 1 on razorback sucker critical habitat would be the same as the bonytail in the Colorado River and the Colorado pikeminnow in the San Juan River, and therefore would be negligible (Smith 2017).

4.9.2 Alternative 2: No Action

Under Alternative 2, mining operations would cease in the Permit Area upon OSMRE's decision to deny the Renewal. Disturbance would occur on 472 acres in the Affected CRAs between July 6, 2015 and OSMRE's decision to deny the permit Renewal. There would be negligible to minor effects similar to under Alternative 1. PWCC would initiate closure activities and complete final reclamation per SMCRA requirements and Permit AZ-0001E. As under Alternative 1, the reclaimed areas would be monitored twice annually for a period of 10 years to monitor the establishment of seeded vegetation and control of noxious weeds. These activities would have the potential to adversely impact the species that occur in those areas; however, as reclamation would occur under Alternative 1 and produce less noise than mining, this impact to terrestrial species would be negligible.

Alternative 2 assumes that the mining operations would cease in the Permit Area upon the OSMRE's decision to deny the Renewal. Considering the administrative delay, Alternative 2 would include approximately 40 percent of the total particulate emissions that would occur under

Alternative 1 (**Section 4.5.2**). Therefore, the indirect effects from the combustion of coal at the NGS would be negligible.

4.9.3 Conservation Measures

Although no measurable impacts to Federally listed fish are anticipated through 2019, out of an abundance of caution and to address the uncertainty in the modeling of emissions impacts from NGS, two conservation measures are proposed to be implemented in 2017 by SRP as operator of the NGS. The measures would aid in the conservation and recovery of the endangered fish species, specifically the Colorado pikeminnow in the San Juan River, the razorback sucker in the San Juan River and the Colorado River below the Glen Canyon Dam, and the humpback chub in the Colorado River below the Glen Canyon Dam.

1. Support Non-native Fish Management (Emergency Rapid Response) in the Colorado River, Grand Canyon Area

   The NGS would provide funding support to the NPS or other state, federal, or tribal agencies to monitor for and eradicate, as necessary, predatory non-native fish in the mainstem Colorado River and tributaries below Glen Canyon Dam to the confluence of Lake Mead. The measure would protect and conserve razorback sucker and humpback chub.

   The funding would support implementation of the Comprehensive Fisheries Management Plan developed by the NPS in 2013 to conserve and protect listed and other native fish in Grand Canyon National Park. Nonnative fish could negatively impact populations of endangered humpback chub and razorback sucker within the Grand Canyon due to predation and competition. The measure would ensure agencies have funding and supplies to implement an effective rapid emergency response to nonnative fish detections. Funds could also be used by agencies (e.g., AGFD, USFWS, and NPS) to assist with monitoring the Colorado River and tributaries below Glen Canyon Dam and critical areas of the watershed (e.g., Little Colorado River) that act as a conduit or source for nonnative fish. Funds would be provided to agencies annually (or as needed for rapid responses) for labor, travel expenses, and the purchase of chemicals, nets, and other equipment to conduct monitoring, fish eradication projects, and post-project surveys.

2. Support Transport of Colorado Pikeminnow and Razorback Sucker above the Waterfall Barrier in the San Juan River

   The NGS would provide funding (likely through National Fish and Wildlife Federation) to support agencies and organizations (e.g., BOR, Utah Division of Wildlife Resources, NNDFW) to implement capture and transport Colorado pikeminnow and razorback sucker upstream of a waterfall barrier in the San Juan River arm of Lake Powell, which allows the fish access to habitat in the San Juan River. Currently, BOR is managing the implementation of the project with assistance from other state and tribal agencies. Funding to support the capture and transportation of these fish around this barrier would increase the number of potentially spawning fish in the San Juan River and serve as a mechanism to connect the river and lake below the waterfall with fish and habitat in the river upstream of the barrier.

For over 20 years, a large waterfall (about 30 feet high) has existed in the San Juan River near Paiute Farms, Utah, where the river enters Lake Powell. The waterfall is present when Lake Powell reservoir elevations are below 3,660 feet amsl, which has been continuous since 2000, except for a one-month period in 2011. This waterfall serves as a barrier to movement for all fish species. While the waterfall effectively keeps nonnative fish from moving upriver, it also prevents native fish, especially Colorado pikeminnow and razorback sucker, from moving back upstream after they have drifted over the waterfall as larvae, juveniles, or adults. Ryden and Ahlm (1996) identified this barrier as a major impediment to migrating fish. In the spring of 2016 a pilot program was conducted by BOR to relocate Colorado pikeminnow and razorback sucker over the waterfall using buckets to move tagged fish. Approximately 170 razorback sucker and four Colorado pikeminnow were translocated.

The collection and translocation would be implemented in approximately March, April, and June every year through 2020. The frequency, timing, or duration of field work could be adjusted in coordination with USFWS to maximize effectiveness of the translocation effort. The funding could be used to support staff time, travel cost, field equipment, tagging equipment, and holding and transportation of fish.

The injury estimates used by USFWS (Smith 2017) and presented in **Section 4.9.1.2**, **Endangered Fish Species**, were based on the analysis that was prepared for BOR (2016) (Years 2020-2044), using 10 percent of that to represent the Renewal period, so the effects determination did not take into account the above conservation measures when it concluded the effects of the deposition during the Renewal period would be insignificant. The USFWS has stated that the cumulative effects were eliminated because the effects would be negligible and therefore analysis of cumulative effects is unnecessary.

In addition to the measures listed above for the endangered fish species, the Special Condition pertaining to the monitoring plan for the Mexican spotted owl (PAP) would be incorporated into Alternative 1.

4.9.4 Mitigation

There would not be any mitigation measures for wildlife and fish. However, two conservation measures are proposed to be implemented in 2017 by SRP as operator of the NGS. The measures would aid in the conservation and recovery of the endangered fish species, specifically the Colorado pikeminnow in the San Juan River, the razorback sucker in the San Juan River and the Colorado River below the Glen Canyon Dam, and the humpback chub in the Colorado River below the Glen Canyon Dam (**Section 4.9.3**).

4.10 CULTURAL RESOURCES

The Renewal could affect two aspects of the cultural environment: 1) archaeological and historical resources, and 2) traditional cultural life ways and resources. Adverse effects on cultural resources can be direct or indirect and include the following:

- Physical destruction or alteration of a property or relocation from its historic location;

- Isolation or restriction of access;
- Change in the character of the property's use, or of physical features within the property's setting, or the introduction of visible, audible, or atmospheric elements out of character with the significant historic features of the property;
- Neglect leading to deterioration or vandalism; and
- Transfer, sale, or lease from federal to non-federal control without adequate and legally enforceable restrictions or conditions to ensure preservation of the historic significance of the property.

4.10.1 Alternative 1: Renewal of Permit AZ-0001E

OSMRE has conducted Section 106 consultation for the entire Permit Area through the BMAP, and is continuing consultation for the Renewal. PWCC would continue to consider historic properties pursuant to other laws through standard conditions and terms attached to the Renewal for continuing mining operations. Those terms would be incorporated into the Renewal. Pursuant to those terms, PWCC would:

- Report the discovery of any previously unrecorded cultural resources to OSMRE and to suspend work near discoveries until OSMRE determines appropriate disposition;
- Take into account any sacred and ceremonial sites brought to the attention of PWCC by local residents, clans, or tribal government representatives of the Hopi Tribe and Navajo Nation; and
- Identify and respectfully treat any human remains associated with archaeological sites pursuant to NAGPRA.

To date, 35 prehistoric sites and 19 historic sites have been recorded within the Affected CRAs through the BMAP and four additional cultural sites in CRA J-21 as part of the Data Quality Assessment Survey. In addition, three cultural resources (two inadvertent discoveries of human remains and one discovery of three possible historic gravesites) were discovered in CRAs J-19 and J-21 and treated in accordance with PWCC's permit terms. A total of 58 prehistoric burials were found at 15 archaeological sites in CRA J-19; 12 prehistoric burials and one historic burial were found at six sites in CRA N-9; and, eight prehistoric burials and two historic burials were found at seven sites in CRA J-21. Discovered human remains and associated funerary objects have been documented, removed, and reburied in accordance with the ongoing program that has been established to comply with the permit terms. Through the BMAP, the anticipated impacts on archeological sites in the Affected CRAs have already been identified and mitigated, and no additional studies to recover information and artifacts within the Affected CRAs are proposed.

As mining has continued, additional cultural resources have been occasionally discovered and additional discoveries could be made under Alternative 1. By definition, it is not possible to predict unexpected discoveries, but the number of discoveries since 1990 (**Section 3.10**) suggests that continued coal mining under the Renewal would be unlikely to result in more than one or two additional unanticipated discoveries of archaeological, historical, or traditional cultural resources that could be affected by coal mining. Although continued mining in the Affected CRAs could have impacts on cultural resources, it is expected that continued

implementation of the standard conditions and permit terms described above satisfactorily mitigate any such impacts. Under Alternative 1, PWCC would continue to report any discovery of cultural resources and to suspend work in the area of the discovery until OSMRE determines appropriate disposition. In addition, PWCC would continue to address the potential effects on sacred and ceremonial sites that might be affected during the Renewal and address any human remains that might be disturbed in accordance with the NAGPRA and Navajo Nation Policy for the Protection of Jishchaá: Gravesites, Human Remains, and Funerary Items. If human remains are encountered, they would be either recorded and reburied in locations that would not be disturbed by future mining-related activities or fenced and avoided. The Tribes would participate in the development of reburial protocols and their consent for reburial would be required. In sum, potential direct and indirect impacts to cultural resources, human remains, and sacred and ceremonial sites would be long term but minor.

4.10.2 Alternative 2: No Action

Under Alternative 2, mining operations would cease in the Permit Area upon OSMRE's decision to deny the Renewal. There is the potential for unanticipated discoveries on 472 acres that would be disturbed in the Affected CRAs between July 6, 2015 and OSMRE's decision to deny the permit Renewal (none have yet occurred since July 6, 2015). These would be minor effects similar to under Alternative 1. PWCC would initiate closure activities and complete final reclamation per SMCRA requirements and Permit AZ-0001E. No additional impacts to cultural resources would be expected as a result of reclamation activities; however, if any cultural resources were discovered during the course of facility removal and reclamation activities, protection measures would be implemented pursuant to the terms of the permit. Under Alternative 2, potential direct and indirect impacts to cultural resources, human remains, and sacred and ceremonial sites would be negligible.

4.10.3 Mitigation

There would not be any mitigation necessary for cultural resources.

4.11 INDIAN TRUST ASSETS

4.11.1 Alternative 1: Renewal of Permit AZ-0001E

4.11.1.1 Minerals

Under the coal lease agreements, the Navajo Nation and Hopi Tribe would continue to receive combined annual lease, royalty, and bonus payments. These revenues would not be sensitive to fluctuations in interest rates and energy commodity prices and would escalate in response to general inflation. Although there would be a loss of Indian trust mineral assets as a result of mining activities, the impacts to these assets would be negligible because the existing lease agreements, permits, and rights-of-way were negotiated between PWCC, the Navajo Nation, and Hopi Tribe, and are therefore considered consistent with the Department of the Interior's trust responsibilities for Indian Trust Assets.

4.11.1.2 Land

Combined mining activities in the Affected CRAs would disturb 842 acres of land used for livestock grazing and traditional uses, resulting in a localized moderate and short-term impact. However, these disturbed lands would be reclaimed pursuant to the approved reclamation plan and existing lease agreements to support post-mining land uses such as livestock grazing, cultural plant gathering, or wildlife habitat. The reclaimed land would meet or exceed the local carrying capacity of pre-mine conditions; as such, the effects to Indian trust land assets would be negligible to minor and long-term. After satisfactory reclamation is determined by the OSMRE, BIA, Navajo Nation, and Hopi Tribe, and following the release of bonds, the control of surface use would revert back to the Navajo Nation and Hopi Tribe.

4.11.1.3 Water

The ongoing coal mining activities have the potential to impact the flow and quality of surface water and the shallow groundwater system, and the deeper N- and D-Aquifers. Qualitative assessment and measurements and data were used to assign the degree of impacts. Based on the findings, the effects on surface water flow would be minor and the effects on surface water quality would be short-term and negligible. Water quality effects in the Wepo Formation, alluvial aquifers, and associated springs and seeps would be negligible to minor, and would be localized to a few isolated locations (**Section 4.7**). Any impacts to existing water uses would be mitigated by PWCC ponds and impoundments and ongoing seep mitigation.

Beginning in 2006 through 2014, the Kayenta Mine operations pumped about 1,330 af/yr from the N-Aquifer, with a minor amount made available as a potable water supply to local residents. PWCC would continue to pay an average of $1.3 million in water royalties per year to the two tribes under lease agreements. The amount of water projected to be pumped from the N-Aquifer would continue at a lower rate (1,200 af/yr) under Alternative 1. Potential impacts to the aquifer under Alternative 1 would be negligible (**Section 4.7**); therefore, impacts to Indian trust water assets also would be negligible. Additionally, the Navajo Nation and Hopi Tribe would continue to be compensated for use of the aquifer water.

4.11.1.4 Hunting and Gathering and Other Natural Resources

The Navajo Nation and Hopi Tribe have rights to hunt and gather on their lands, as well as continue to use their lands for livestock grazing and any other traditional uses. Hunting and gathering would not be allowed in areas of active mining; however, these areas would be available following successful reclamation. The vegetation mix most likely would be different compared to pre-mining conditions, resulting in negligible to minor impacts to Indian trust hunting and gathering assets.

4.11.2 Alternative 2: No Action

Under Alternative 2, mining operations would cease in the Permit Area upon OSMRE's decision to deny the Renewal. Potential impacts to Indian Trust Assets would only occur on 472 acres in the Affected CRAs and only until OSMRE's decision to deny the permit Renewal. There would be negligible to minor effects similar to under Alternative 2. PWCC would initiate closure activities and complete final reclamation per SMCRA requirements and Permit AZ-0001E. Decommissioning and reclamation activities would occur under OSMRE and tribal guidelines and

the provisions of existing lease agreements, thereby reducing potential impacts to Indian trust land assets. After satisfactory reclamation is determined by the OSMRE, BIA, Navajo Nation, and Hopi Tribe, and following the release of bonds, the control of surface use would revert back to the Navajo Nation and Hopi Tribe.

Groundwater pumping would continue at reduced rates for decommissioning operations and reclamation, but would end as reclamation activities are completed and vegetation becomes established. Water royalty payments to the tribes would continue at a reduced rate until reclamation was complete and the reclaimed lands are returned to the tribes. Livestock grazing, hunting, gathering, and other traditional land uses would resume at the discretion of the tribal governments. The potential effects on Indian Trust Assets (minerals, land, water, hunting, gathering, and other natural resources) as a result of Alternative 2 would be negligible.

4.11.3 Mitigation

There would not be any mitigation necessary for Indian trust assets.

4.12 LAND USE AND RECREATION

4.12.1 Alternative 1: Renewal of Permit AZ-0001E

4.12.1.1 Land Use

Under Alternative 1, approximately 842 acres of potential rangeland dominated by piñon-juniper woodland and shrubland with low forage availability and quality would be disturbed as a result of mining in the Affected CRAs under Alternative 1. Approximately 8 AUMs would be removed from the study area based on the current weighted average stocking rate of 107 acres/AUM for these rangeland types (assuming 100 percent piñon-juniper woodland and shrubland coverage, decrease of 0.06 percent); this would be a negligible impact on grazing capacity in the study area.

Reclamation eventually would improve the forage productivity and quality of the land by converting the piñon-juniper woodlands to shrubland and grassland vegetation communities that have higher grazing productivity. Concurrent reclamation activities would occur immediately after an area is mined to completion, returning disturbed areas to productive livestock grazing lands, which is the primary historical land use in the area. The resulting shrub grassland communities would increase the livestock carrying capacity and would improve the potential for grazing management. Based on the revegetation monitoring results, forage production for livestock could increase to as much as 10 times over the original forage productivity of the land (OSMRE 1990). The stocking rate after reclamation would be managed at 4.6 acres/AUM, which would increase the AUMs to 183 in the Affected CRAs; this would be a short-term negligible adverse effect in the study area, but would be a moderate, long-term, beneficial impact on grazing capacity after reclamation in the Affected CRAs. Most of the currently reclaimed mine areas now provide a greater amount of forage vegetation than was available under pre-mine conditions; however, this use of the land would be realized only when a temporary moratorium on grazing reclaimed lands is not in effect, future reclamation is successful, and grazing is managed appropriately.

Water quality at impoundments and ponds within the Permit Area could exceed water quality standards for livestock as a result of mining in the Affected CRAs. Localized water quality exceedances could include high TDS, low pH, high levels of sulfate, or high levels of selenium (**Section 4.7.1.1**). Permanent water impoundments must meet specific performance standards as outlined in 30 CFR 816.49(b), including making water quality suitable for the intended land use of livestock grazing. PWCC is required to submit information to OSMRE to demonstrate that each of the permanent impoundments meets these performance standards. If any of the impoundments do not meet the performance standards, OSMRE would not approve these for retention in the landscape. PWCC's seepage management plan, and other environmental protection measures to protect water quality would help maintain or improve water quality standards, protect livestock, humans, and the environment. Localized areas with poor water quality could affect the health of livestock until reclamation of these areas is completed (approximately six years); however, protective measures such as using fence enclosures, the seep management plan, and pond reclamation would reduce these effects to negligible levels.

There are no households in the study area that would require relocation under Alternative 1.

4.12.1.2 Recreation

Under Alternative 1, recreation would be unavailable to the public on 842 acres in the long term until reclamation is completed; this would be a negligible effect due to the low intensity of recreation that currently occurs in the study area as well as the large acreage of other lands available for recreation. Although there are no developed recreation facilities in the study area, Alternative 1 could shift where dispersed recreation activities such as wildlife watching occur. The 842 acres under Alternative 1 would be available for dispersed recreation use by tribal members or members of the public with a permit to recreate on tribal land after reclamation is completed.

4.12.2 Alternative 2: No Action

Under Alternative 2, mining operations would cease in the Permit Area upon OSMRE's decision to deny the Renewal. Between July 6, 2015 and OSMRE's decision to deny the permit Renewal, 472 acres of potential rangeland with low forage available and quality would be removed in the Affected CRAs. Based on the stocking rate of 107 acres/AUM, approximately 3 AUMs would be removed during this period. PWCC would initiate closure activities and complete final reclamation per SMCRA requirements and Permit AZ-0001E. Forage production and recreational opportunities would be returned sooner to tribal members or those with a tribal permit, in the study area. This would be a moderate long-term beneficial impact after reclamation is complete. Less acres would be revegetated into improved livestock forage than under Alternative 1.

4.12.3 Mitigation

There would not be any mitigation necessary for land use or recreation.

4.13 VISUAL RESOURCES

4.13.1 Alternative 1: Renewal of Permit AZ-0001E

Continuing mining under Alternative 1 would create high visual contrasts with the surrounding natural and reclaimed landscapes. Short-term visual contrasts that would occur include changes in form and line of the topography and changes in appearance of the vegetation and soil. However, topography and vegetation would screen the most sensitive viewers – occupied structures within one mile of the Affected CRAs – from the mining operations. Occupied structures that are located in valleys would be blocked from viewing mining operations by the valley sides. Occupied structures on elevations above the Affected CRAs have topography that would block their views of the mining operations. Vegetation also could screen views, and the more distant viewers would perceive less contrast. The views of the mining operations from occupied residential structures would be completely or partially screened by topography and vegetation (PWCC 2012).

Sensitive viewers traveling on Navajo Route 41, from U.S. 160 would have most of their views screened by hills. Views of the mining operations would be brief for viewers moving along the road. Views from U.S. Highway 160 and Arizona Route 564 would be screened by topography. Reclamation would reduce the short-term contrasts of colors and textures related to vegetation removal. Most of the reclaimed areas would be revegetated with grasses, forbs, and shrubs. Some sections of the reclaimed areas would be chosen for cultural plant, woodland, and wildlife habitat revegetation.

Once mining operations end, the disturbed areas would be reclaimed to meet approved post-mining land uses as per the permit. Reclamation includes regrading the land to its approximate original contours, replacing topsoil, and replanting vegetation according to the approved post-mining land uses of livestock grazing, wildlife habitat, and cultural plant use (**Appendix A**). Reclaimed topography would vary from the natural landscape in scale, complexity, and slopes. This would create contrasts in form, line, and texture. Mine highwalls would be graded to a slope of 3:1 or less, and linear rock features and rock structures would be established for wildlife habitat. Once the vegetation has matured, the newer reclaimed areas would blend into the older ones, and there would be less contrast between the reclaimed landscape and the adjacent undisturbed landscape. The scenic integrity would blend from one landscape to another.

With little visibility of continued mining operations by the moderately and highly sensitive viewers, the relatively short-term high visual contrasts of the mining operations are anticipated to result in minor effects on visual resources. However, after reclamation is completed according to the requirements of the permit closure plan and SMCRA regulations, impacts on visual resources under Alternative 1 would be reduced to negligible.

Indirect effects on visual resources related to regional haze are provided in **Section 4.5.1.4**.

4.13.2 Alternative 2: No Action

Under Alternative 2, mining operations would cease in the Permit Area upon OSMRE's decision to deny the Renewal. The same changes to visual resources as would occur under Alternative 1 would occur on 472 acres in the Affected CRAs between July 6, 2015 and OSMRE's decision to

deny the permit Renewal. PWCC would initiate closure activities and complete final reclamation per SMCRA requirements and Permit AZ-0001E. Less acres of the natural landscape would be mined and these acres would not be converted to a reclaimed landscape. The short-term visual contrasts from mining operations in the Affected CRAs would cease. The long-term effects on visual contrasts of the reclaimed areas would be similar to Alternative 1. The reclamation activities would reduce the effects on visual resources to negligible over time.

4.13.3 Mitigation

There would not be any mitigation necessary for visual resources.

4.14 TRANSPORTATION AND ACCESS

4.14.1 Alternative 1: Renewal of Permit AZ-0001E

Under Alternative 1, the existing roads would continue to be used until the mining and reclamation operations are completed. Mining would be an extension of existing operations and would rely on existing transportation facilities. Ancillary roads leading to exploration and development areas, pit, and spoil ramps would be constructed and used to complete mining activities in the Affected CRAs. Because the rate of coal production under Alternative 1 would remain constant, vehicle traffic on the Permit Area roads, Navajo Route 41, U.S. Highway 160, and Arizona Route 89 would not increase from current levels. The mine-related vehicle traffic would not change during the permit period, and no changes to the transportation network would be required for mine-related vehicle traffic.

All roads used or built by PWCC on or after December 16, 1977 would be reclaimed to their original state by the conclusion of the reclamation period, unless these have been approved by the regulatory authority as part of the post-mining land use plan. There are about 57 miles of primary roads and 109 miles of ancillary roads that would be totally reclaimed, and 28 miles of primary haulage roads that would be narrowed for use as permanent roads for the public. Due to the size and nature of PWCC's mining activities, very few of the roads identified as part of the post-mining land use plan would be reclaimed until the end of mining. Exceptions include roads in the immediate vicinity of pits and ramps, which are created in the spoil and reclaimed as reclamation activities progress within a CRA. Consistent with 30 CFR Sections 133 and 150, mitigation measures would continue to be enforced through regulatory inspections and reporting (**Appendix B**). Mitigation requirements would continue through the conclusion of the reclamation period. The potential effects on traffic volumes and the existing transportation network would be negligible.

4.14.2 Alternative 2: No Action

Under Alternative 2, mining operations would cease in the Permit Area upon OSMRE's decision to deny the Renewal. The same transportation and access conditions would occur until OSMRE's decision to deny the permit Renewal. The impacts would be negligible. PWCC would initiate closure activities and complete final reclamation per SMCRA requirements and Permit AZ-0001E. Although vehicle traffic would be less than Alternative 1, reclamation-related traffic under Alternative 2 would still need to use the transportation network to complete reclamation

activities. However, under Alternative 2, there would be no increase in roadway development within the Permit Area, and roads not identified for retention in the post-mining land use plan would be reclaimed. The effects to transportation and access under Alternative 2 would be negligible.

4.14.3 Mitigation

There would not be any mitigation necessary for transportation and access.

4.15 SOCIAL AND ECONOMIC CONDITIONS

4.15.1 Alternative 1: Renewal of Permit AZ-0001E

Under Alternative 1, employment, benefits, and economic contributions from PWCC to the community (**Section 3.15**) would continue at current levels through December 22, 2019 (end of active mining) and reduced levels from December 22, 2019 to July 5, 2020. The number of people employed at the Kayenta Mine during the Renewal period would stay the same (317) through December 22, 2019, and the annual amount paid in salaries to the employees would be similar to the 2014 value of approximately $61 million. From December 22, 2019 through July 5, 2020, the employment would be approximately 175 people, and a reduced payroll. The coal production rate would remain constant through December 22, 2019, and royalties from PWCC to the Navajo and Hopi tribes would be maintained at current annual values. Other economic contributions of PWCC to the local economy community would be expected to remain the same, e.g., scholarship funds, property taxes, water fees, and grazing payments. Under Alternative 1, PWCC would contribute an additional $731 million to the local economy and community (**Table 4.15-1**). PWCC would continue to make annual payments into the Black Lung Disability Benefit program and Abandoned Mine Land Funds, which over the three-year period would total $21.4 million into these mining-related assistance programs.

Table 4.15-1 Economic Contribution, Alternative 1

Economic Contribution	Alternative 1 Total Economic Value ($)[1]
Payroll Expenses[2]	303 million
Navajo Nation and Hopi Scholarship Funds	2.0 million
Royalties and Coal Bonus Payments	240.5 million
Taxes and Fees	126.5 million
Water Fees and Electrical Payments	56.0 million
Grazing Compensation Payments	2.5 million
Total	**731 million**

[1] Calculated for the five-year permit renewal period, and assuming no change in current contribution rate/amount.
[2] Includes wages and salaries, retirement payments, and benefits.

Additional employees would be available from the existing workforce on the Navajo Nation and Hopi Reservation; therefore, no influx of residents would occur under Alternative 1. No additional demands on the existing infrastructure or services in the communities on or near the Permit Area would be anticipated. The social and economic contributions to the community would be a major, beneficial short-term impact.

4.15.2 Alternative 2: No Action

Under Alternative 2, mining operations would cease in the Permit Area upon OSMRE's decision to deny the Renewal. PWCC would initiate closure activities and complete final reclamation per SMCRA requirements and Permit AZ-0001E. Employment at the mine would be gradually reduced from 317 jobs to zero jobs in 2032. Based on the higher dependency ratios on the Navajo Nation and Hopi Reservation (**Section 3.15**), the loss in household income would have a greater effect on households than in areas where less persons per household depend on one income.

Under Alternative 2, economic contributions from the mine would still occur between July 6, 2015 and OSMRE's decision to deny the permit Renewal, which would be approximately $252 million. In comparison to Alternative 1, the local economy and community would receive $479 million less in economic contributions from the mine. In recent years, the revenue from the Kayenta Mine operation has been the single largest source of revenue in the Hopi and Navajo tribal budgets. The discontinuation of the mining operations at the Kayenta Mine under Alternative 2 would significantly influence the tribes' operating budgets, which control tribal facilities and programs such as education and health care. Local mining revenues support as much as 50 percent of the Hopi tribal government revenue, and as many as 500 jobs in the Hopi Tribe and local mining revenue funds as much as 26 percent of the total Navajo Nation non-grant budget. The loss of PWCC's contribution to local mining revenues would reduce the number of employment opportunities within the tribal organizations. While the Kayenta school district, which receives the most benefits from mining tax revenue, is an Arizona public school district, the majority of the students and employees of the district are members of the Hopi Tribe or Navajo Nation.

These social and economic impacts would be a major, adverse long-term impact associated with Alternative 2.

4.15.3 Mitigation

There would not be any mitigation necessary for social and economic conditions.

4.16 ENVIRONMENTAL JUSTICE

4.16.1 Alternative 1: Renewal of Permit AZ-0001E

Under Alternative 1, employment opportunities and revenues paid to the Navajo Nation and Hopi Tribe would continue through July 2020. Native Americans hold the majority of the jobs at Kayenta Mine and those related to the mining operation. In addition, the Township of Kayenta, which has an economy driven by the mine, the 14 Navajo Chapters within the Western and Chinle agencies that were identified within the area of socioeconomic influence, and the Hopi Village of Moenkopi are American Indian communities. The number of Kayenta Mine employees would remain at or near 2010 levels and there would be no direct or indirect effects on the local workforce. The continued operation of the Kayenta Mine would not require employees to move into or closer to the Permit Area. These social and economic effects would have a major, beneficial short-term impact that would disproportionately affect environmental justice populations.

Alternative 1 would have negligible to minor impacts on air quality (**Section 4.5**) in the study area; therefore, there would be negligible to minor impacts to environmental justice populations related to air quality. Similarly, Alternative 1 would have negligible impacts on GHGs and climate change (**Section 4.5.1.4**), which would consequently have a negligible impact on the environmental justice populations.

Noise from mining operations would remain at or near 2010 levels (**Section 4.6**) and the potential effects on environmental justice populations would be negligible.

The population directly affected by and concerned about the effects of water withdrawals upon the continuing availability of local water for grazing and agriculture is almost entirely an environmental justice population. Continuing use of the N-Aquifer wells by the mine operations would result in a continued concern that withdrawal of water from the N-Aquifer for mine-related purposes would interfere with water use for grazing, agriculture, and domestic wells. Almost all of the use of the N-Aquifer water other than by the Kayenta Mine is by the environmental justice populations. However, impacts on the N-Aquifer would be considered negligible, as there would be less pumping of the N-Aquifer than in the past (**Section 4.7.1.2**); therefore, the impact on environmental justice populations would be negligible.

The households that would experience the effects of mining on grazing lands are environmental justice populations. The effects on land use under Alternative 1 would be negligible after reclamation is completed (**Section 4.12.1**). Health and safety effects of continued mining operations also would have negligible effects on residents and employees of the mine (**Section 4.17**), and therefore the potential effects on environmental justice populations would be negligible.

No adverse human health (**Section 4.17**) or environmental effects would fall disproportionately on environmental justice populations under Alternative 1.

4.16.2 Alternative 2: No Action

Under Alternative 2, mining operations would cease in the Affected CRAs upon OSMRE's decision to deny the Renewal and no additional ground disturbing activities would occur. PWCC would initiate closure activities and complete final reclamation per SMCRA requirements and Permit AZ-0001E. Environmental justice populations would be beneficially affected by less mining traffic and noise. Less land would be disturbed by mining and would instead be available for the collection of plants and other materials used for medicinal, ceremonial, or household needs. More undisturbed land would remain available for grazing; however, in the long term, the unmined area would not be subject to reclamation revegetation and the corresponding improved productivity for livestock grazing.

Economic effects including the loss of 317 total jobs, 96 percent of which are currently held by Navajo and Hopi workers, and the loss of Kayenta Mine-related revenues of $479 million to the Navajo Nation and Hopi Tribe, would in turn reduce services and employment on the two reservations. This would be a major, long-term impact for the two tribes. Employment losses would have corresponding social effects and potentially result in relocation for affected Navajo and Hopi families or wage earners. These economic and social impacts would be considered long

term, major, and adverse, and they would accrue disproportionately on environmental justice populations.

4.16.3 Mitigation

There would not be any mitigation necessary for environmental justice.

4.17 HEALTH AND SAFETY

4.17.1 Alternative 1: Renewal of Permit AZ-0001E

Under Alternative 1, the current health and safety practices would continue. Regulatory changes in health and safety requirements would be included in standard operating procedures, and compliance with mandated safety rules would continue to be required. Similar safety risks would continue to be present, including exposure to dust, noise, heat stress, and chemicals. The opportunity for accidents due to working directly with or in proximity to large equipment would also be present. Blasting operations would continue with pre-blast surveys conducted as requested. The mine would continue to provide emergency health care services to the workforce and local residents Under Alternative 1, neither the type or quantity of any wastes generated and disposed of by the mine would change. These impacts on public health and safety would be negligible.

Air quality modeling (AERMOD) was conducted for both the Kayenta Mine and the NGS and the results of a combined impact methodology were used in the HHRA for the Kayenta Mine (Flatirons Technology 2016). The Kayenta Mine and NGS modeling receptors grids overlapped in a small region along the western edge of the mine's grid. As a result, a grid marker was selected to represent a combined impact assessment. Model results at these overlapping grid markers were applied as a single estimate of air quality impacts from one project site onto the other project site. A grid marker at 80 km from NGS was used for characterization of the impacts of NGS at the mine (Figure 6, Flatirons Technology 2016) and a receptor grid in the northwest corner of the mine model was used to characterize the impacts of the Kayenta Mine at NGS (Figure 7-1, MMA 2016).

The COPC 95 percent upper confidence limit (UCL) concentrations were applied directly to the respective source-group impacts for TSP and PM_{10} generated by AERMOD to determine the respective COPC impacts. The PM_{10} air concentration and TSP deposition flux from the coal and dirt source groups at each receptor were multiplied by the respective 95 percent UCL COPC concentration, and then the coal COPC and dirt COPC products were summed to obtain the total impacts from the mine for that COPC (MMA 2016).

Impacts predicted by AERMOD are linear with respect to emission rates, given identical source parameter inputs. Thus, this post-processing routine generates the same results as would be achieved if the individual COPC emissions were modeled in AERMOD. Tailpipe emissions were considered as a COPC entity unto itself as DPM, and the PM concentration and deposition results for the tailpipe sources equate to DPM without further post-processing.

COPC air concentration and deposition flux impacts for this single receptor were generated for the 8.1 mtpy production scenario for years 2027 and 2042 using both TSP and PM_{10} emissions.

The 8.1 mtpy production scenario represents the highest impacts from the Kayenta Mine at this distance. Five-year averages were generated for this particular analysis, better reflecting the overall mine impact. Each COPC air concentration and deposition flux was calculated using the equations described in the Kayenta Mine modeling report (MMA 2016) as the proxy impact to be added to the NGS receptors for their combined risk assessment.

The HHRA performed for direct effects on human health of mining under Alternative 1 (Flatirons Toxicology 2016) indicated that:

- The only potentially significant health risk exposure pathway was air via inhalation of fugitive dust and diesel emissions from mining activities.
- The chronic noncancer HI would be 0.02, which is substantially less than the target HI value of 1.
- The hypothetical cancer risk would be 1 in 1,000,000 which is within the EPA acceptable cancer risk range of 1 in 1,000,000 to 1 in 10,000.

The results of the HHRA for mining under Alternative 1 (Flatirons Toxicology 2016) demonstrate that the direct effects on human health would be negligible.

Indirect effects on human health under Alternative 1 would result from the burning of Kayenta Mine coal at the NGS during the Renewal period. The results of the HHRA performed for the maximum exposed individual (MEI) for the Alternative 1 (3-Unit) risk case (Ramboll Environ 2015) indicated that:

- The primary exposure pathway identified was inhalation of DPM in air.
- The chronic noncancer HI estimate ranged from 0.01 (Recreational Users at Lake Powell [child]) to 0.2 (Child Farmer); which is substantially less than the target HI value of 1.
- The hypothetical cancer risk estimates for the MEI under Alternative 1 varied between 3 in 100,000,000 (Recreational Users at Lake Powell) to 4 in 100,000 (Farm Family), which is within the EPA acceptable cancer risk range of 1 in 1,000,000 to 1 in 10,000.
- The average daily intake of dioxins and furans by breastfeeding infants would range from 0.0004 percent (Residents) to 0.009 percent (Farm Families) of the permissible maximums for these COPCs.
- Estimated blood levels of lead in children would be below EPA recommended reference levels.

The results of the HHRA for the burning of Kayenta Mine coal at the NGS under Alternative 1 (Ramboll Environ 2015) demonstrate that the indirect effects on human health would be negligible.

Health effects related to the burning of Kayenta Mine coal for Navajo household heating and cooking would depend on the proper use of the coal, including the adequacy of stoves, boilers, and ventilation. PWCC would continue to provide information on the safe handling and burning of coal indoors during the Renewal period.

4.17.2 Alternative 2: No Action

Under Alternative 2, mining operations would cease in the Permit Area upon OSMRE's decision to deny the Renewal. The effects on human health would be similar to under Alternative 1 and would be negligible. PWCC would initiate closure activities and complete final reclamation per SMCRA requirements and Permit AZ-0001E. During the reclamation period, PWCC would continue to comply with all applicable federal, tribal, and state rules and regulations regarding health and safety and handling and disposal of hazardous materials and wastes. Safety procedures regarding truck traffic would continue to be observed through the reclamation period, although fewer vehicles would be required for these activities. Emergency health care services provided by the mine would continue during the three-year reclamation period but would cease afterwards during the reclamation monitoring period. This would be a moderate, long-term effect on the availability of emergency health services in the study area.

4.17.3 Mitigation

There would not be any mitigation necessary for health and safety.

5.0 CUMULATIVE IMPACTS

5.1 INTRODUCTION

The cumulative impact analysis is required to evaluate the "impact on the environment which results from the incremental impact of [Alternative 1] when added to other past, present, and reasonably foreseeable future actions" (40 CFR 1508.7). The contribution to cumulative effects of Alternative 2 are described where cumulative impacts related to No Action would be relevant.

Cumulative impacts can result from individually minor but collectively significant actions that take place over time. The following analysis identifies those resources where adverse effects from the alternatives identified in **Chapter 4** may combine with the effects of other past, present, and reasonably foreseeable actions (**Table 5.3-1**), and assesses the contributing effect of the alternative compared to the combined effect on those resources. According to Department of the Interior NEPA regulations, 43 CFR 46.115, past actions in cumulative effect analysis must be considered in accordance with the CEQ's June 2005 guidance or superseding CEQ guidance. The June 2005 memorandum, *Guidance on the Consideration of Past Actions in Cumulative Effects Analysis*, provides that "[t]he environmental analysis required under NEPA is forward-looking, in that it focuses on the potential impacts of the proposed action that the agency is considering…[w]ith regard to past actions, agencies look for present effects of past actions that are, in the judgment of the agency, relevant and useful because they have a significant cause-and-effect relationship with the direct and indirect effects of the proposal for agency action and its alternatives" (CEQ 2005). Because there would not be any changes to noise and vibration or transportation and access under the Renewal, these resources are not discussed in this chapter.

CEQ has further advised that "[t]here may be instances when the timeframe of the project-specific analysis will need to be expanded to encompass cumulative effects occurring further into the future" (CEQ, *Considering Cumulative Effects Under the National Environmental Policy Act*, January 1997). For this action, the temporal scope of analysis, as well as the geographic scope of cumulative analysis for each resource, also known as the CIAA (**Figures 5.1-1** and **5.1-2**), both depend upon the affected resource and the extent to which there is a combined effect from the various actions. Consequently, the CIAA and the duration of the combined effects are described below in relation to each relevant resource or group of resources.

The Renewal period would be from July 6, 2015 to July 5, 2020; the Renewal action would not authorize any mining beyond July 5, 2020. The Renewal is presumptively approved under SMCRA with limited discretion granted to OSMRE to deny a renewal application. However, it is currently likely that the NGS will operate only until December 22, 2019. Since the NGS is the only market for the Kayenta Mine coal, Kayenta coal mining operations under Alternative 1 for the Renewal also likely would cease on December 22, 2019[1], although reclamation activities would continue beyond that date through the end of the Renewal period, July 5, 2020, and until PWCC's reclamation obligations are met. Under Alternative 2, mining and NGS operations would cease

[1] For the purposes of this analysis, it will be assumed to cease on December 22, 2019.

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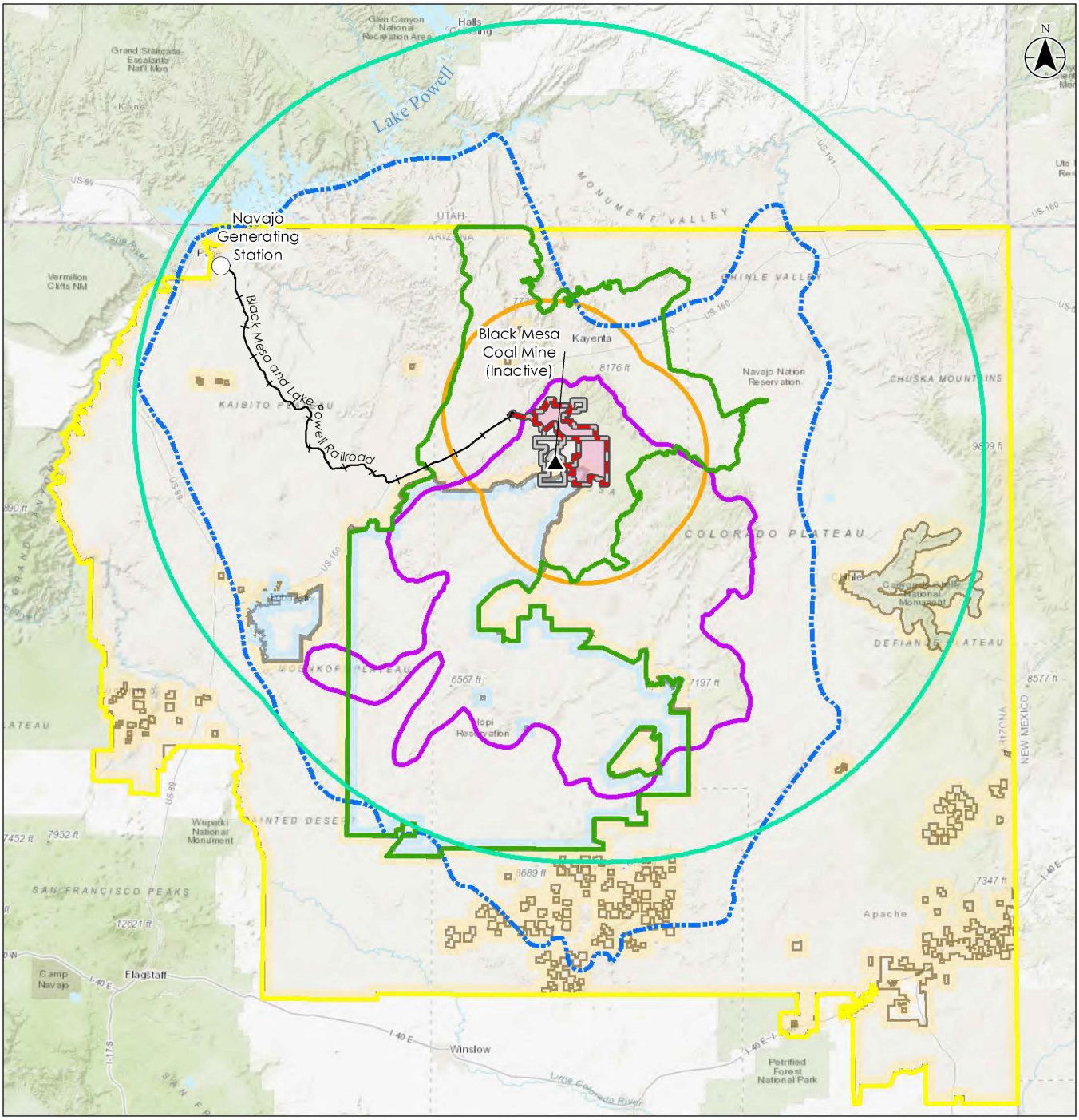

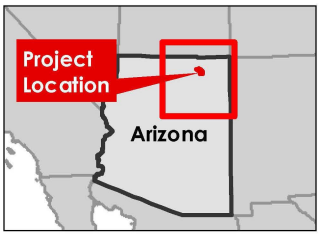

Notes

1. Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 Feet
2. Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Legend

- Black Mesa Coal Mine (Inactive)
- Navajo Generating Station (NGS)
- Railroad
- Kayenta Mine Permit Area
- PWCC Lease Area
- CIAA for Indian Trust Assets
- CIAA for Geology & Mineral Resources, Soils, Fish & Wildlife, Vegetation, and Topography
- CIAA for Social & Economic Conditions and Environmental Justice
- CIAA for Visual Resources
- CIAA for Air and Climate Resources
- CIAA for Land Use
- CIAA for Water Resources

Land Status

- Hopi Indian Res.
- Navajo Indian Res.

0 10 20 miles

1:1,600,000 (at original document size of 8.5x11)

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Project Location 203706045
T35N R18E, T35N R19E, T36N R17E, T36N R18E, T36N R19E, T37N R18E
Navajo County, AZ

Prepared by CLG on 2017-09-21
Technical Review by SL on 2017-09-21
Independent Review by DK on 2017-09-21

Client/Project
PWCC
Kayenta Mine SMCRA Permit
Environmental Assessment

Figure No.
5.1-1

Title
Cumulative Impacts Analysis Areas (CIAA) for All Resources Except for Air and Climate Resources

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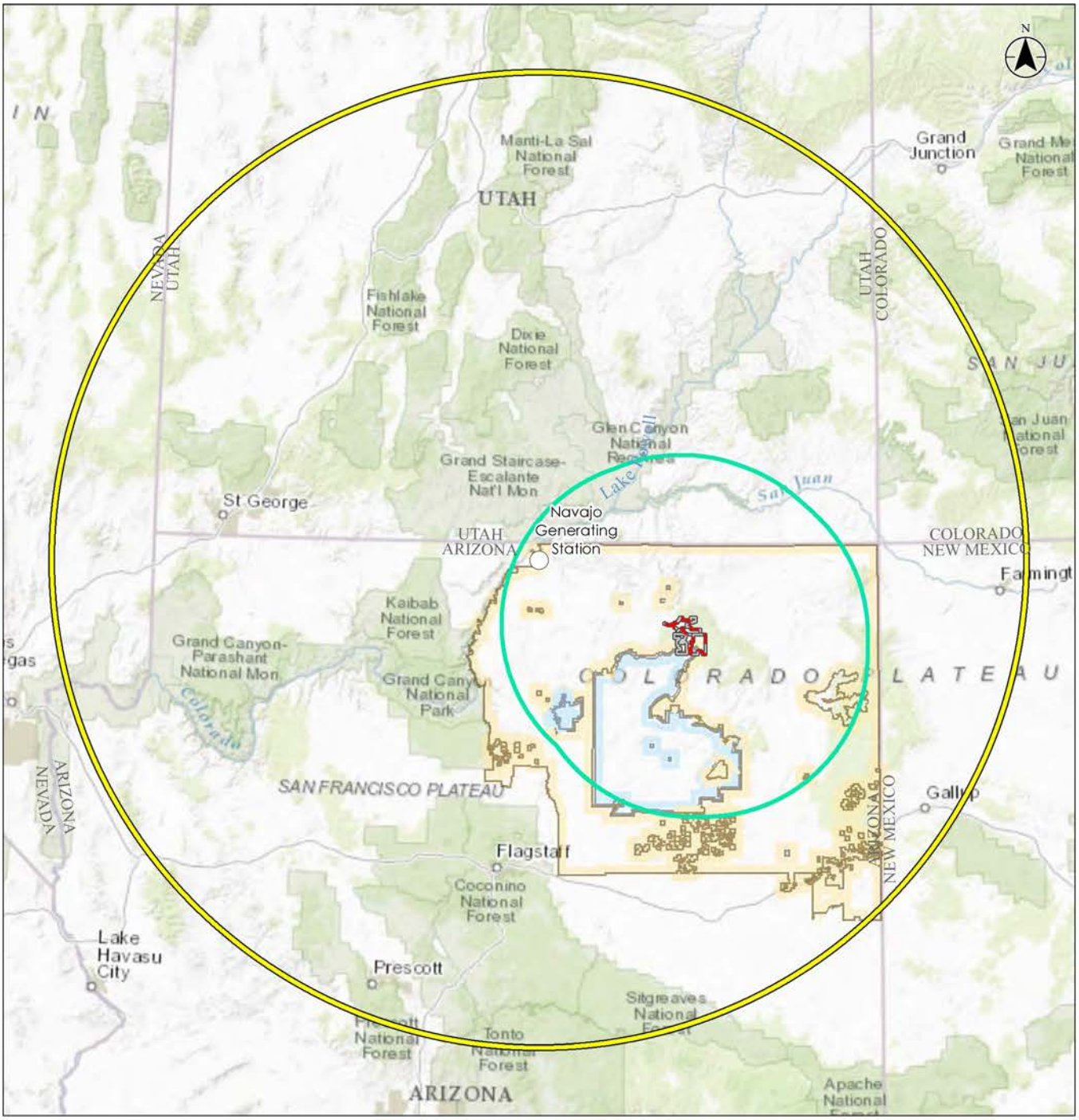

Legend

- Navajo Generating Station (NGS)
- Kayenta Mine Permit Area
- PWCC Lease Area
- 100-km of Kayenta Mine Permit Area CIAA
- 300-km of NGS CIAA

Land Status

- Hopi Indian Res.
- Navajo Indian Res.

0 20 40 miles

1:3,712,029 (at original document size of 8.5x11)

Stantec

Project Location 203706045

T35N R18E, T35N R19E, T36N R17E, T36N R18E, T36N R19E, T37N R18E
Navajo County, AZ

Prepared by CLG on 2017-01-20
Technical Review by EC on 2017-01-20
Independent Review by DK on 2017-01-20

Client/Project
PWCC
Kayenta Mine SMCRA Permit
Environmental Assessment

Figure No.
5.1-2

Title
Cumulative Impacts Analysis Areas (CIAA) for Air and Climate Resources

Notes

1. Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 Feet
2. Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

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V:\2037\Active\203706045\03_data\gis_cad\gis\maps\EA\Ch 5\Figure 5.1_2 Air Quality CIAAs.mxd Revised: 2017-01-20 By: cgallegos

upon OSMRE's decision to deny the Renewal. Final reclamation operations would continue until PWCC's reclamation obligations are met. For this cumulative effects analysis, only those reasonably foreseeable future actions that would overlap with Kayenta Mine active mining and reclamation operations during and beyond the Renewal period – until PWCC's reclamation obligations are met – are analyzed.

In an effort to provide a conservative analysis, impacts related to the combustion of Kayenta Mine coal during the Renewal period, but ending on December 22, 2019 with the shutdown of the NGS, were analyzed in **Chapter 4** as indirect effects of Alternative 1 for air quality and climate. Other impacts from the operation of the NGS during the Renewal period are addressed as cumulative impacts only to the extent that they overlap or combine with those of the Renewal. The 1969 lease for the NGS expires in December 2019. The BOR and BIA are preparing an EA to evaluate the potential environmental effects of proposed Federal actions to extend the time available to retire the NGS and related facilities under a replacement lease and related agreements (New Lease). The purpose of the federal action in that EA is for the U.S., acting through BOR, to consent to the New Lease, and for BIA approval of the New Lease and issuance of the appropriate grants to operate the NGS through December 2019 followed by its retirement and decommissioning. The New Lease would allow generation to occur through December 22, 2019, allow five years after that for retirement of the NGS and its associated facilities, and provide access for remediation and long-term monitoring of the plant site and ash disposal area.

Because the New Lease does not provide for operation of the NGS beyond December 22, 2019, the relevant indirect impacts associated with the power generation during the Renewal are already evaluated in **Chapter 4**. Accordingly, cumulative impacts, to the extent any occur, would be the result of post-2020 retirement and remediation activities at the NGS when combined with the reclamation activities at Kayenta Mine or when combined with any lasting effects from the mine operations beyond the Renewal period.

5.2 PAST AND PRESENT ACTIONS

Past and present actions in the general area include coal mining, electricity generation, community water systems, ranching, and agriculture. Also, the area has been previously developed with roads, housing, and the electric railroad from the Kayenta Mine to the NGS.

5.2.1 Coal Mining

Past coal mining in the area began in 1973 with the Kayenta Mine, which supplies coal to the NGS, and in 1970 with the Black Mesa Mine that supplied coal to the Mohave Generating Station. The Mohave Generating Station was closed by December 31, 2005 and was decommissioned afterwards. The Black Mesa Mine ceased shipping coal to the Black Mesa Pipeline Company and Mohave Generating Station as of December 31, 2005. Approximately 6,500 acres were disturbed as part of the Black Mesa Mine operations and approximately 5,900 of those have been reclaimed (graded, topsoiled, and seeded) as of September 2016. There are no other active coal mines within the CIAAs.

As of September 2016, about 19,050 acres have been disturbed at the Kayenta Mine, of which 12,200 acres have been reclaimed. Approximately 10,397 acres of that disturbance, and

7,225 acres of reclamation to some degree, have occurred in the Affected CRAs (**Table 2.2-1**). All areas disturbed by the mining operations at the Kayenta Mine would be reclaimed in accordance with permit requirements to meet post mining land uses of livestock grazing, wildlife habitat, and cultural plant use.

5.2.2 Electricity Generation

The NGS is the only coal-fired power plant within the CIAAs (**Figures 5.1-1** and **5.1-2**). The indirect effects of the present operation of the NGS (i.e., during the Renewal period up to December 22, 2019) have been analyzed in **Chapter 4**.

The NGS has historically employed approximately 553 full- and part-time employees, almost 90 percent of whom are Navajo or Hopi, with a payroll for 2010 that exceeded $43 million. About 75 percent of the employees live in Page, LeChee, and Kaibeto, Arizona, close to where NGS is located, and about 11 percent live in other communities within the Navajo and Hopi reservations. The remaining employees reside in Gallup, New Mexico; southern Utah; Flagstaff, Arizona; and the Phoenix, Arizona metropolitan area. The NGS also employs hundreds of other Native Americans on a part-time basis for maintenance activities.

The NGS also has historically provided a significant source of revenue to the Hopi Tribe and Navajo Nation through permit fees, lease payments, scholarships, and other contributions. Between 2005 and 2010 the average annual EPA Title V Emission Permit fee was $367,208 and lease payments were $608,000 per year. The NGS also has provided more than $83,000 in college scholarship funding over the last six years. The NGS has regularly provided financial support for various community efforts in the City of Page and surrounding Navajo community including the Technology Center at the Page campus of Coconino Community College, and the LeChee Chapter of the Navajo Nation for the LeChee Senior Citizen Center (OSMRE 2011b).

The LeChee Electrification project that provides electricity to 63 homes was completed in 2015. The project included construction of over 75 miles of power line.

5.2.3 Community Water Systems

The BIA, NTUA, and Hopi Tribe operate about 70 N-Aquifer wells that are combined into 28 water supply systems that provide water to communities near Black Mesa. The closest communities to the PWCC wells are Forest Lake, Kitsillie, Chilchinbito, and Kayenta. The largest water users are Tuba City, Kayenta, and Shonto (Truini et al. 2005).

Community pumping would continue to increase during the period from 2015 to 2032 and beyond due to increased demand for water. The projected conservative increase in demand is around 2.7 percent per year (OSMRE 2011b). Community water use in 2008 was around 2,900 af/yr. Projected water use by 2025 at a growth rate of 2.7 percent per year is around 4,500 af/yr; by year 2038, community water use would be around 5,400 af/yr.

5.2.4 Ranching and Agriculture

Many residents graze livestock (mainly cattle, sheep, and goats) on reclaimed and undisturbed lands in the region, as well as within the Permit Area, for a food source and for economic and

cultural reasons. Grazing permits issued by the BIA prescribe the units and number of animals that can be grazed. Livestock grazing occurs year-round, but this practice has proven not to be sustainable for the region. Drought conditions and over-grazing have compromised the overall condition of certain reclaimed areas where grazing has been allowed; therefore, in 2015, a temporary moratorium was placed on livestock grazing on reclaimed areas in the Permit Area. However, in 2016, due to improved range conditions, the moratorium was lifted and grazing resumed. Livestock ranching, without proper management, can impact water resources, wetlands, and vegetation and may potentially create competition for resources with big game species.

Other agriculture-related uses of the land by residents in the region, as well as within the Permit Area, include the gathering of plants for food, medicine, cultural purposes, and firewood, and dry land farming small agricultural plots (approximately four to five acres in size).

5.3 REASONABLY FORESEEABLE FUTURE ACTIONS

Reasonably foreseeable future actions included here are those that would intersect or interact with Kayenta Mine operations within the Renewal period and/or the reclamation that would follow the Renewal. Reasonably foreseeable future actions within and in the vicinity of the Permit Area and the CIAAs include retirement and decommissioning of the NGS; power line construction, operation, and maintenance[2]; water supply improvements including pipeline construction, the Manymules Water Development project, and community groundwater pumping; road construction and maintenance; housing development; grazing; ranching; and agriculture. **Table 5.3-1** describes each action that was considered for the cumulative analysis; however, not all actions have a combined effect on all resources. As explained above, the following cumulative impact analysis looks only at those resources for which direct and indirect impacts from the alternatives described in **Chapter 4** would overlap and/or combine with the quantified or qualified effects of those past, present, and reasonably foreseeable actions identified in **Table 5.3-1**. The future actions described in this analysis are those that are reasonably foreseeable; that is, they are prior actions that are ongoing (and would continue into the future), pending applications for government approval, proposed actions that are already funded for future implementation, or those that are included in firm near-term plans.

Table 5.3-1 Past, Present, and Reasonably Foreseeable Projects

Type	Project	Status	Description
Energy Development	LeChee Electrification Project	Past and Present	75+ miles of power line and 63 residential connections.

[2] Not related to the NGS.

Type	Project	Status	Description
Groundwater Use	Community Well Fields	Past, Present, and Future	The BIA, NTUA, and Hopi Tribe operate about 70 N-Aquifer wells that are combined into 28 water supply systems that provide water to communities near Black Mesa. The closest communities to the PWCC wells are Forest Lake, Kitsillie, Chilchinbito, and Kayenta. The largest water users are Tuba City, Kayenta, and Shonto (Truini et al. 2005). Community pumping would continue to increase during the period from 2015 to 2032 and beyond due to increased demand for water. The projected conservative increase in demand is around 2.7 percent per year (OSMRE 2011b). Community water use in 2008 was around 2,900 af/yr. Projected water use by 2025 at a growth rate of 2.7 percent per year is around 4,500 af/yr; by year 2038, community water use would be around 5,400 af/yr.
Mineral and Energy Development	Coal Resource Development, Kayenta Mine	Past	Completed coal mining, regrading, and reclamation. A total of 19,050 acres have been disturbed; of that, 12,200 acres have been reclaimed as of September 2016.
Mineral and Energy Development	Black Mesa Mine	Past	PWCC began construction operations for mining on Black Mesa in 1968; coal production at Black Mesa Mine began in 1971. Until 2005, this was one of North America's largest strip coal mining operation and site of the only operating long-distance coal slurry pipeline (owned by Black Mesa Pipeline Company). During its operation, the Black Mesa coal mine supplied the Mohave Generating Station, a power plant in Laughlin, Nevada, via the 273-mile-long pipeline. Coal shipments ceased as of December 31, 2005, after which the Mohave Generating Station was decommissioned and portions of the coal slurry pipeline were removed. Approximately 6,500 acres were disturbed; of that about 5,900 acres have been reclaimed as of September 2016.
Power Plant	NGS	Past, Present, Future	Located about five miles east of Page, Arizona, the NGS is a coal-fired power plant that began commercial operation in 1974, with a capacity of 2,250 MW from three 750-MW units and provides power to more than one million electric customers in Arizona, California, and Nevada. Coal mined at the Kayenta Mine (60 miles to the southeast) is the only source of coal for the power plant and is hauled by the Black Mesa and Lake Powell Railroad (electric). The BOR and BIA have proposed an extension lease for the NGS that would result in operation of the NGS until December 2019, followed by the retirement and decommissioning of the facility. *The indirect effects of the NGS coal combustion on air quality, water quality, special status wildlife, and human health are analyzed in* ***Chapter 4*** *of this EA.*
Water Supply Improvements	Manymules	Present and Future	Using two PWCC existing water wells and a portion of a PWCC water line, the Manymules project when completed would convey a high-quality sustainable water supply to residences within the Permit Area using funds from Indian Health Service and other entities. The project includes 46 miles of water pipeline, two water treatment units, pump stations, and water storage. The total 2030 water demand projected for the Manymules project is about 252 af/yr. Based on conceptual level designs, the Navajo Nation Department of Water Resources estimates the project cost is approximately $10.6 million dollars.

5.4 GEOLOGIC, MINERAL, AND PALEONTOLOGICAL RESOURCES

The CIAA for geologic, mineral, and paleontological resources is the Black Mesa coal field (**Figure 5.1-1**; 1.8 million acres). The cumulative impacts from Alternative 1 would be from the past, present, and continued removal of coal from the Wepo Formation that would occur under the proposed NGS-KMC Project. Since 1973, 320 mt of coal has been extracted at Kayenta Mine. Under Alternative 1, approximately 40 mt more would be mined between July 6, 2015 and December 22, 2019, which would contribute a negligible cumulative effect on the coal reserves in the Wepo Formation, which contains 4.8 billion tons of coal.

Other actions that may cumulatively impact geologic, mineral, and paleontological resources are limited to additional future mining and oil and gas development. However, there is no reasonably foreseeable future mining other than the Renewal or oil and gas development in the CIAA.

5.5 SOIL RESOURCES

The CIAA for soils is the Black Mesa coal field (**Figure 5.1-1**; 1.8 million acres). Past, present, and reasonably foreseeable actions in the region that have or are expected to impact soils include activities in the current Permit Area, power line construction, pipeline construction and other water developments, continued grazing, agriculture, roads and housing development, and other surface disturbing projects described in **Table 5.3-1**. These activities result in a range of short- and long-term impacts to soils including temporarily or permanently increasing disturbance of soils, temporarily or permanently increasing erosion in areas where best management practices or reclamation are not employed, and reducing soil loss to erosion where reclamation and revegetation occurs.

Surface disturbance from past coal mining in the CIAA totals 25,550 acres, which includes 18,150 acres that have been reclaimed as of September 2016. This represents 1.4 percent of the CIAA.

Coal mining during the Renewal period, the Manymules water improvement project, ranching, and agriculture would disturb an unknown acreage of soils and alter the existing soil profiles in the CIAA. Soils removed from the Affected CRAs during the Renewal period would be either directly placed on the regraded slopes or stockpiled for use during future reclamation activities. These stockpiles could result in wind and water erosion in localized areas; however, PWCC best management practices and reclamation activities of diverting runoff away from stockpiles, placing stockpiled soil on a stable site protected from wind and water erosion, replanting the stockpiles with a stabilizing seed mix, mulching, and not disturbing them until required for redistribution reduces the potential for soil loss. Soils disturbed by the Manymules project would be temporary in nature, but it is unknown if stockpiles would be used during construction.

Mined areas are reclaimed using fractured overburden that is graded to approximate landforms and drainage characteristics that existed prior to mining, and overlain with soil to create a 4-foot-thick suitable plant root zone over the entire reclaimed area and established with a diverse and permanent vegetation cover. Reclamation of the Affected CRAs would improve soil productivity and stability on 3,493 acres (**Table 2.3-1**, total acres regraded and reclaimed) of the

soils within the CIAA. The contribution to cumulative effects of Alternative 1 on soil loss and productivity when combined with other cumulative actions would be negligible.

5.6 LANDFORMS AND TOPOGRAPHY

The CIAA for topography is the Black Mesa coal field (**Figure 5.1-1**; 1.8 million acres). Surface disturbance from past coal mining totals approximately 25,550 acres, of which 18,150 acres has been reclaimed as of September 2016. (PWCC 2016). This disturbance represents 1.4 percent of the CIAA. There are no reasonably foreseeable actions that would have noticeable effects on landforms and topography. The additional disturbance of 842 acres under the Renewal would add negligible cumulative effects to landforms and topography.

5.7 AIR AND CLIMATE RESOURCES

The CIAAs for air and climate resources are a 100-km area centered on the Kayenta Mine Permit Area and – up until 2019 when the NGS shuts down (**Section 5.1**)[3] – a 300-km radius around the NGS, respectively **(Figure 5.1-2**).

Regional air quality is good with no non-attainment areas within 300 km of the NGS. Other major emission sources within the 300-km region include coal-fired and natural gas power plants, oil and gas compressor stations and gas processing plants, cement plants, and other industrial sources (**Table 5.7-1**). Emissions from regional urban sources, as well as pollutants transported over long distances (e.g., mercury from China) were included in the monitored background concentrations. There are no reasonably foreseeable new sources of air emissions within the 50-km AERMOD modeling area. Thus, the contribution to cumulative effects from Alternative 1 would be related to only direct and indirect emissions associated with Alternative 1 as well as past effects.

Table 5.7-1 Major Emission Sources, Associated Emissions in the NGS CIAA

Facility	Pollutant Concentration (tpy)[1]				
	NO_X	SO_2	PM_{10}	$PM_{2.5}$	VOC
Arizona Public Service Company - Cholla Power Plant	10,995	6,738	378	361	-
Ash Grove Cement Company: Leamington Cement Plant	1,729	-	-	-	-
Catalyst Paper (Snowflake) Inc.	2,184	2,896	133	110	-
Chemical Lime Nelson Plant	1,103	1,995	300	-	-
Coronado Generating Plant	9,017	7,352	768	594	-
El Paso Natural Gas - Mojave Topock Compressor Station	118	-	-	-	-
El Paso Natural Gas - Williams Compressor Station	915	-	-	-	-
ETC Canyon Pipeline, LLC: San Arroyo Plant	192	-	-	-	-
Four Corners Power Plant	38,729	11,822	3,117	1,859	15
Genpak Corporation: Polystyrene Foam Production Facility	-	-	-	-	107
Graymont Western Us Incorporated: Cricket Mountain Plant	1,065	-	225	121	-

[3] After 2020 the CIAA does not include the 300 km radius around the NGS because there will not be NGS emissions and any deposition impacts from the 2015-2020 (Renewal period) operation would be negligible.

Facility	Pollutant Concentration (tpy)[1]				
	NO_X	SO_2	PM_{10}	$PM_{2.5}$	VOC
Intermountain Power Service Corporation: Intermountain Generation Station	25,296	4,937	1,703	1,398	-
Union Pacific Railyard; Lynndyl, Utah	194	-	-	-	-
Navajo Generating Station	20,468	9,720	2,172	1,502	250
Novo Biopower, LLC	212	-	-	-	-
Pacificorp: Carbon Power Plant	3,665	7,740	633	532	-
Pacificorp: Hunter Power Plant	13,720	4,662	595	349	117
Pacificorp: Huntington Power Plant	6,192	2,531	428	121	-
Patara Midstream, LLC: Lisbon Natural Gas Processing Plant	157	-	-	-	-
Phoenix Cement – Clarkdale, Arizona	716	-	-	-	-
San Juan Generating Station	17,104	4,741	496	438	192
Sunnyside Cogeneration Associates: SunnysideCogeneration Facility	421	545	-	-	-
Tucson Electric Power Company - Springerville	6,859	6,050	2,913	2,104	211
BNSF Railyard; Winslow, Arizona	256	-	-	-	-
Total Emissions	**161,307**	**71,729**	**13,861**	**9,489**	**892**

Table 5.7-1 lists data from the EPA source inventory for 2011 for major sources (i.e., with emissions of any pollutant above 100 tpy), for sources in southern Utah, northern Arizona, and the northwestern corner of New Mexico (San Juan County). Note that those pollutants less than 100 tpy were assumed to be zero. This approach is both consistent with the analysis prepared for the NGS-KMC DEIS (BOR 2016) and predicts a more conservative contribution from the NGS when compared to the cumulative totals as outlined in **Tables 5.7-2** and **5.7-3**.

Table 5.7-2 Contribution of Alternative 1 to Cumulative Emissions, Criteria Pollutants

Activity	PM_{10} (tpy)	$PM_{2.5}$ (tpy)	NO_x (tpy)	VOC (tpy)	SO_2 (tpy)
Mining direct emissions	745	115	617	36.86	0.7
NGS indirect emissions	2,172	1,502	20,468	250	9,720
Total cumulative emissions (all sources)[1]	14,607	9,604	161,924	929	71,730
Contribution of mining and reclamation to cumulative emissions	5.10%	1.20%	0.38%	3.97%	0.001%
Contribution of NGS to cumulative emissions	14.87%	15.64%	12.64%	26.91%	13.55%

[1] Includes all emissions identified in **Table 5.7-1** plus the direct mining emissions. NGS values are already included in **Table 5.7-1**.

Table 5.7-3 Cumulative Emissions Contribution for Alternative 2

	PM_{10} (tpy)	$PM_{2.5}$ (tpy)	NO_x (tpy)	SO_2 (tpy)	VOC (tpy)
July 2015 - December 2015					
Direct mine emissions	377	57.5	291.5	0.35	18.4
Indirect NGS emissions	1,086	752	10,233	4,860	125
Total cumulative emissions (all sources)[1]	13,152	8,796	151,364	66,869	785

	PM_{10} (tpy)	$PM_{2.5}$ (tpy)	NO_x (tpy)	SO_2 (tpy)	VOC (tpy)
Contribution of mining and reclamation to cumulative emissions	2.87%	0.65%	0.19%	0.0005%	2.87%
Contribution of NGS to cumulative emissions	8.26%	8.54%	6.76%	7.27%	15.92%
2016					
Direct mine emissions	745	115	617	0.7	36.86
Indirect NGS emissions	2,172	1502	20,468	9,720	250
Total cumulative emissions (all sources)[1]	14,607	9,604	161,924	71,730	929
Contribution of mining and reclamation to cumulative emissions	5.10%	1.20%	0.38%	0.001%	3.97%
Contribution of NGS to cumulative emissions	14.87%	15.64%	12.64%	26.91%	31.8%
January 2017-August 2017					
Direct mine emissions	496	77	411	0.47	24.6
Indirect NGS emissions	1,448	1,001	13,644	6,479	167
Total cumulative emissions (all sources)[1]	13,883	9,103	155,100	68,489	846
Contribution of mining and reclamation to cumulative emissions	3.57%	0.85%	0.26%	0.0007%	2.91%
Contribution of NGS to cumulative emissions	10.43%	11.00%	8.80%	9.46%	19.74%

[1] Includes all emissions identified in **Table 5.7-1** plus the direct mining emissions. NGS values are already included in **Table 5.7-1**. Also the cumulative total is reduced for 2015 as NGS emissions are reduced by 50% (July – December). The 2017 cumulative total is reduced as the NGS emissions are reduced 33.3% (January – August).

5.7.1 Cumulative Criteria Pollutant Emissions Contributions

The annual mining rate of 8.1 mt generates both direct mining and indirect NGS coal combustion criteria pollutant emissions as all Kayenta Mine coal production would be utilized by the NGS (**Section 4.5.1**). These emissions contribute to the cumulative criteria pollutants generated by all applicable sources both within the mine and the NGS CIAAs. However, criteria pollutants generally dissipate and cannot be distinguished from background levels beyond approximately 50 km (31 miles) from the source. The mine is about 97 km (60 mi) from the NGS; therefore, the NGS and Kayenta Mine emissions were not modeled together and combining emissions from both the NGS and Kayenta Mine for comparison to total major source emission would not be appropriate. Criteria pollutant emissions totals generated by direct mining activities and indirect coal combustion activities for Alternative 1 are provided and their contributions to cumulative emissions are compared to total cumulative emissions within the mine and NGS CIAAs, respectively, in **Table 5.7-2**. Note that there will be temporary construction activity following the closure of NGS at the end of 2019. However, the decommissioning impacts is considered negligible for cumulative purposes.

Under Alternative 1, up until shutdown of both the mine and NGS on December 22, 2019, the criteria pollutant emissions generated by the mine would contribute a negligible to minor amount, ranging from 0.001 percent to 5.1 percent, to the cumulative criteria pollutant emissions within 300 km of the NGS. Those criteria pollutants generated by the NGS would contribute a minor to moderate range of 12.64 percent to 26.91 percent to the cumulative emissions within 300 km of the NGS and within the CIAA overall. Upon shutdown of the mine on December 22, 2019, reclamation operations would continue to contribute to cumulative criteria pollutants within the CIAA at a negligible level for the remaining six months of the Renewal period and until PWCC's reclamation obligations are met. Upon shutdown of the NGS, the contribution of criteria

pollutants from the power plant to the cumulative amount within the CIAA would be negligible for the remainder of the Renewal period.

Alternative 2 assumes that both the mine and NGS would cease operations in August 2017. Therefore, the timeframe over which criteria pollutant emissions would occur would be reduced to approximately 40 percent when compared to Alternative 1. **Table 5.7-3** identifies criteria pollutant emission totals generated by mining and coal combustion separately by year of operation. Additionally, their contributions to cumulative emissions are compared to total cumulative emissions within the mine and NGS CIAAs. For Alternative 2, the information is displayed individually by year because of the short duration of the operation.

Under Alternative 2 beginning in July 2015 through August 2017, the criteria pollutant emissions generated by the mine, on an annual basis, would contribute a negligible to minor amount, ranging from 0.0005 percent to 5.1 percent, compared to the cumulative criteria pollutant emissions within 300 km of NGS. Those criteria pollutants generated by the NGS, on an annual basis, would contribute a minor to moderate range of 8.80 percent to 31.80 percent compared to the cumulative emissions within 300 km of the NGS.

Under Alternative 2 beginning in August 2017, the contributions by both the mine and the NGS to cumulative emissions from all sources, within their respective CIAAs, would be reduced to negligible. Reclamation operations at the mine would continue to contribute to cumulative emissions at a negligible level until PWCC's reclamation obligations are met.

5.7.2 Cumulative NAAQS Compliance

The modeled concentrations of criteria pollutants (NO_2, CO, SO_2, PM_{10}, and $PM_{2.5}$) were in compliance with the NAAQS within the 50-km near-field modeling study area for the mine and NGS respectively (**Section 4.5**). There are no identified existing permitted nearby sources and no reasonably foreseeable new sources within the near-field modeling study area that would affect the highest predicted concentrations near the Kayenta Mine or the NGS.

For the NGS, **Table 5.7-4** presents a summary of the cumulative modelling results at near-field air modeling receptors 50 km from the NGS (Ramboll Environ 2016a). Typically, the near-field modeling techniques used to assess the NAAQS are applied to receptor distances within 50 km of the source. The NGS contributions included in **Table 5.7-4** are from the simulations of the 3-Unit Operation pre-SCR installation case with the highest emissions, which result in the highest modeled impacts.

The results show that estimated cumulative concentrations of criteria pollutants are much lower than the NAAQS at 50 km from the NGS. The maximum concentrations are generally east and east-northeast of the NGS. Moreover, the near-field modeling results from AERMOD are conservative especially regarding the 1-hour standards as they reflect worst case meteorological conditions and maximum emission rates. Also, it is very unlikely that peak emissions of criteria pollutants from the NGS will overlap both in time and space with the peak contributions of other cumulative sources that are farther away than 50 km and potentially subject to different wind patterns.

Table 5.7-4 Cumulative Emissions, Near-field Modeling for NGS

Pollutant	NAAQS Primary or Secondary Standard (µg/m³)	Averaging Time	Highest Predicted Conc. due to NGS at 50 km in any Direction (µg/m³) [1]	Background (µg/m³)	Cumulative Concentration (µg/m³)	NGS % of NAAQS	Total Conc. % of NAAQS	Bearing from NGS Plant
NO_2	188	1-hour	***	Varies [2]	112.3	***	60%	ENE
NO_2	100	Annual	1.25	6	7.2	1%	7%	E
CO	40,000	1-hour	84.4	3,664	3,748.4	0%	9%	E
CO	10,000	8-hour	26.8	2,633.5	2,660.3	0%	27%	ENE
SO_2	196	1-hour	50.1	22.5	72.6	26%	37%	E
SO_2	1,310	3-hour	30.4	24.6	55.0	2%	4%	NE
PM_{10}	150	24-hour	1.08	44.5	45.6	1%	30%	E
$PM_{2.5}$	35	24-hour	0.499	20.8 [3]	21.3	1%	61%	E
$PM_{2.5}$	12	Annual	0.0909	5.9 [4]	6.0	1%	50%	E
Lead	0.15	3-month	0.00002	0.01	0.0	0%	7%	E

[1] NGS Contributions based on design concentrations for the worst year and rank by pollutant and averaging period as follows: SO_2 1-hr: 4th highest, SO_2 annual: 1st highest, NO_2 1-hour: 8th highest, NO_2 annual: 1st highest, PM_{10} 24-hour: 6th highest over 5 years, $PM_{2.5}$ 24-hour: 8th highest, $PM_{2.5}$ annual: 1st highest and lead 3-month: 1st highest.

[2] NO_2 1-hour was modeled in AERMOD with seasonal, hourly background values.

[3] $PM_{2.5}$ 24-hour background includes 1.0 µg/m³ secondary aerosol formation from CAMx simulation

[4] $PM_{2.5}$ annual background includes 0.26 µg/m³ secondary aerosol formation from CAMx simulation

As shown in **Table 5.7-4**, the highest cumulative concentrations are east of the NGS, in the direction of two other major coal fired power plants, including the Four Corners power plant on Navajo Nation lands in New Mexico. Cumulative modeled results for the Four Corners power plant showed compliance with the ambient air quality standards in the vicinity of that plant (OSMRE 2015).

For the reasons stated above, the NGS would contribute a negligible amount to the cumulative concentrations approaching the value of the NAAQS both at distances within 50 km and within the overall CIAA. All criteria pollutant levels are well within the applicable NAAQS.

For the mine, NAAQS compliance at the mine permit boundary was demonstrated (**Table 4.5-13).** All criteria pollutant values were below the applicable standards. That analysis included the regional background concentrations of each evaluated pollutant. The background values were derived from onsite or surrounding regional monitors and represent the total of all other cumulative sources. There are no other major sources of pollutants within 50 km of the mine. Since NAAQS compliance was demonstrated at the mine permit boundary, it is reasonable to infer that the cumulative criteria pollutant emissions also would meet, and actually be lower, than the applicable NAAQS at greater distances such as at the 50-km radius surrounding the mine. Although the contribution of the mine criteria pollutants to the cumulative total varies, the total cumulative values are still well within the NAAQS.

While no cumulative modeling was conducted for Alternative 2, under Alternative 2 both mining and NGS operations would cease nearly three years prior to Alternative 1. Criteria pollutant emissions, and therefore the contribution of Alternative 2 to cumulative emissions sources, would be approximately 40 percent lower than under Alternative 1. As is the case for Alternative 1 (**Table 5.7-4**), concentrations of criteria pollutants from all cumulative sources under Alternative 2 within the CIAAs would be maintained below the NAAQS.

5.7.2.1 Ozone NAAQS Compliance

Ramboll Environ conducted a CAMx modeling analysis that included thirteen ozone monitoring stations (Ramboll Environ 2016d). A projection of 2020 due to the assumed closure of both the Kayenta Mine and the NGS demonstrated compliance across all sites. The modeled impacts ranged from 61.4 ppb at Bloomfield, New Mexico to 69.8 ppb at Canyonland National Park. Therefore, all ozone stations would be in compliance with the current 70 ppb NAAQS.

5.7.3 Cumulative Arsenic, Mercury, and Selenium Contribution

Dispersion and deposition of trace metals from the NGS stacks (including mercury, selenium, and arsenic) as well as various regional and global sources, which include the Four Corners power plant, San Juan Generating Station, and non-U.S. sources, were utilized to assess cumulative impacts (EPRI 2016). The NGS contribution to the regional deposition pattern, including cumulative sources, varies by metal.

The deposition of mercury has been studied in detail within the region surrounding the NGS (EPRI 2016). At locations such as Shiprock and Navajo Lake, New Mexico, the annual deposition from all sources would be 12.7 micrograms per square meter and the NGS would contribute to the cumulative total between 1.7 and 2.2 percent of the annual deposition of mercury from all sources (EPRI 2016). A similar pattern was observed at receptor points in Lake Powell and at

Glen Canyon Dam, where the NGS would contribute less than 1 percent to the cumulative mercury deposition. Under Alternative 1, over the five-year Renewal period, the NGS would contribute negligible amounts of mercury when compared with the cumulative amounts contributed by all other sources. Direct mining mercury emissions would be negligible and would not contribute to the overall cumulative impact. Under Alternative 2, both mining and NGS operations would cease in August 2017 and due to the shorter duration of NGS operation when compared to Alternative 1, contributions to cumulative mercury totals would be about 40 percent of those under Alternative 1.

For arsenic and selenium, since the NGS is the primary regional air emission source within the CIAA and there is no readily available information on cumulative totals from other sources for the region, to be conservative it is assumed that the NGS provides much of the contributions to the cumulative totals. The NGS operation during the Renewal period under Alternative 1 would contribute less than 1 percent to the baseline arsenic levels in the soils and about 4.6 percent to the baseline selenium levels (**Section 4.5.1**).

Under Alternative 2, since the operation of the NGS would be a 60 percent shorter duration than under Alternative 1, with shutdown assumed to occur in August 2017, the contributions to baseline soil concentrations for these trace metals would also be negligible and at a lower level when compared to Alternative 1.

In summary, the contribution of these metals from NGS combustion to the cumulative totals over the five-year Renewal period would not substantially contribute to the cumulative amounts from other existing and foreseeable regional and global emissions sources. Trace metals emissions associated with direct mining activities would be negligible and would not contribute to the overall cumulative impact. Deposition for these metals would result primarily from other sources outside of the regional study area.

Under Alternative 2, which assumes NGS shutdown in August 2017, the cumulative trace metal contribution to cumulative totals would be approximately 40 percent of Alternative 1. Thus, under Alternative 2 the NGS would not contribute significantly to the cumulative total of arsenic, mercury, or selenium in the CIAA. **Sections 5.6** and **5.16** provide further discussion regarding HAP impacts on wildlife and fish and health and safety, respectively.

5.7.4 Cumulative GHG Emissions

Climate change by nature is a cumulative process to which sources contribute GHGs from around the globe. The discussion of direct mine and indirect NGS emissions relative to the current global GHG emissions rates and the projected impacts are provided in **Section 4.7**.

The values detailed in **Table 5.7-5** represent the total GHG emissions under Alternative 1, including those from the combustion of all coal that would be produced and those from all mine-related activities such as blasting and vehicle exhaust. Note that only methane is released from the coal itself during mining and subsequent handling.

Table 5.7-5 Cumulative GHG Emissions

GHG Source	CO_2e (mtpy)
Mine combustion	78,415
Mine methane release from coal	15,230
NGS combustion	18,387,000
Total	**18,480,645**

Table 5.7-6 compares the calculated GHG emissions from Alternative 1 to nationwide and global totals from the 2014 EPA inventory.

Table 5.7-6 Annual Alternative 1, Statewide, and National GHG

GHG Source and % Comparison	CO_2e (mmt/yr)
Total GHG Nationwide[1]	6,870.45
Mine plus NGS - % of nationwide total	0.27%
Total GHG Global[2]	46,049.4
Mine plus NGS - % of Global total	0.04%

[1] EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks:1990-2014. https://www3.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2016-Main-Text.pdf.
[2] CAIT Climate Data Explorer; includes total 2012 GHG emissions from land use change and forestry. http://cait.wri.org/
Derived from all 60 sectors of the 2011 NEI database and all 50 states plus the District of Columbia. Puerto Rico, Virgin Islands, and tribal land was excluded.

Table 5.7-6 shows that GHG emissions under Alternative 1 would contribute negligibly to total global and nationwide cumulative GHG emissions from all sources, as well as to the cumulative impact on climate change, because of their comparative small amounts and the short duration of their contribution under the Renewal period. Reclamation activities would continue until PWCC's reclamation obligations have been met. Reclamation operations would contribute even smaller amounts of GHGs to cumulative sources than during mining.

Climate change can contribute to changes in resources of local and regional significance, such as surface water quantity and discharge timing, wildlife and livestock forage availability, and fish habitat. However, these local and regional effects cannot be accurately quantified due to the limitations in current climate change models, the complexity of ecosystems, and the effects of natural climate variability over a timeframe as short as the Renewal period. Further, the Renewal would have would have no measurable impact to cumulative effects of climate change. Therefore, Alternative 1 would not measurably contribute to cumulative climate change effects on local and regional resources.

Under Alternative 2, there would be no further mining operations at the Kayenta Mine after August 2017. All mining GHG emissions would cease but reclamation emissions would continue to contribute to cumulative GHGs nationally and globally as reclamation of the entire mine would begin. Reclamation emissions would decrease over time as the inventory of un-reclaimed mined areas decreases to essentially zero when PWCC's reclamation obligations are met. Similarly,

GHG emissions associated with coal combustion at the NGS also would decline to zero with the shutdown of the NGS in August 2017. Alternative 2 would contribute about 40 percent of the project emissions under Alternative 1. The contribution to cumulative GHGs nationally and globally would have no measurable impact to cumulative effects of climate change and would be less than the contribution of Alternative 1.

5.8 WATER RESOURCES

The CIAA for surface and groundwater is the Black Mesa Basin area of the N-Aquifer extending to the gauges on measured streams and other tributary streams and springs located in the unconfined portions of the aquifer (**Figure 5.1-1**).

Cumulative actions included in this analysis are previous, present, and future groundwater pumping by PWCC during the Renewal period and reclamation post-2019; projected increased community wellfield pumping of the N-Aquifer, and the proposed Manymules Water Supply project. The retirement of the NGS beginning at the end of 2019 would not cumulatively affect the N-Aquifer because the NGS obtains its potable and processing water from the Colorado River.

Within the CIAA on Black Mesa, 419 springs have been cataloged (PWCC 1999; BOR 2016). Of the cataloged springs, only 18 have more than two flow measurements or documented observations; four are monitored by the USGS, and the Pasture Canyon spring has a continuous monitoring gage. Under Alternative 1, reasonably foreseeable changes in groundwater levels in the N-Aquifer, groundwater discharge to streams, and stream flow and spring flow in the Black Mesa Basin would be the result of: 1) declining pumpage in the Permit Area and reclamation of the Permit Area by PWCC during the Renewal period and the following period of reclamation (2020-2032); 2) community wellfield pumping during the same time period and beyond; and 3) the Manymules Water Supply project.

When combined with the previous reduction in Kayenta Mine water use initiated at the end of 2005, declining groundwater use by PWCC during the Renewal period from 2015 through 2019, followed by further reduced mine water use during reclamation post-2019, would result in a negligible cumulative adverse effect on N-Aquifer groundwater levels in the Permit Area and adjacent areas in the Black Mesa Basin. The continued and increased community groundwater withdrawal in the Black Mesa area will negate most of the groundwater rebound related to the cessation of mining at the PWCC at the end of 2019.

The expected future impact of community wellfield pumping on the N-Aquifer is displayed in **Appendix D**, Figures 7, 8, and 9. Community pumping would continue to increase during the period from 2015 to 2032 and beyond due to increased demand for water. The projected conservative increase in demand is around 2.7 percent per year (OSMRE 2011b). Community water use in 2008 was around 2,900 af/yr. Projected water use by 2025 at a growth rate of 2.7 percent per year would be around 4,500 af/yr; by year 2038, community water use would be around 5,400 af/yr. This would result in increased drawdown in the N-Aquifer in the areas of the community wellfields, with drawdown increasing by 30 feet in 2025 compared to 2010 and by about 50 feet in 2038 compared to 2010. This increased drawdown would be in the areas of the community wellfields, and would gradually expand outward from those wellfield areas. The

simulated drawdown at community wells and the contribution to that drawdown from PWCC activities is summarized in **Appendix F**, Table 2. The PWCC allocation of simulated drawdown at community wellfields is mostly negative from 2015 to 2038, indicating that decreased water use by PWCC during that time period would contribute to a slight groundwater rebound at the community wellfields. Impacts of community wellfield pumping on groundwater discharge to streams would be expected to increase over time and exceed that discussed in **Section 4.7.1.3**. Community wellfield water use would be expected to result in moderate impacts to N-Aquifer water levels and N-Aquifer discharge to streams over time.

The Manymules Water Supply project would use N-Aquifer water from wells within the Lease Area provided by PWCC to supply water to residents within and near the Kayenta Mine leasehold. The project was scheduled to start in 2012 using 154 af/yr of water and would increase in demand to a maximum of 322 af/yr by year 2026 (OSMRE 2011b); the project has not yet started. PWCC pumpage would decline during this time period (**Section 4.7.1.3**). PWCC pumping averaged about 1,273 af/yr from 2006 through 2012 and by 2023 PWCC pumpage would be 100 af/yr. Beginning around year 2023, the projected water use by the Manymules project would exceed PWCC pumpage by at least 200 af/yr. After year 2032, PWCC water use would cease, while water use by the Manymules Project would be expected to continue. The Manymules project would be expected to have negligible impacts on N-Aquifer water levels and N-Aquifer discharge to streams as proposed because of the relatively low volume of water use.

Alternative 1 in conjunction with past, present, and reasonably foreseeable actions would contribute minor to moderate cumulative impacts on water resources.

Under Alternative 2, withdrawals from the N-Aquifer would be reduced from an average of 1,329 af/yr (2006 through 2017) to around 500 af/yr beginning in 2020 to support reclamation activities. Reclamation includes regrading, spreading of topsoil, and revegetating disturbed areas. For the next ten years, withdrawals would be about 100 af/yr during the reclamation monitoring and maintenance period. PWCC would cease groundwater withdrawals from the N- and D-Aquifers and impact to the Wepo Aquifer and streams related to mining at the end of the reclamation monitoring and maintenance period, which would be around year 2032.

During the reclamation period, the Manymules Water Supply project would continue to pump about 154 af/yr from the N-Aquifer. By 2026, pumping to support the Manymules project would approach 322 af/yr from the N-Aquifer near the PWCC wellfield. By 2030, the rate of groundwater use is projected to be around 252 af/yr (OSMRE 2011b). This rate of groundwater use in the N-Aquifer is below the projected water use under Alternative 1. The reduced pumping under Alternative 2 would produce a negligible impact to the N-Aquifer.

Community groundwater use from the N-Aquifer would continue during and beyond the period of mine reclamation under Alternative 2. Assuming that the rate of growth in community water use continues at the projected (conservative) rate of 2.7 percent annually, community groundwater use from the N-Aquifer may approach 4,500 af/yr by 2025 and 5,400 af/yr by 2030. Because Alternative 2 would have less direct impact to water resources than Alternative 1, it would contribute negligible to minor cumulative effects.

5.9 VEGETATION

The CIAA for vegetation is the Black Mesa coal field (**Figure 5.1-1**; 1.8 million acres). Vegetation composition in the CIAA has been most affected by mining disturbance and grazing. Past, present, and future activities that would cumulatively affect vegetation include past, present, and future Kayenta Mine activities under the Renewal and reclamation; grazing; water project development; road and housing development; and other actions listed in **Sections 5.2** and **5.3**.

Past activities within the piñon/juniper woodland, saltbush and greasewood, and sagebrush shrubland communities have resulted in the permanent or long-term removal or modification of these natural vegetation communities. The greatest impacts have resulted from mineral resource extraction, energy infrastructure, and water development in the CIAA. Vegetation also has been affected by livestock grazing, the introduction of non-native invasive species, mechanical and chemical vegetation treatments, as well as naturally occurring events such as wildfires and drought. Future development and activities would continue to alter naturally occurring vegetation communities.

Alternative 1 would result in negligible to minor direct effects on vegetation. Alternative 1 in conjunction with the past, present, and reasonably foreseeable actions in the CIAA would contribute negligible cumulative effects to vegetation because the primary impact to vegetation – mining – is associated with reclamation that restores or improves plant communities. Re-establishment of vegetation under reclamation converts existing vegetation communities to a reclaimed grassland and shrubland vegetation community.

Grazing is anticipated to continue within the CIAA outside of the Permit Area as currently practiced. Within the Permit Area, most of the reclaimed mine areas now provide a greater amount of forage vegetation than was available under pre-mine conditions; however, this use of the land would be realized only when a temporary moratorium on grazing reclaimed lands is not in effect, future reclamation is successful, and grazing is managed appropriately. Historical and ongoing monitoring of reclaimed areas show reseeding is occasionally needed over about 10 percent of the reclaimed areas to meet SMCRA and Permit AZ-0001E requirements.

Wildlife usage of vegetation communities is not likely to be adversely impacted over the long term. Reclamation activities would add seral and community diversity and increased production of forage for livestock and wildlife. The ongoing reclamation activities would restore areas to an all-purpose rangeland composed of species similar to existing grassland-shrublands. The extent of reclaimed vegetation in the CIAA would total 1,893 acres (**Table 2.3-1**). This would represent a 0.24 percent increase in the amount of original vegetation in the CIAA replaced by mining reclamation vegetation, which would be a negligible change. The vegetation in reclaimed areas would transition to a stable state and includes native species that could provide a seed source for other areas (Peters et al. 2006).

The additional disturbance under the reasonably foreseeable projects would increase the potential for establishment of noxious weeds and non-native invasive species in the CIAA. The contribution of cumulative effects from Alternative 1 would be negligible because there would be negligible change in the composition of the vegetation communities from noxious weeds or non-native

invasive species due to measures included in the permit to eliminate or minimize the introduction of noxious weeds or non-native invasive species by mine and reclamation operations.

5.10 WILDLIFE AND FISH

The CIAA for wildlife and terrestrial special status species is the Black Mesa coal field (**Figure 5.1-1**; 1.8 million acres). Cumulative projects included in the analysis within the Renewal period are the Manymules project; past, present, and future coal mining under the Renewal and reclamation; and those presented in **Table 5.3-1**. The ERAs developed for this project (Ramboll Environ 2016a, 2016b) examine the contribution to cumulative effects of Alternative 1 compared with other sources of air toxics and are discussed below.

Surface disturbance in areas mined during the Renewal period, past coal mining, and the Manymules project could degrade or remove wildlife habitat in the CIAA. Alternative 1 could increase the extent of degraded or lost wildlife habitat, and increase barriers to wildlife movement in the CIAA. However, reclamation activities to replant these areas with grassland/shrubland species overall and cultural plantings in select areas would reduce these short-term effects, such that these constitute minor impacts that would not eliminate any of the currently documented species from the region.

Under Alternative 1, mining and reclamation, and vehicles used for the Manymules project would remove or degrade over 842 acres of wildlife habitat in the CIAA. Wildlife species such as collared lizards and sagebrush lizards are some of the more common wildlife species that would be displaced by the loss of woodland and shrubland vegetation or complex, rocky habitats in areas disturbed by these actions. However, the existing disturbance affects approximately 0.1 percent of the approximately 1.8 million acres of these wildlife habitats within the CIAA, and Alternative 1 would contribute negligible cumulative effects to these habitats when combined with past, present, and reasonably foreseeable actions.

The CIAA for the endangered fish species are the various areas described in the ERAs (Ramboll Environ 2016a, 2016b) conducted for Alternative 1 and the study for the San Juan River (EPRI 2016). The Near-field ERA is a 20-km buffer around the NGS. The Colorado River ERA looked at areas upstream (eastern portion of Lake Powell up to the confluence of the Colorado and Green Rivers approximately 274 km upstream of the Glen Canyon Dam), and downstream (Lee's Ferry to the confluence of the Colorado and Little Colorado Rivers approximately 100 km downstream of the Glen Canyon Dam). Additionally, the San Juan River study is from State Route 371 Bridge in Farmington, New Mexico downstream to the San Juan arm of Lake Powell. The ERAs and the San Juan River study looked at the baseline conditions, the operations of the NGS at 2,250 kW from 2015-2020, and other emitters of mercury and other pollutants.

The ERAs and EPRI Study determined that while mercury, selenium, and other pollutants would enter the habitat for the endangered fish species in the CIAA, those adverse effects would be negligible compared to the baseline and other emitters. The ERAs and EPRI Study determined that baseline conditions and contributions from other global sources of mercury may be contributing to the risk of these species but the contributions from the NGS emissions would not pose an unacceptable risk to these species as the contributions are orders of magnitude lower than the baseline conditions. While some mortality to eggs/larvae, juveniles, or adult fish

may occur, those impacts would be within the natural variability of those species (**Section 4.9.1.2**). Therefore, the contribution to cumulative impacts to the endangered fish species under Alternative 1 would be negligible to minor.

The two conservation measures proposed for the endangered fish species as discussed in **Section 2.3.2.6** would provide a net benefit to these species. These measures are not designed to offset the direct or indirect impacts from Alternative 1 (i.e., mitigation). Rather, they are voluntary measures committed to by NGS that would have a net beneficial contribution to cumulative impacts to the species by addressing known threats. These threats include non-native species competition/predation and barriers to movement. Both of these threats have been identified in the listing of the species. These measures are reasonably foreseeable to be implemented by the NGS.

5.11 CULTURAL RESOURCES

The CIAA for cultural resources is the Permit Area (**Figure 5.1-1**). Cumulative actions to the Renewal in the CIAA include the Manymules project and past and present mining.

To date, 54 cultural resources have been documented in the Affected CRAs. Cumulative effects on cultural resources could occur through past and future disturbance of previously identified or undiscovered cultural resources within the CIAA. However, the same regulations and protections that have been, are currently, and would be in place during the Renewal under the terms of the permit (**Section 4.10.1**) would apply to the cumulative actions within the CIAA. Pursuant to the terms of their permit, PWCC continues to report the discovery of any previously unrecorded cultural resources and suspend work in the area of the discovery; to take into account any sacred and ceremonial sites brought to their attention; and to identify and respectfully treat any human remains in accordance with NAPGRA and the Navajo Nation policy for the Protection of Jishchaá: Gravesites, Human Remains, and Funerary Items. In the case of the Renewal, further NHPA Section 106 consultation is not required (**Section 4.10.1**); however, OSMRE has previously completed Section 106 consultation for the study area through the BMAP, and continues to consider historic properties pursuant to other laws through the standard conditions and terms attached to mining permit renewals issued for continuing coal mining operations.

Based on the previous compliance with Section 106 of the NHPA, NAGPRA, Navajo Nation Policy for the Protection of Jishchaá, and the terms of the permit, potential adverse effects to cultural resources, human remains, and sacred and ceremonial sites are anticipated to be long-term and minor. Because the Renewal period is of limited length (five years) and Renewal activities are primarily within previously disturbed and previously surveyed areas, the number of unanticipated discoveries since 1990 suggest the probability of substantial future unanticipated discoveries is low, and there are conditions in place to protect unanticipated discoveries, Alternative 1 would contribute negligible cumulative effects to cultural resources.

5.12 INDIAN TRUST ASSETS

The CIAA for Indian Trust Assets is the Permit Area (**Figure 5.1-1**). The cumulative actions to the Renewal include the Manymules project, past and present mining, and reclamation.

Past effects on Indian Trust Assets have been associated with prior mining in the Permit Area under the terms of the respective leases. Those effects are negligible to minor because the provisions of the respective lease agreements have been negotiated between PWCC and the Navajo Nation and Hopi Tribe, and it has been determined by these parties that compensation associated with the lease agreements would adequately compensate the tribes for use of the mineral, water, land, and hunting/gathering trust assets. As such, the contribution of cumulative effects to Indian Trust Assets as a result of the Renewal also is expected to be negligible to minor.

Under Alternative 2, mine closure and reclamation procedures would occur under OSMRE, BIA, and tribal guidelines and the provisions of existing lease agreements. No additional coal would be mined and the coal royalties paid to the Navajo Nation and Hopi Tribe would cease. Reclamation activities and associated use of pumped groundwater would continue per the requirements of the current lease agreements. PWCC's existing leases with the tribes requires N-Aquifer wells to be left properly cased for Tribal use after PWCC successfully completes reclamation and relinquishes the lease. Land uses such as livestock grazing, wildlife habitat, and hunting and gathering of traditional plants would return following successful reclamation. Under this alternative, the potential contribution of cumulative effects to Indian Trust Assets (minerals, land, water, hunting, gathering, and other natural resources) would be negligible.

5.13 LAND USE AND RECREATION

The CIAA for land use and recreation was defined as the boundaries of the Hopi Reservation and Chilchinbeto, Forest Lake, Kayenta, and Shonto Chapters within the Navajo Nation (**Figure 5.1-1**; 2.6 million acres). Cumulative actions to the Renewal include energy development, the Manymules project, past and present mining, reclamation, and other actions described in **Table 5.3-1**.

Approximately 842 acres of primarily piñon-juniper woodland with low forage availability and quality would be disturbed by mining in the Affected CRAs under Alternative 1 and 3,493 acres would be regraded and topsoiled/reseeded (**Table 2.3-1**). Reclamation would increase forage productivity and quality for livestock use by converting the piñon-juniper woodlands to more productive shrubland and grassland vegetation communities. After completing reclamation, reclaimed areas would meet post-mining land uses for livestock grazing, wildlife habitat, and cultural plant use. Reclaiming areas disturbed by coal mining would increase the amount of forage and the quality of forage available for livestock grazing in local areas. The contribution to cumulative impacts from mining during the Renewal period would be negligible because the total reclaimed area is about one percent of the CIAA.

5.14 VISUAL RESOURCES

The CIAA for visual resources is a 5-mile buffer from the Affected CRAs (**Figure 5.1-1**). Cumulative actions to the Renewal include the Manymules project, and past and present mining, and reclamation.

Past mining has caused changes to the landscape in the CIAA that has affected the viewshed. Reclamation, and construction of Manymules water pipelines and facilities could increase the area where vehicles and equipment are visible. Sensitive viewers, including the relocated households,

on higher ground views would be partially or totally screened by the intervening topography and distant viewers would perceive less contrast. Views of the reclamation and Manymules construction would be partially or completely screened. In addition, the view for travelers on Navajo Route 41, from U.S. 160 to Red Peak Valley Wash, would continue to be brief, as most of their view would be screened by topography and vegetation. The Renewal would contribute negligible cumulative effects to visual resources.

5.15 SOCIAL AND ECONOMIC CONDITIONS

The CIAA for socioeconomics is the Navajo Nation and Hopi Reservation boundaries (**Figure 5.1-1**). Cumulative actions to the Renewal in the CIAA include past and present mining, Manymules project, LeChee Electrification Project, retirement of the NGS at the end of 2019 and consequent decommissioning activities , and other projects listed in **Sections 5.2** and **5.3**. **Table 5.15-1** lists the cities and places within the Navajo Nation and Hopi Reservation where the Kayenta Mine and the NGS employ more than 10 percent of the total population employed.

Table 5.15-1 Kayenta Mine and NGS Employment of 10 Percent Population

City/Place	Population employed (2010)	Kayenta Mine (2015 total)	Kayenta Mine (%)	NGS (2015 total)	NGS (%)	2015 Total	Total (%)
Kaibito	350	11	3%	36	10%	47	13%
Kayenta	1,273	229	18%	8	1%	237	19%
Page	3,396	17	1%	414	12%	431	13%
Shonto	206	19	9%	12	6%	31	15%
Tonalea	132	31	23%	13	10%	44	33%

Source: U.S. Census Bureau 2000 (SF3, QT-P24), OSMRE 2011b

The Renewal would contribute minor cumulative beneficial economic effects through July 2020 when combined with NGS operations. In addition to adding to social services available in the CIAA, the Manymules and LeChee Electrification projects also would provide short-term employment during construction. Active mining at the Kayenta mine and NGS operations would both conclude in December 2019. Although there would be some social and economic contribution during Kayenta Mine reclamation and NGS decommissioning activities, overall there would be a major, negative cumulative impact to social and economic conditions in the CIAA. Ceasing operations at the Kayenta Mine and the NGS would reduce employment in areas where the Kayenta Mine and NGS employees reside. As shown in **Table 5.15-1**, there are five cities and towns where 10 percent or more of the total population are employed by either the Kayenta Mine or the NGS. This could indirectly increase the unemployment in other communities within the CIAA and the loss of tribal revenues if other businesses close due to the loss of revenues from employees purchasing goods or services. The closure of the Kayenta Mine under Alternative 2 in conjunction with cessation of NGS operations would contribute major cumulative effects to social and economic conditions in the CIAA.

5.16 ENVIRONMENTAL JUSTICE

The CIAA for environmental justice is the Navajo Nation and Hopi Reservation boundaries (**Figure 5.1-1**). Cumulative actions to the Renewal in the CIAA include past and present mining, Manymules project, LeChee Electrification Project, retirement of the NGS at the end of 2019 and consequent decommissioning activities through 2021, and other projects listed in **Sections 5.2** and **5.3**.There would be a negligible contribution to cumulative effects related to air quality on environmental justice populations, because there would be negligible cumulative total emissions, contributions to NAAQS, metals, and GHGs (**Section 5.7**). Similarly, there would be a negligible contribution to cumulative effects to environmental populations related to noise and land use because there would be only negligible direct or indirect effects on these resources.

During the last five years of the NGS operations that would overlap with the Renewal, there would be minor, beneficial, cumulative incremental socioeconomic effects on environmental justice populations due to the continued contribution of employment, tax, and royalty benefits to the Navajo Nation and Hope tribes. There would be a negligible contribution to cumulative effects to environmental justice populations related to air quality, noise, land use, and water resources. However, in December 2019 the Kayenta Mine would cease active operations at the same time the NGS would be retired; this would be a major, negative cumulative impact that would fall disproportionately in the CIAA for the reasons stated in **Section 5.15**. Cumulative effects under Alternative 2 would be similar to those under Alternative 1, but the contribution to environmental justice cumulative effects of the Kayenta Mine would occur sooner (August 31, 2017).

5.17 HEALTH AND SAFETY

The CIAA for health and safety is the same as that for air and climate resources (**Figure 5.1-2**) There would be negligible direct and indirect effects to human health and safety under Alternatives 1 and 2. According to the HHRA for the Renewal (Flatirons Toxicology 2016), the baseline human health conditions include historic accumulation of contaminants in soils and the modeling for Alternative 1 assumes long-term (future) exposure. The total cumulative action (Baseline+Proposed Action+Other Cumulative Sources) human health risk exposure scenarios were all indistinguishable from baseline (**Section 3.17**) in terms of the non-cancer HI. The total cumulative action hypothetical cancer risk estimates were slightly higher than baseline at a maximum of 3 in 1,000,000 for the adult case to 8 in 1,000,000 for the child case, which are well within the EPA acceptable cancer risk. Therefore, there would be negligible project contribution to cumulative effects to human health and safety.

6.0 COORDINATION AND CONSULTATION

6.1 AGENCIES AND PERSONS CONTACTED

The following tribes and agencies were contacted prior to and during the preparation of this EA:

- Navajo Nation
- Hopi Tribal Council
- U.S. Fish and Wildlife Service

6.1.1 Public Involvement Process

PWCC published public notices in two local newspapers announcing the availability of the application for review and comment. The newspaper notices ran for four consecutive weeks beginning on April 8 and ending on April 30, 2015. As indicated in these notices, the public comment period continued for 30 days beyond April 30, extending to June 1, 2015. By the conclusion of the public comment period OSMRE had received two comments from the public on the Renewal application and two requests for an informal conference (**Appendix H**, **Section 1.6**).

OSMRE released the EA on August 17, 2017 for the public to review and comment during a 30-day period ending on September 15, 2017. OSMRE held two informal conferences to receive comments on PWCC's application to renew SMCRA Permit AZ-0001E for the Kayenta Mine, and to collect comments on the EA and FONSI:

- September 5, 2017, 6 – 8 p.m., Veteran's Center, Kykotsmovi, Arizona (Hopi language interpreter was present).
- September 6, 2017, 10 a.m. - noon, Forest Lake Chapter House (Navajo language interpreter was present).

Notification of the availability of the EA, informal conferences, and comment opportunity were announced in the Navajo Times and Navajo/Hopi Observer, and on the Navajo and Hopi radio stations (in the Navajo and Hopi languages, respectively). Comments *were* accepted via mail, email, and at the informal conferences via court transcriber. A total of 26 comment letters, emails, or comments recorded at an informal conference were received. Revisions were made to the EA, as appropriate, and responses to comments prepared (**Appendix H**).

6.1.2 Tribal Consultation

OSMRE has conducted Section 106 consultation for the entire Permit Area through the BMAP, and is continuing consultation with the Navajo Nation and Hopi Tribe for the Renewal. PWCC would continue to consider historic properties pursuant to other laws through standard conditions and terms attached to the Renewal for continuing mining operations. Those terms would be incorporated into the Renewal. These terms are described in **Section 4.10.1**. The currently approved (PAP) process for unanticipated cultural discoveries are also described in **Section 4.10.1**.

Formal government-to-government consultation was not conducted by OSMRE for the Renewal, because formal, first approval consultation is not typically required for a permit renewal and the tribes did not request formal consultation. OSMRE discussed the Renewal with the Navajo Nation Mineral Department in four quarterly meetings in 2015 and three quarterly meetings in 2016. Similarly, OSMRE discussed the Renewal with the Hopi Minerals Department in four quarterly meetings in 2015 and three quarterly meetings in 2016.

Several chapter houses and Navajo Nation and Hopi tribal agencies received a notification letter dated April 2, 2015 informing the chapter house or tribal agency that OSMRE had received an application to renew the Kayenta Mine coal mining permit for five additional years. The letter included an invitation to review PWCC's permit renewal application and submit written comments. The Navajo Nation and Hopi Minerals Department were copied on PWCC's Administrative Completeness Review Findings letter mailed to PWCC on April 2, 2015, as well as the Administrative Delay in Decision letter mailed to PWCC on June 29, 2015.

6.1.3 USFWS Section 7 Process

Informal consultation with the USFWS was initiated on July 29, 2016. During the course of that meeting, it was determined that formal consultation should be completed to determine the full range of potential effects of the proposed Renewal on threatened and endangered species. A BA was completed that determined the Proposed Action May Affect, but is Not Likely to Adversely Affect federally listed species. The USFWS concurred with these findings with the issuance of a Concurrence Letter on September 19, 2017 (**Appendix G**).

6.2 PREPARERS AND PARTICIPANTS

Table 6.2-1 provides a list of the preparers for this EA and those who participated in the preparation of this EA from OSMRE.

Table 6.2-1 Office of Surface Mining Reclamation and Enforcement

Name	Title
Marcelo Calle	Manager, Program Support Division
Mychal Yellowman	Manager, Indian Programs Branch
Amy McGregor	Environmental Protection Specialist
Bobbi Martinez Hernandez	Environmental Engineer
Paul Clark	Hydrologist
Jeremy Iliff	Archaeologist
Alex Birchfield	Ecologist

Table 6.2-2 provides a list of the preparers of this EA and those who participated in the preparation of this EA from the third-party consultant Stantec Consulting Services.

Table 6.2-2 Stantec Consulting Services

Name	Title	Resource/Role
Greg Brown	Principal	Review and project oversight
Doug Koza	Environmental Scientist	Project Manager
Neil Lynn	Environmental Scientist	Wildlife, Vegetation, Special Status Species
Robert Berry	Senior Hydrogeologist, Geochemist	Water Resources
Schelle Davis	Environmental Scientist	Visual Resources
Stephanie Lauer	Environmental Scientist	Assistant Project Manager; Geology, Topography, Noise and Vibration, Land Use and Recreation, Transportation, Socioeconomics, Environmental Justice, Solid and Hazardous Wastes, Soils
Kim Munson	Environmental Scientist	Cultural Resources, Indian Concerns, Paleontology
Daniel Heiser	Manager, Engineering	Air Quality, Climate, and Modeling
Eric Clark	Project Engineer	Air Quality, Climate, and Modeling
Claudia Gallegos	GIS Analyst	Geographic Information Systems, Mapping

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Appendix A

Public Notice, April 2015

PUBLIC NOTICE

Pursuant to the Code of Federal Regulations (CFR), Title 30, Chapter VII, Subchapter E, Part 750 and Subchapter G, Parts 773 and 774, notice is hereby given that Peabody Western Coal Company (PWCC) has filed an application with the Office of Surface Mining Reclamation and Enforcement, Western Region (OSMRE) for renewal of Permit AZ-0001E covering mining operations at Kayenta Mine, Navajo County, Arizona. The permit renewal does not affect any terms and conditions of the existing coal leases, and no new coal leases are associated with the renewal. No new permit area is proposed beyond that which is currently approved. The term of the renewed permit will be from July 6, 2015 through July 5, 2020. This notice is hereby given that:

1. The name and business address of the applicant is: Peabody Western Coal Company, P. O. Box 650, Navajo Route 41, Kayenta, Arizona, 86033.

2. The Kayenta Mine Permit AZ-0001E area is located in northeastern Arizona near the northern edge of Black Mesa within the protracted boundaries of Townships 35 through 37 North, Ranges 17 through 19 East. The operation is contained within the areas shown on the following U.S. Geological Survey 7.5-minute quadrangle maps: Longhouse Valley, Marsh Pass S.E, Owl Spring, Great Spring, Yucca Hill, and Cliff Rose Hill. The permit area is located within the following lands of Navajo County, Arizona that are described relative to the Gila and Salt River Base Meridian.

   T35N, R18E - Sections 13, 14, 24, 25, and 36;
   T35N, R19E - Sections 1-5 and 7-36;
   T36N, R17E - Sections 1-4, 11, and 12;
   T36N, R18E - Sections 1-18, 20, and 22-26;
   T36N, R19E - Sections 15-22, 25-30, and 32-36;
   T37N, R18E - Sections 28, 29, and 32-36.

   The permit area with important landmarks is shown on the map included with this public notice.

3. An electronic copy of the application is available for review on the OSMRE, Western Region, Internet website at http://www.wrcc.osmre.gov. Paper copies of the application are available for public review and/or inspection at the following four listed locations:

Navajo Nation Minerals Department
Office of Surface Mining
Window Rock Boulevard
Window Rock, AZ 86515

Forest Lake Chapter House
Navajo Route 41
14 miles north of Pinon
Pinon, AZ 86510

The Hopi Tribe
Office of Mining and Mineral Resources
Highway 264
1 mile east of Kykotsmovi
Kykotsmovi, AZ 86039

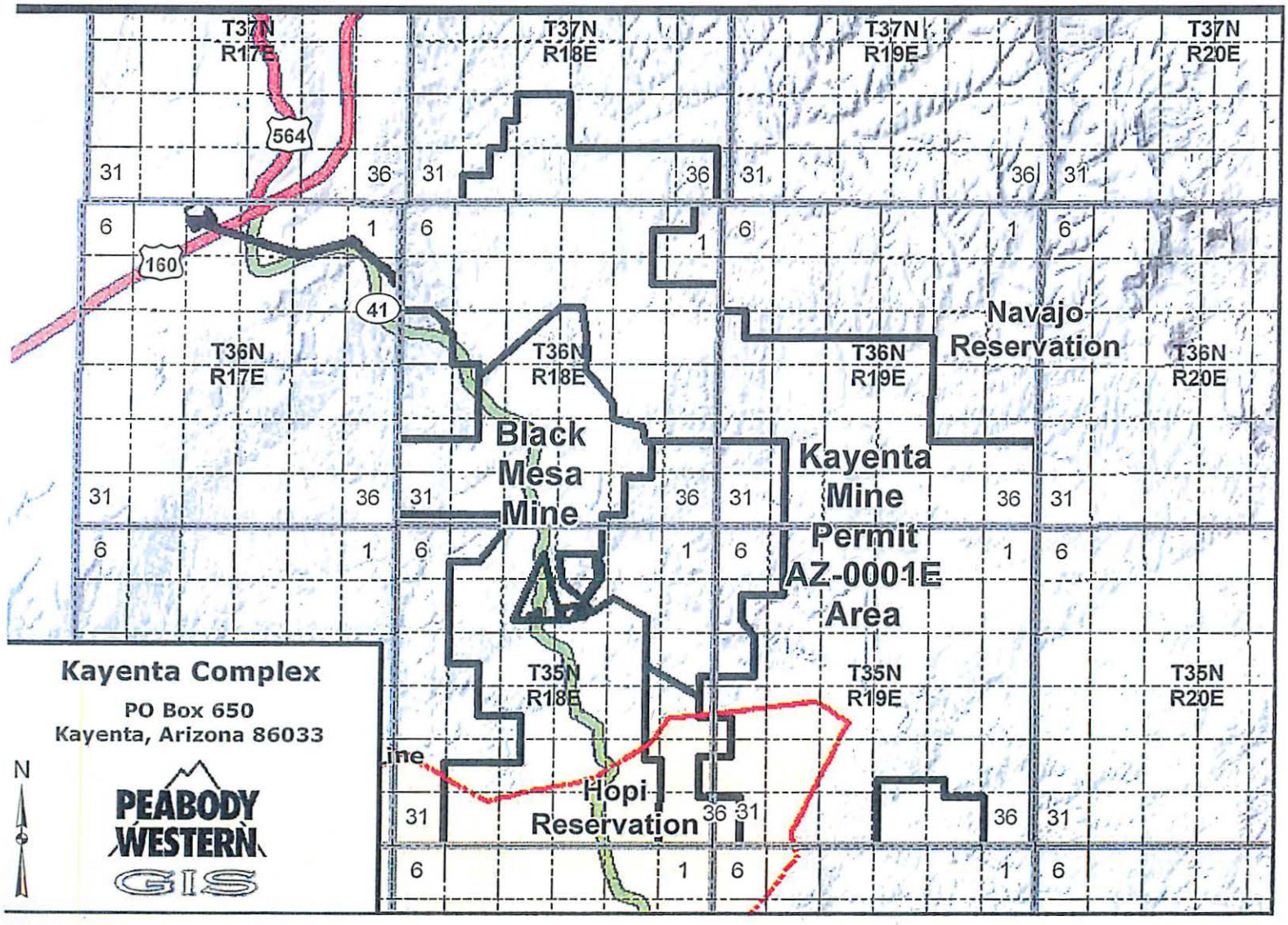
Office of Surface Mining
Reclamation and Enforcement
Western Region Office
1999 Broadway, Suite 3320
Denver, CO 80202-3050

4. The name and address of the OSMRE representative where written comments, objections, or requests for an informal conference may be submitted is:

Ms. Amy McGregor
Office of Surface Mining
Reclamation and Enforcement
Western Region Office
1999 Broadway, Suite 3320
Denver, CO 80202-3050
(303) 293-5040
email: amcgregor@osmre.gov

Any written comments, objections, or requests for an informal conference must be submitted to OSMRE before 5:00 p.m., m.d.t., June 1, 2015, which is no less than thirty (30) days after the last publication date of the two newspapers.

In accordance with 30 CFR 773.6(c), any person having an interest that is or may be adversely affected by the decision on the application may request an informal conference. The request must briefly summarize the issues to be raised by the requestor and must state whether the requester desires to have the conference conducted in the locality of the proposed operation.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Additional Updated Information, 774.15(b)(2)(v).

No new items are being submitted with this five-year Kayenta Mine Permit AZ-0001E renewal application to update information per 30 CFR 774.15(b)(2)(v). PWCC will provide information during the technical review as required by OSM.

Appendix B

Mining and Reclamation Procedures

A. GENERAL

A.1 AUTHORIZATION TO MINE

Since the 1970s, Peabody Western Coal Company (PWCC) has been surface mining coal in Navajo County, Arizona through coal leases located within the boundaries of the Hopi and Navajo Indian Reservations. In operation since 1973, the Kayenta mine operates under an Office of Surface Mining Reclamation and Enforcement (OSMRE) Permanent Program Permit AZ-0001E, originally issued as Permit AZ-0001C, on July 6, 1990. Permit AZ-0001E is renewable at up to five-year intervals and currently authorizes mining operations in active coal resource areas (CRAs) N-9, J-19, and J-21, and in reserve CRAs N-10 and N-11 Extension under future mining sequences. These five CRAs combined contain enough coal to sustain the Kayenta mining operation through 2026 at the current production rate of 8.2 million tons of coal per year (mtpy). Permit AZ-0001E has been renewed on four occasions: July 6, 1995; July 6, 2000; July 6, 2005; and July 6, 2010. The proposed action would renew Permit AZ-0001E to allow continued mining in CRAs N-9, J-19, and J-21 through July 5, 2020. Future renewals of the permit beyond July 5, 2020 would require additional action by OSMRE only after subsequent review of environmental effects in accordance with NEPA at the time.

The following table provides a list of permits or approvals for the Kayenta Mine operations issued to PWCC.

Table A-1 Federal and Tribal Entities and Permitting Requirements

Agency	Permit/Authorization/Filing
FEDERAL	
Army Corps of Engineers	Authorization of Dredge and Fill Activities Authorized under Nationwide Permit 21
Bureau of Alcohol, Tobacco, and Firearms	Explosives Use and Storage Permit
Bureau of Indian Affairs	Approval of Coal Lease on Tribal Coal Approval of Surface Use Agreements Grant of Easement for a Right-of-Way
Bureau of Land Management	Approval of Mine Plans
Department of Transportation	Hazardous Waste Shipment Notification
Environmental Protection Agency	National Pollution Discharge Elimination System (NPDES) Spill Prevention Control and Countermeasure (SPCC) Plan Pollution Prevention Plan Toxic Release Inventory (TRI)
Agency	**Permit/Authorization/Filing**
Fish and Wildlife Service	Compliance with Endangered Species Act
Mine Safety and Health Administration Safety	Permit and Legal ID Ground Control Plan Major Impoundments Explosives Use and Storage Permit
Office of Surface Mining Reclamation and Enforcement	Permit to Mine EA and Record of Decision Mitigation of Historic Properties and Archaeological Sites

TRIBAL ENTITIES	
Environmental Protection Agency (on behalf of the U.S. Environmental Protection Agency)	Title V Air Permit to Operate Hazardous Waste Permit Stormwater Discharge Permit Public Water System Permit Public Water Systems Construction Permit Clean Water Act Section 401 Water Quality Certification Clean Water Act Section 402
Historic Preservation Department	Mitigation of Historic Properties and Archaeological Sites
Resources Committee	Revocable Use Permit
Fish and Wildlife Department	Biological Investigation Permit
National Heritage Program	Biological Investigation Permit
Department of Water Resources	Notice of Intention to Drill and Abandon an Exploration Well Notice of Intention to Drill, Deepen, Replace or Modify a Well Appropriations of Surface Water Withdrawal and Use of Groundwater Individual Aquifer Protection Permit
Minerals Department	SMCRA Oversight
Department of Natural Resources	SMCRA Oversight Clean Water Act Section 401 Water Quality Certification Clean Water Act Section 402
Cultural Preservation Office	Mitigation of Historic Properties and Archaeological Sites

A.2 COAL MINING LEASES

PWCC holds coal-mining leases with the Hopi Tribe and Navajo Nation, shown on Figure A-1, to produce up to 290 million tons (mt) from the exclusive Navajo Lease Areas (Contract 14-20-0603-8580 originally executed on February 1, 1964) and up to 380 mt from the Hopi and Navajo Joint Minerals Ownership Lease Area (Contracts 14-20-0603-9910 and 14-20-0450-5743 originally executed on June 6, 1966) for a combined total of 670 mt. While the specified leased coal tonnages are certain, the assignment of coal parcels to a particular buyer of the coal may change, depending upon customer demand and coal-quality needs.

The coal-mining leases also provide PWCC rights to prospect, mine, and strip leased lands for coal and kindred products, including other minerals, except for oil and gas, as may be found. PWCC also is given the right to construct support facilities such as buildings, pipelines, tanks, plants, and other support structures; make excavations, openings, stockpiles, dumps, ditches, drains, roads, spur tracks, transmission lines, and other improvements; and to place machinery and other equipment and fixtures and do all other things upon the leased lands necessary for the efficient operation of mining. PWCC may occupy that portion of the leased

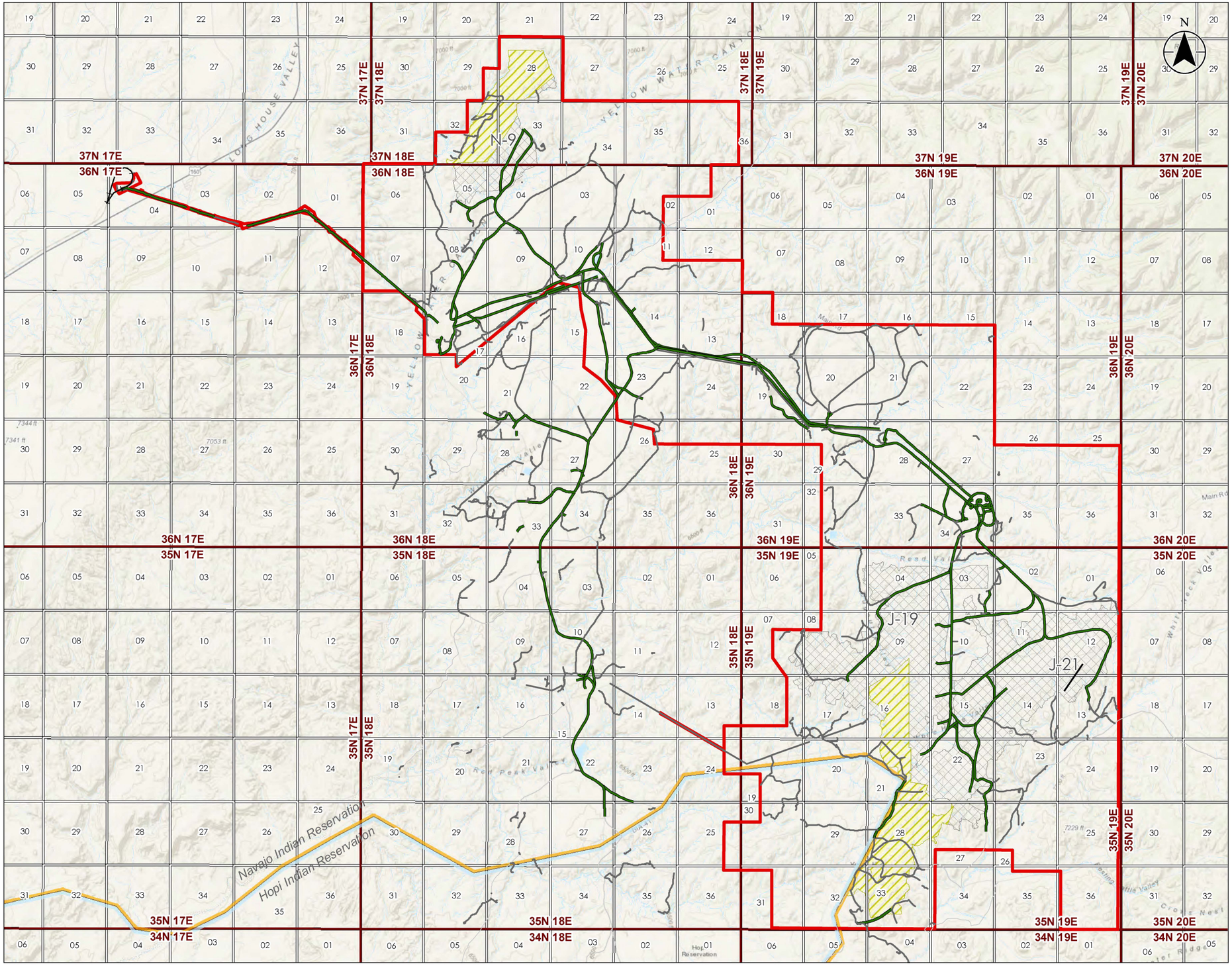
lands as is necessary to carry on mining operations, including right of ingress and egress, and may develop and use water for the mining operations.

A.3 RIGHTS-OF-WAY AND EASEMENTS

There are several existing grants of rights-of-way and easements allowing PWCC access and use of lands outside the existing coal lease areas. A grant of right-of-way and easement for an overland conveyor and coal-loading site was issued to the Navajo Generating Station project participants by the Secretary of the Interior with the approval of the Navajo Nation on December 10, 1969, that was ultimately transferred to PWCC. A grant of right-of-way and easement for two parcels of land providing access for utilities, haul roads, maintenance roads, sediment-control ponds, and a rock-borrow area was approved by the Navajo Nation and BIA on August 19 and 28, 1996, respectively. The BIA with the consent of the Navajo Nation issued a grant of right-of-way for an electrical transmission line on September 9, 1984.

A.4 COAL-SUPPLY AGREEMENTS

PWCC has an amended coal-supply agreement with the participants of the Navajo Generating Station containing a term ending in December 2019. This coal supply agreement provides the right to extend the term for a period or periods of time not to exceed 15 years from April 30, 2011.



Stantec

Legend

- Intermittent Stream/Drainage
- Rail
- Navajo-Hopi Partition Line
- Kayenta Mine Permit Area
- Proposed Renewal Period Disturbance Area
- Previously Mined Area
- Township/Range
- Section

PWCC Mine Road

- Primary
- Ancillary
- PWCC Mine Road

0 1 2 miles

1:100,000 (At original document size of 11x17)

Notes

1. Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 Feet
2. Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Project Location
T35N R19E, T37N R18E,
T36N R18E
Navajo County, AZ

203706045
Prepared by CLG on 2017-09-21
Technical Review by SL on 2017-09-21
Independent Review DK on 2017-09-21

Client/Project
PWCC
Kayenta Mine SMCRA Permit
BA/BE

Figure No.
2-1

Title
Project Area

Disclaimer: Stantec assumes no responsibility for data supplied in electronic format. The recipient accepts full responsibility for verifying the accuracy and completeness of the data. The recipient releases Stantec, its officers, employees, consultants and agents, from any and all claims arising in any way from the content or provision of the data.

B. MINE FACILITIES

This section contains a description of the existing and proposed facilities that do and would support the mining operation. These facilities include water-control facilities, transportation facilities, and other support facilities. The mine facilities within the PWCC lease area but outside the Kayenta Mine permit area have been separately authorized by OSM as part of the Initial Regulatory Program and are authorized for use in Kayenta mining operations in accordance with SMCRA regulations. This Environmental Assessment includes effects from the use of all mine facilities, within and outside the permit area, to the extent such facilities are necessary to the mining operations that would be authorized by the proposed action.

B.1 WATER-CONTROL FACILITIES

B.1.1 Sediment- and Water-Control Facility Plan

PWCC must design, construct, and maintain appropriate sediment-control measures including sediment ponds, diversions, culverts, and other sediment- and water-control structures in accordance with 30 CFR 816.45 in order to prevent, to the extent possible, additional contributions of sediment to stream flow or to runoff outside the permit area due to mining activity, and to minimize erosion. Sediment-control measures include practices used within and adjacent to the mining-disturbance areas. Sediment-control measures consist of the use of proper mining and reclamation methods and sediment-control practices, singly or in combination. Sediment-control methods may include, but are not limited to, the following:

- Disturbing the smallest practicable area at any one time during the mining and construction operation;
- Stabilizing graded material to promote a reduction in the rate and volume of runoff, and retaining sediment within disturbed area;
- Diverting runoff away from disturbance areas, including stockpiles, back slopes, and material storage;
- Diverting runoff through disturbed areas using stabilized earth channels, culverts, or pipes so as to prevent, to the extent possible, additional contributions of sediment to stream flow or to runoff outside the permit area;
- Using straw dikes, silt fences, small V-ditches, riprap, mulches, check dams, ripping, contour furrowing, vegetative sediment filters, small depressions, sediment traps, and other measures that would reduce overland flow velocity, reduce runoff volume, or trap sediment; and
- Treating traffic areas with water or dust suppression to reduce the potential for wind and water erosion.

Siltation structures or sedimentation ponds are used primarily for controlling sediment from all disturbed areas, except those permitted areas exempted by the requirements of these regulations. Other alternative sediment-control methods may be used in conjunction with the siltation structures or, in the case of the permitted areas that are exempt (i.e., roads), they may be used individually.

B.2 TEMPORARY SEDIMENTATION PONDS

PWCC constructs sedimentation ponds to control runoff and sediment from disturbed areas pursuant to 30 CFR 816.46, 816.47, 816.49, and 816.56. Sediment ponds generally are recognized in the coal-mining industry as the best available control technology to prevent, to the extent possible, additional contributions of suspended solids sediment to stream flow or runoff outside the permit area due to mining disturbance. All surface drainage from the disturbed areas passes through a siltation structure before leaving the permit area, except in certain small areas that are exempt from these regulations. In the exempt areas, alternative sediment-control methods are used to eliminate additional contributions of sediment off the permit area. Most of the sediment ponds are designed to be temporary, and are reclaimed when they are no longer needed to treat runoff from disturbed areas. Certain temporary ponds may be proposed for permanent retention in the post-mining landscape, but must be upgraded to meet permanent impoundment regulatory requirements.

One hundred fifty-six sedimentation structures exist within or adjacent to the Kayenta Mine permit area, and 73 temporary sedimentation structures have been removed and reclaimed as of 2010. Ten additional sediment impoundments are planned for construction during the Renewal period, and 51 sediment impoundments would remain permanently after mining and reclamation.

Sedimentation ponds and impoundments are designed to comply with the requirements of 30 CFR 780.11, 780.12, 780.25, 816.46, 816.47, 816.49, and 816.56, and other applicable regulations.

B.3 PERMANENT IMPOUNDMENTS

Fifty-one water sources consisting of three categories of impoundments determined to be needed to provide water for wildlife and livestock have been or are being proposed to exist permanently after mining is completed. These categories include pre-SMCRA internal impoundments, existing and proposed post-SMCRA internal impoundments, and existing and proposed water-control structures (sediment ponds). Nineteen permanent internal impoundments currently exist that are available for wildlife and livestock use as a part of the post-mining landscape.

Mine Safety and Health Administration-Size Impoundment Structures

PWCC uses 11 existing structures that meet the criteria of 30 CFR 77.216(a). Two structures would be temporary and nine structures would be permanent. The primary purpose of these structures, except for the Kayenta mining operation fresh-water pond, is to control sediment from disturbed mining areas. The Kayenta mining operation fresh-water pond's purpose is to hold groundwater pumped from nearby Navajo-aquifer wells used for dust suppression.

B.4 TOPSOIL STOCKPILES

Where prompt replacement of topsoil recovered ahead of mining disturbances is infeasible, numerous topsoil stockpiles are developed throughout the mine areas to store topsoil pursuant to 30 CFR 780.14(b)(5) and 816.22(c) until it is needed for revegetation operations. Stockpiled topsoil remains in place from less than 3 months to more than 10 years, depending on the location with respect to revegetation operations and the revegetation schedule. Stockpile dimensions, slopes, and volumes vary based on total salvage volumes, the configuration of the location site, and proximity to access roads. Using best management practices, stockpiles are placed on a stable site protected from wind and water erosion, and are not disturbed until required for redistribution.

B.5 ROADS

There are four types of roadways inside or crossing PWCC's permit area: primary roads, ancillary roads, non-mining-related roads (i.e., public roads and private roads), and pit ramps or routes of travel that are within the mining and spoil grading areas.

Primary and ancillary roads are located, designed, constructed, used, maintained, and reclaimed in accordance with the regulations and performance standards set forth under 30 CFR 816.150 and 816.151. Appropriate regulatory approval must be obtained for mine-related road crossings of stream buffer zones prior to construction of these crossings.

Within the primary and ancillary road classifications there are five sizes of roads based on use and traffic volume. There are three typical sizes of primary roads: (1) haul roads and mine-vehicle roads; (2) coal-haulage, mine-vehicle, and dragline-deadheading roads; and (3) mine-access roads. Two types of ancillary roads are used by lighter duty vehicles on a less frequent basis to access remote mine-facility sites, such as environmental monitoring sites; the first type is typically a two-lane road where an all-weather road is required to access remote sites, and the second type is usually a single-lane road that follows the natural topography (typically less frequently used than the first type).

All roads used or built by PWCC on or after December 16, 1977, would be reclaimed, unless they have been approved by the regulatory authority as a part of the post-mining land use plan. Because of the size and nature of PWCC's mining activities, very few of the roads in the latter category would be reclaimed until the end of mining activities on the entire leasehold. Exceptions include roads in the immediate vicinity of pits and ramps, which are created in the spoil and reclaimed as the general reclamation activities progress within a specific coal resource area.

B.6 SUPPORT FACILITIES

Support facilities include, but are not limited to, the following: mine buildings, offices and shops, bath houses, storage silos and cap magazines, coal-loading facilities, coal-crushing and -sizing facilities, coal-storage areas, equipment storage areas, water diversions and culverts, sheds constructed on permanent foundations and greater than 100 square feet in size, utilities, permanent fuel-storage and -tank farms, environmental monitoring sites, wells, and railroad and surface-conveyor systems. New support facilities would be approved by OSMRE prior to construction regardless of their location. All disturbances for construction of facilities to support mining operations are contained within a designated disturbance area.

Maintenance of all facilities and reclamation of temporary facilities is in accordance with the approved mining plan.

B.7 PWCC WELL FIELD

Used primarily for mining operations, the PWCC well field consists of eight wells that are located on the PWCC lease area. No new wells are proposed in the current permit renewal application.

C. COAL MINING

This section contains a description of the mining methods, equipment, and coal production rates proposed by PWCC for the Kayenta mining operations for July 2015 through July 2020.

C.1 MINING METHODS AND EQUIPMENT

The mining operation practices a conventional form of strip mining called "area mining" wherein the overburden above the uppermost coal seam and the innerburdens or partings between the lower coal seams are removed in parallel strips across the coalfield until the area is completely mined. The overburden and partings are disposed of behind the active pit in previously mined pits where the bottom seam has been completely removed.

C.1.1 Clearing and Grubbing

Immediately prior to topsoil removal the area to be mined is cleared of large vegetation consisting primarily of piñon and juniper trees to facilitate topsoil recovery. The vegetation debris removed is placed at locations that would not interfere with mining operations. A majority of this material is made available to local residents as firewood and the remainder is either piled at the edges of the mining area to provide cover and nesting habitat for wildlife or buried in the pit during mining operations.

C.1.2 Topsoil Removal

All suitable topsoil is removed from disturbed areas prior to initiating mining or mining-related activities. Prior to the start of removal operations, the proper salvage depth is staked or otherwise identified under the supervision of a soil scientist or other qualified person. Salvage-depth information must be adhered to by equipment operators. Topsoil material is removed throughout the year, weather permitting in 1,000- to 2,000-foot-long by 300-foot-wide sections. It is removed using scrapers or other earth-moving equipment and either hauled directly to recontoured areas for redistribution or transported to topsoil storage areas (stockpiles) located throughout the mine area for storage prior to eventual redistribution. Topsoil materials are removed up to 1,500 to 2,000 feet in advance of the active mining operation (i.e., active pit highwall) for safety and resource protection reasons.

PWCC implements dust control measures for topsoil stripping and redistribution operations. The cut of the topsoil removal areas and the ingress and egress routes to this area are included in watering operations. The ingress and egress routes to the topsoil lay-down area, where the final grading has occurred, also are watered. To reduce compaction, the lay-down area generally is not watered. Similarly, topsoil removal operations that

place salvaged soil in stockpiles include watering as described above and often on the stockpile itself. Additional watering operations are conducted in the access routes to and from the equipment parking lot and the equipment parking and support areas.

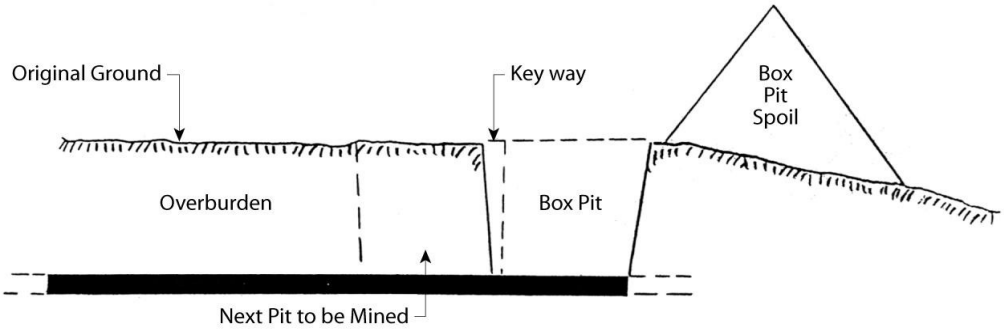
Overburden Removal

After being drilled and blasted, overburden material covering the shallowest coal seam is removed. The overburden is placed in piles in the previously mined pit along the side of the current cut using draglines and auxiliary excavating equipment. This process is repeated in sequential fashion as the pit advances into the coalfield (Figures A-2 and A-3).

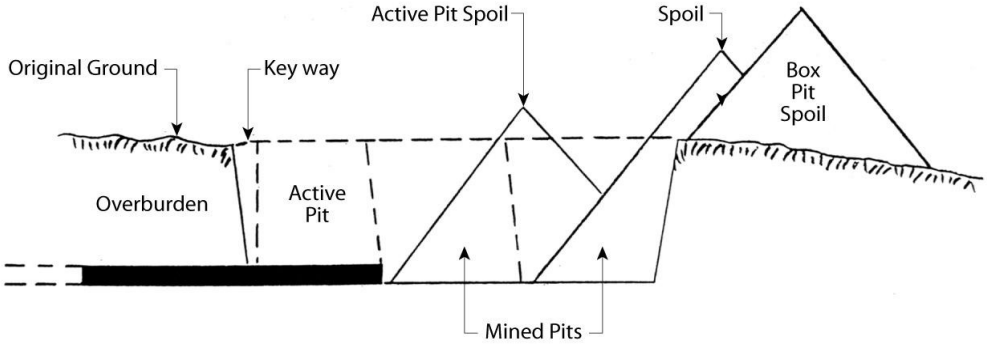
Overburden and spoil material that would be used as topsoil supplements is identified and removed in much the same manner as topsoil material. Topsoil supplements may be handled throughout the year. Topsoil supplements are not stockpiled and therefore are hauled directly to recontoured areas for redistribution.

Draglines are also the primary excavators of partings or innerburdens (material between the coal seams) as thickness and field conditions indicate. Partings may vary in thickness from 6 inches to more than 50 feet in the lateral distance of one cut. After being drilled and blasted, partings are removed and placed within or alongside the cut by draglines, backhoes, bulldozers, and/or truck and backhoe combinations, according to the operational requirements of each pit. Equipment such as trucks and backhoes or loaders and scrapers also may be used to assist with overburden or parting removal. When trucks and backhoes or scrapers are used, excavated material remains in the cut or pit area. A bulldozer is continually assigned to each dragline to perform bench leveling, access road preparation, trailing cable relocation, and miscellaneous duties.

INITIAL BOX PIT (End Cut Method)



SUBSEQUENT PITS



Note: Not to Scale

Figure A-2

Typical Pit Cross Sections

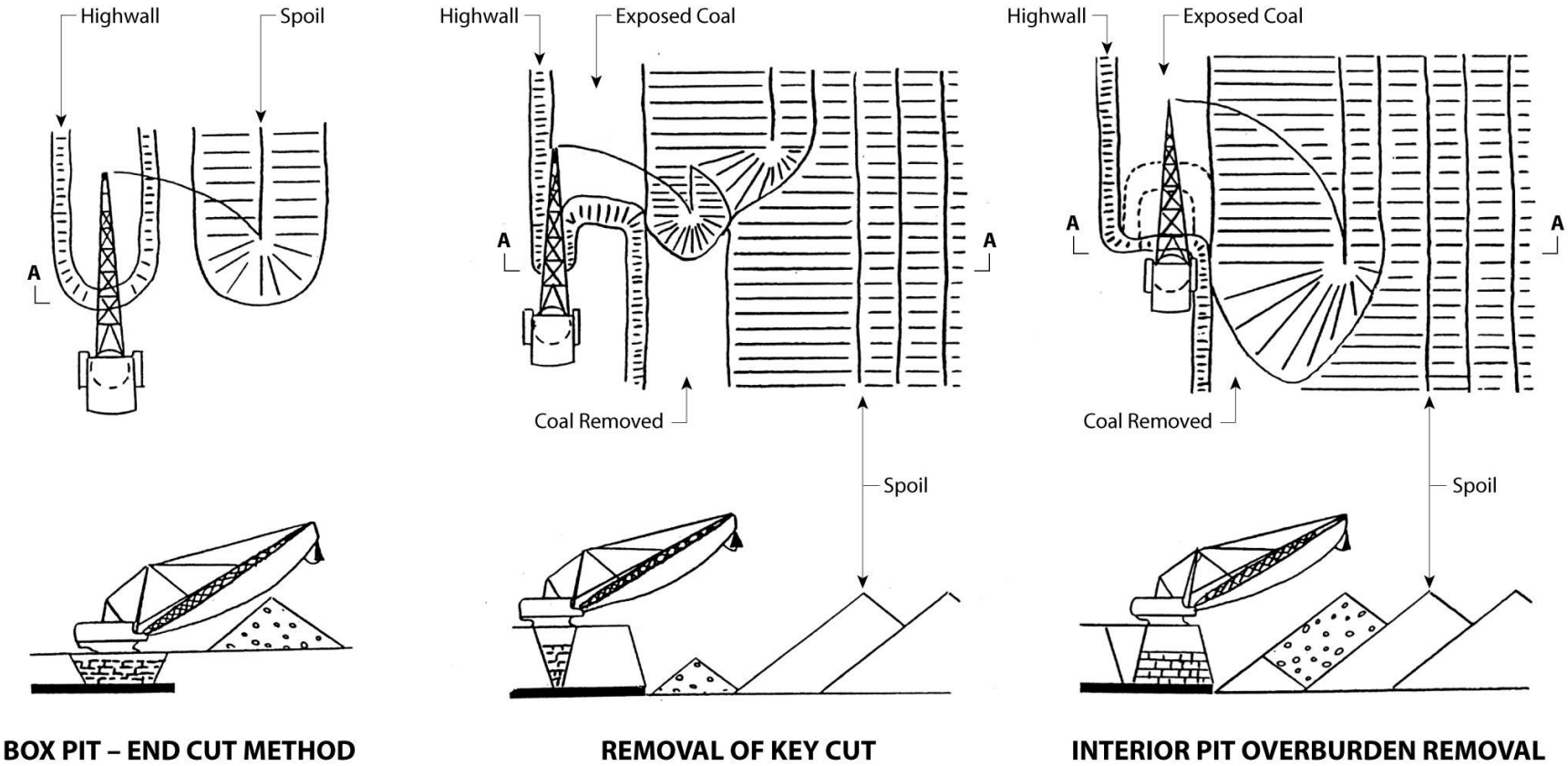


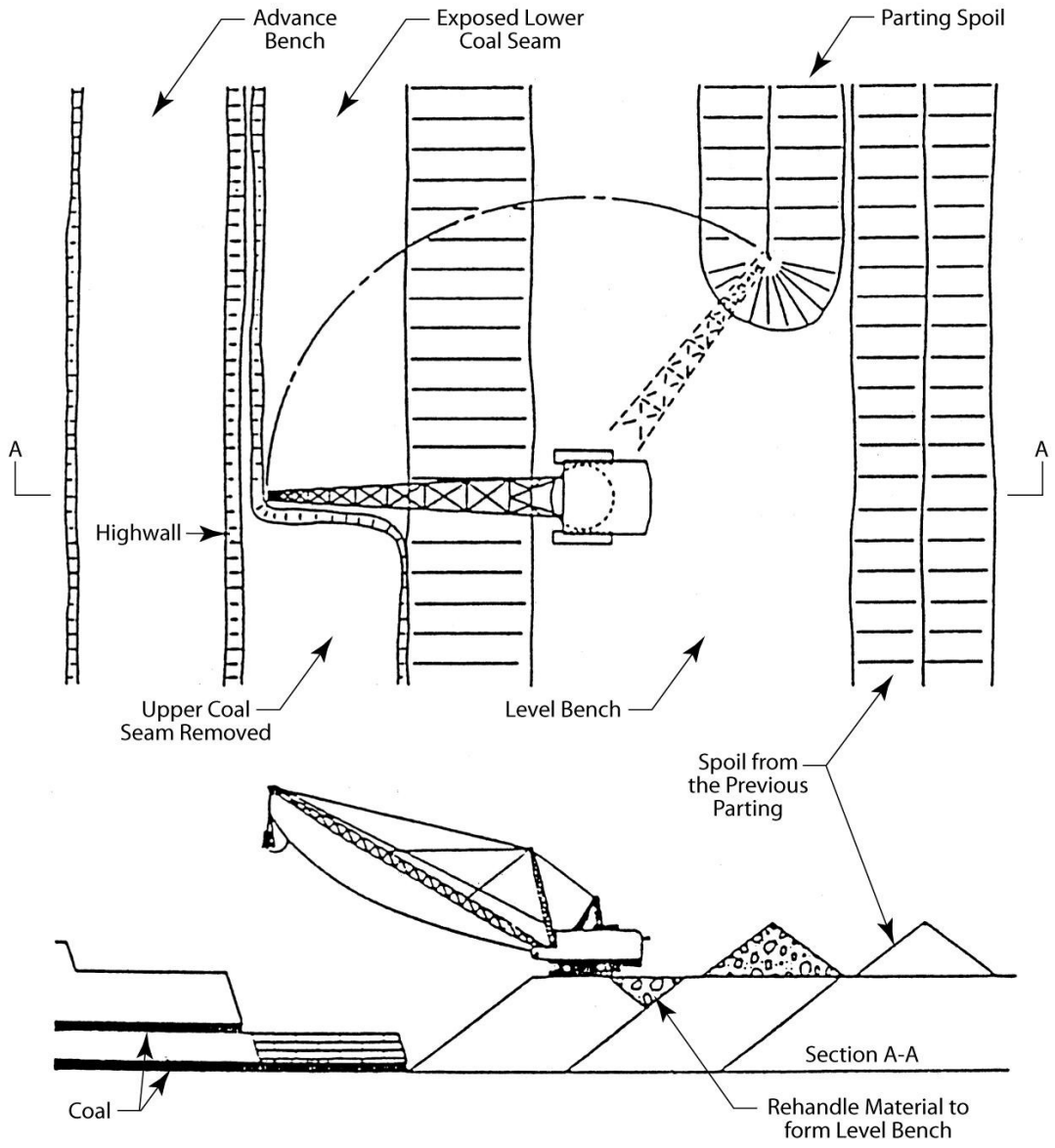
Figure A-3

Typical Pit Cross Section Showing Initial Box Pit and Subsequent Pits

The overburden excavation process begins with the digging of a narrow slot, or key cut, down to the coal seam to establish the highwall (Figure A-3). The location of the key cut and the spoil establishes the width of the pit. The dragline is positioned above the area to be excavated and in line with the direction the cut is progressing. The dragline bucket is lowered to the material to be excavated, drawn toward the dragline, lifted, and swung to the side, at which point it dumps or spoils the excavated material into a previously mined cut or along the side of the cut onto unmined ground. This process is repeated until the entire area in front of the dragline has been excavated. The dragline then is repositioned and begins another key cut and starts the process again. This procedure is followed until the operational limits of the machine are achieved or pit boundaries are reached. At this point, the dragline "walks," or deadheads, to where the next cut is to begin. The entire process starts again with each successive cut being excavated parallel to the previously mined cut and continues until excavation activities are complete within the pit.

An alternative to the highwall-side overburden excavation process is to level a bench on the spoil side and position the dragline on the spoil side to excavate the overburden and pull back the spoil over the coal seam (Figures A-4 and A-5). The main advantage of this method is to enable the dragline, which has limited operating radius to handle overburden covers of greater depth than would normally be contemplated. Other advantages of this overburden excavation process include better coal recovery in deeper overburden, reduced auxiliary equipment required for overburden excavation, increased spoil stability, reduced material rehandle, and maintaining an adequate pit width. The disadvantages include the need to prepare a spoil-side bench, sequencing the spoil-side benching operation with the pit operations, and increased dragline cycle times.

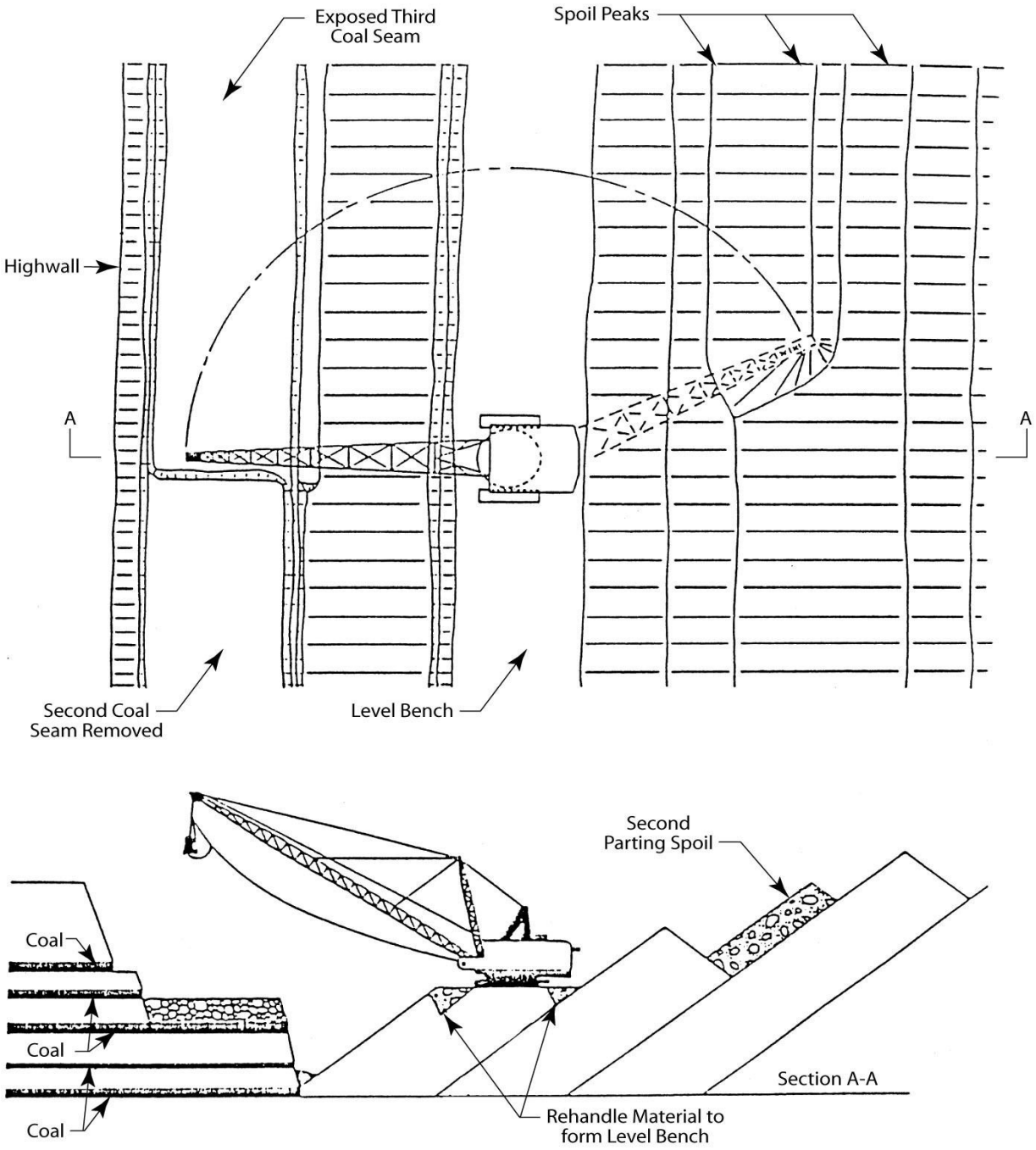
Typically, in deeper overburden, the upper coal seams may be uncovered on the highwall side and the lower seams uncovered on the spoil side. The positioning of the overburden removal equipment would be determined pit-by-pit to allow the most efficient coal recovery.



PLAN AND CROSS-SECTIONAL VIEW

Figure A-4

Spoil-Side Overburden Stripping



PLAN AND CROSS-SECTIONAL VIEW

Figure A-5

Spoil-Side Overburden Stripping

The selection of parting removal equipment is dependent upon the operational requirements within each pit. A dragline generally removes partings in excess of 15 feet; however, it may occasionally remove partings as thin as 5 feet. Backhoes and front-end loaders are used to remove partings that range in thickness from 3 to 15 feet. Occasionally, end-dump trucks are used in conjunction with a backhoe or front-end loader to remove partings within a pit. Bulldozers may remove partings that are less than 3 feet thick by first ripping the parting and afterwards pushing it off the coal seam to be removed.

Once the overburden or parting has been removed from above the coal seam, any remaining overburden material is cleared from the top of the coal seam using rubber-tired or track-type dozers.

The coal seam then is drilled and blasted using the same procedures that are followed to fragment overburden and partings. Rubber-tired front-end loaders and backhoes primarily are used to load the coal into haulage trucks for transportation to preparation areas. Backhoes are used in areas where thicker coal seams are to be loaded and mobility of the loader is not a prime consideration.

Haulage from pits to preparation areas is accomplished by bottom-dump trucks ranging in capacity from 150 to 250 tons. Occasionally, 150-ton end-dump trucks or smaller equipment also may be used. Haulage trucks are routed to pits as necessary to meet production and coal-quality requirements.

C.2 BACKFILLING

When all of the coal has been removed from the pit, overburden from the next parallel cut would be placed in the initial pit for backfilling. This would produce, in effect, an advancing pit that would continue until all the coal has been removed from the given coal resource area.

D. RECLAMATION AND MITIGATION

D.1 SURFACE STABILIZATION

PWCC has developed a plan in the permit application for establishing a reclaimed landscape that would minimize erosion and support post-mining land uses. The plan is currently implemented and is based on 25 years of reclamation operations at the Kayenta Mine. Under this plan, factors such as hill slope gradient and length, soil properties, surface-soil mechanical manipulation techniques, site characteristics, and revegetation practices are evaluated using prescribed criteria to design the surface form, soil placement, and drainage plan. With this plan, soil losses are predicted to be less than soil losses in pre- mining conditions.

D.2 POST-MINING LAND USES

The primary historical land use in the area has been livestock grazing—primarily sheep and goats. In recent years, the numbers of cattle and horses have increased. Other land uses include agriculture (primarily corn production in dry land, small area family plots), gathering of plant materials (for cultural, medicinal, and edible purposes), commercial trapping, various forms of outdoor recreation, and preservation of wildlife habitat. Reclamation efforts at the mine are directed toward restoring the land to be used for livestock gazing, wildlife habitat, and cultural plant use.

D.3 POST-MINING TOPOGRAPHY

Backfilling and grading operations are designed to produce a diverse topography similar to the original premining landform , as discussed above regarding the surface stabilization plan. Overburden that is spoiled in the previously mined pit is graded to eliminate spoil ridges and to produce the approved postmining topography. Material, including highwalls, would be graded to slopes of 3 horizontal:1 vertical or less. Bulldozers, scrapers, and occasionally draglines would perform rough- grading operations. Bulldozers and scrapers are used for final grading.

D.4 MINE-SOIL RECONSTRUCTION

Topsoil and topsoil-supplement redistribution operations ensure the replacement of a minimum of 4 feet of suitable plant growth media for revegetation, of which a minimum of 9 to12 inches would be topsoil. Coal combustion residuals (byproducts) are not allowed as plant growth media at any permitted surface coal mine including the Kayenta Mine. Graded spoils determined to be suitable as a rooting medium would be covered by a minimum of 9 to 12 inches of topsoil. Graded spoils determined to be unsuitable are covered with a minimum of 4 feet of suitable material (overburden and/or topsoil). Redistribution of plant-growth media is accomplished whenever weather and soil moisture conditions permit, using scrapers, bulldozers, front-end loaders, backhoes, and end-dumps, and miscellaneous support equipment (road graders, water trucks, and farm tractors). This material is obtained from topsoil storage piles or hauled directly from topsoil material removal areas and supplemental sources (highwalls and spoil banks). Scoria or red rock that is suitable for plant growth is used in localized areas for reclamation of cultural plants, woody plants, and wildlife habitat.

Mine spoils are scarified prior to or immediately after topsoil material is distributed, to increase adhesion at the interface between the respective materials and relieve compaction. After redistribution operations are complete, contour furrows are installed perpendicular to the slope, using an offset disk unit with 36-inch disks. Revegetation treatments such as seeding, mulching, and erosion repair are all conducted on the contour to reduce the potential for downslope water flow.

D.5 REVEGETATION PLAN

D.5.1 General

The revegetation plan has been developed to meet the requirements of 30 CFR 816.95, 816.97, 816.111, 816.113, 816.114, 816.116, and 816.133. The plan is currently implemented and is based on 25 years of reclamation operations at the Kayenta Mine. Following topsoil replacement, surface mechanical manipulations, and seedbed preparation, revegetation is completed using a combination of applied seed mixes, mulching, and seedling planting programs. The best technologically available practices are used to accomplish all revegetation activities. The Rangeland Seed Mix, the primary seed mix used for revegetation, is composed of a minimum of 21 species, including warm and cool season grasses, forbs, and shrubs. The predominantly native seed mix is designed to meet the requirements of the above-cited regulations and meet nutritional requirements for livestock and wildlife. The Rangeland Seed Mix is split into drilled and broadcast components based on seedbed ecology needs of the seeded species and physical

seed characteristics. Specialized seeding equipment is used to seed both components at the proper depths in one pass to reduce equipment traffic on the reclaimed surface. Several additional seed mixes are used in revegetating drainages or establishing wildlife habitat and sites for re-establishing cultural plants. The primary seeding season is from May to September, with a secondary seeding season available during spring and fall when ground conditions permit equipment operations.

Immediately following seeding of topsoiled areas, a native grass hay mulch is applied at 2 tons per acre and crimped. Native grass hay is more effective than straw and does not establish volunteer crops. Sites established with suitable plant growth substrates such as red rock or scoria are not mulched because of rough surface configuration and high coarse-fragment content. Following revegetation activities, the reclaimed areas are fenced to exclude livestock and are monitored for establishment. PWCC maintains a twice per year vegetation monitoring and weed program for a minimum of 10 years after reseeding areas. The twice per year vegetation monitoring and weed program identify the measures to control noxious weeds and invasive species establishment.

D.6 CULTURAL PLANT, WOODLAND, AND WILDLIFE HABITAT REVEGETATION

PWCC has developed and implemented a cultural plant restoration program on select reclaimed areas that also serves to reestablish woodland and wildlife habitat. Sites of one to several acres are prepared on north-facing slopes using red rock (scoria) suitable plant growth substrates. These sites are developed to simulate native site requirements of the target species. The sites contain numerous planting microsites due to roughened conditions created during substrate replacement operations. Plant materials are developed from local native seed collections with some regional sourcing as needed to ensure that plants are adapted to environmental conditions at the site and are capable of regeneration. Seedlings from these sources are grown in nurseries specializing in native plants. Specialized nursery cultural practices for the species being grown are used to develop these native plant materials. All seedlings receive mycorrhizal fungi applications for enhanced survivability and growth following planting. This ecological approach considers plant adaptations and symbiotic relationships common to plants in the arid Southwest.

Seedlings are specially handled following greenhouse operations and are hand planted in a random distribution in the microsites present in the planting areas. More than 50 grass, forb, shrub, and tree cultural plant species are commonly included in this program.

Piñon/juniper woodland sites are re-established as a part of the cultural plant restoration program. Seedlings of piñon pine, Utah juniper, and to a lesser extent Gambel oak, are included in these planting efforts. Planted tree densities are 250 to 350 stems per acre and the minimum established density is 75 trees per acre. Live piñon transplants from salvage of 3- to 5-foot-tall trees in grubbing areas ahead of mining are transplanted annually to complement tree seedling planting. Approximately 200 trees are transplanted to select reclaimed sites annually during the winter dormant season.

Revegetation practices to restore wildlife habitat include the overall rangeland-seeding program, cultural plant and piñon/juniper woodland restoration, and additional woody species plantings around ponds and small depressions. The revegetation program is designed to establish diverse vegetation capable of meeting

wildlife nutritional needs and other habitat factors such as cover or nesting. High-density shrub areas (greater than 800 stems per acre) are interspersed within the reclaimed landscape. Cultural plant/woodland/wildlife habitat sites also are interspersed within the reclaimed landscape. These features combine to increase edge and habitat diversity.

D.6.1 Revegetation Success

Revegetation success standards and their evaluation are structured to meet the criteria of 30 CFR 816.111 and 816.116. Standards are based on a combination of native reference areas and approved technical standards that reflect environmental site conditions, ecological considerations, and post-mining land uses. The criteria for evaluation follow both 30 CFR 816 requirements and other Federal guidelines and address the parameters of cover, production, woody density, and diversity.

Revegetated areas are included in a spring and fall annual vegetation monitoring program to identify any needed remedial action, document trend and vegetation performance of reclaimed areas, contribute to the database for revegetation success evaluations, and provide data for implementation of post-mining land uses. The vegetation monitoring data are used to establish grazing levels in an approved grazing management program designed to enhance vegetation community characteristics and demonstrate achievable post-mining land uses.

D7. PROTECTION OF FISH AND WILDLIFE, AND RELATED ENVIRONMENTAL VALUES

D.7.1 General

PWCC's plan for protection of fish, wildlife, and related environmental values addresses the requirements of 30 CFR 816.97. The previous discussion under Revegetation Plan addresses re-establishment, mitigation, and enhancement of vegetative habitat features and needs. Various sections of the approved permit address operations conducted to minimize hazards to raptors from electric power lines and how to design, locate, and operate roads and facilities that avoid or minimize impacts on wildlife and permit passage.

Nonvegetative wildlife-habitat-enhancement-or-replacement features include linear rock features and rock structures established at 1 per 100 acres with specified design criteria in the AZ-0001E permit. Raptor perches are established at a density of 1 per 400 acres. The perches are constructed based on the most appropriate technologically sound design criteria at the time of installation. Permanent impoundments and their numbers have been discussed previously in this appendix. These impoundments significantly enhance habitat, establish wetland vegetation, and provide a critical habitat feature previously not readily available in the pre-mine landscape.

Mine front raptor surveys are conducted adjacent to and within 1/4 mile of active advancing mining operations (currently N-9, J-21, and J-19). These are conducted during the breeding season to minimize and mitigate any impacts to breeding birds and avoidance of activity around nests. Targeted species are Cooper's hawks and northern goshawks. These surveys have been conducted annually for a number of years and to date none have been observed.

Red-tailed hawk nest monitoring is conducted annually on the PWCC lease area. Additionally, information is gathered throughout the year on the presence of red-tailed hawks. This has been ongoing annually for a number of years.

Gunnison's prairie dog colony assessments are conducted annually on and immediately adjacent to the PWCC lease area. The surveys are conducted to determine the potential habitat suitability for black-footed ferrets and if the minimal requirements present are triggering formal black footed ferret surveys. The annual monitoring has been conducted for a number of years and the colony parameters and requirements for formal black footed ferret surveys have not been detected in the surveys. An added benefit of these surveys is that prairie dog colonies may be a source of mountain plover habitat and the emphasis here and the inclusion of special status monitoring during annual surveys has shown no presence of mountain plover in monitored prairie dog colonies or other areas on the PWCC lease area.

Annual monitoring addresses special status species which include the Federal and the Navajo Nation listed endangered, threatened, candidate, and sensitive species of concern. These surveys also look at the presence of suitable habitat, topographic features, and unique areas on the PWCC lease that are or could be important to a variety of wildlife. Mexican spotted owl surveys have been initiated in 2011 in the region on and adjacent to the northeast portion of the PWCC lease area.

Reclaimed area surveys are conducted with the above in mind but with emphasis on reclaimed areas to further broaden the annual wildlife survey base while collecting information to identify species presence and support information as to the success and suitability of the reclaimed areas as habitat for a variety of species.

The annual wildlife monitoring is conducted periodically from February until December with seasonal emphasis based on specific monitoring requirements in the above areas.

D.8 THREATENED AND ENDANGERED SPECIES, AND SPECIES OF SPECIAL CONCERN

Baseline studies and annual wildlife and vegetation monitoring address current species listed as threatened, endangered, or of special concern by Federal, tribal (Hopi or Navajo), or State agencies. PWCC promptly notifies the regulatory authorities of any Federal, tribal, or State listed species occurring on the permit area and would conduct the required mitigation or monitoring following consultation.

Surveys for nesting raptors in advance of active mining operations are conducted annually, and mitigation procedures are implemented as necessary after consultation with the regulatory authority if nesting raptors are located within the survey area. Prairie dog colonies are monitored annually for areal extent and sign of black-footed ferrets. If the size of a prairie dog colony exceeds the minimum acreage requirements in effect at the time, black-footed ferret surveys are conducted in accordance with guidelines specified by the regulatory authority. Mexican spotted owl surveys and monitoring were conducted over a seven-year period ending in 2000. Consistent with Special Condition 2, Mexican spotted owl surveys would be reinitiated when mining activities are within 2 miles of any known nest site or the mixed-conifer habitat type adjacent to the lease area. Mexican spotted owl surveys have been reinitiated in 2011 as a result of the N-9 mining progression

and the requirements of Special Condition 2. Surveys or monitoring have been coordinated with the regulatory authority following approved protocols. Peregrine falcons were delisted in August 1999, and PWCC ended monitoring and breeding surveys in 2000. If listing status for the peregrine falcon changes or if the proximity of mining operations dictates, monitoring would be reinitiated after consultation with the regulatory authority. Mexican spotted owls and peregrine falcons were intensively monitored by PWCC from 1994 to 2000 and 1989 to 2000, respectively, with no apparent impacts on either species.

E. ABANDONMENT OF MINING FACILITIES

Abandonment activities would begin when particular facilities are no longer required to support mining operations. Facilities such as buildings, parking lots, roads, wells, and utilities that are requested to be kept by the tribes would be turned over to them. Other materials having economic value (such as structures and equipment) would be salvaged or recycled. All other materials would be disposed of using approved procedures and in accordance with the Navajo Nation Solid Waste Disposal regulations. All sites would be recontoured to conform to the natural landform, covered with topsoil, and revegetated, using the same post-mining techniques as those proposed for areas disturbed by mining.

In the event that cessation of mining operations was to occur in a coal-resource area with unmined but recoverable coal resources remaining, the following procedures would be implemented. If no further mining operations were to occur in the coal-resource area, final reclamation procedures, including backfilling and grading, topsoil replacement, and revegetation, would be carried out similar to all other areas proposed for mining disturbance as required under 25 CFR 211 and 30 CFR 59 and 132. Accurate survey information at the time of final mining operations would provide the location of final highwalls and coal-recovery limits in case mining is reinitiated at a future date resulting in a minimal loss of the coal resource. These procedures would minimize reaffecting the land in the event of future surface coal- mining operations. In cases where the abandonment is temporary (temporary cessation), the coal seam(s) would be covered, access to the pit area would be blocked, and the highwall would be bermed for safety. Any backfill or cover material that contacts the remaining coal seam(s) would be inert and contain no combustible material. Sediment control and environmental monitoring of the area would be continued.

Survey information at the cessation of operations would provide accurate location of the final highwall and coal-recovery limits to facilitate reinitiation of mining operations with minimal loss of the coal resource and minimizing any reaffecting of the land as specified in 30 CFR 59 and 131. The decision to temporarily or permanently abandon operations is dependent on many factors including operational, market, contract, or customer.

Appendix C

Regional Air Quality Tables

Table C-1 Second-Highest 24-hr PM_{10} Concentrations

Monitor	Concentration µg/m³		
	2011	2012	2013
AIRQ1	31.1	55.8	36.7
AIRQ2R	42.4	62.3	53.1
AIRQ3R	66.0	**109.7**	80.8
AIRQ4R	41.5	39.5	83.8
AIRQ5R	49.9	37.7	80.4
AIRQ6R	32.9	34.1	37.7
AIRQ7R	40.5	26.1	34.8
AIRQ8R	67.2	55.2	56.1
AIRQ12	52.7	67.8	97.1
AIRQ200	33.7	28.2	32.2
AIRQ201	47.2	47.2	72.0
AIRQ202	32.6	53.5	54.4

Note: NAAQS = 150 µg/m³

Table C-2 Highest 24-hr $PM_{2.5}$ Concentrations

Monitoring Period	Concentration µg/m³		
	AIRQ1	AIRQ3R	AIRQ6R
October to December 2013	7	6	5
January to March 2014	8	9	8
April to June 2014	10	11	7
July to September 2014	8	6	5
October to December 2014	10	8	8
January to March 2015	5	4	4
2nd Highest 24-hr Conc. 2014	10	10	8
Annual mean Conc. 2014	4.4	4.3	3.2

Note: NAAQS = 24-hr 3-yr average 98th percentile 35 µg/m³; Annual mean average = 12 µg/m³

Table C-3 1-hr Nitrogen Dioxide Concentrations, Station N9

Monitor Period	Concentration µg/m³	
	Highest 1-hr	3rd Highest 1-hr
8/11 – 10/11	94	73
11/11 – 1/12	71	62
2/12 – 4/12	70	55
5/12 – 7/12	120	79
8/12 – 10/12	79	66
11/12 – 1/13	83	75
2/13 – 4/13	70	62
5/13 – 7/13	73	53
8/13 – 10/13	79	58
11/13 – 1/14	70	68
2/14 – 4/14	68	62

5/14 – 7/14	49	41

Note: NAAQS = 1-hr 3-yr average 98th percentile 188 µg/m³

Table C-4 1-hr Nitrogen Dioxide Concentrations, Station J19/J21

Monitor Period	Concentration µg/m³	
	Highest 1-hr	3rd Highest 1-hr
2/12 – 4/12	79	66
1/13 – 3/13	73	60
4/13 – 6/13	64	60
7/13 – 9/13	68	60
10/13 – 12/13	77	75
1/14 – 3/14	75	56
4/14 – 6/14	66	60

Note: NAAQS = 1-hr 3-yr average 98th percentile 188 µg/m³
Sampled at three different locations in same general area. Poor data recovery due to power issues prior to 2/1/12 and between 5/1/12 to 12/31/12. Data was not considered valid during this period.

Table C-5 Annual Nitrogen Dioxide Concentrations, Station N9

Monitor Period	Concentration µg/m³	
	8th Highest 1-hr	Annual Mean
8/11 – 7/12	73	5.0
8/12 – 7/13	68	4.6
8/13 – 7/14	62	5.1
Three-year Mean	68	-
Max Annual Mean		5.1

Note: NAAQS = 1-hr 3-yr average 98th percentile 188 µg/m³; Annual = 100 µg/m³

Table C-6 Highest and 2nd Highest 8-hr Ozone Concentrations, Station N9

Monitor Period	Concentration µg/m³	
	Highest 8-hr	2nd Highest 8-hr
8/11 – 10/11	137	127
11/11 – 1/12	96	92
2/12 – 4/12	137	137
5/12 – 7/12	143	141
8/12 – 10/12	125	125
11/12 – 1/13	100	98
2/13 – 4/13	123	116
5/13 – 7/13	133	129
8/13 – 10/13	114	112
11/13 – 1/14	98	98
2/14 – 4/14	120	118
5/14 – 7/14	125	123

Table C-7 Annual 4th Highest 8-hr Ozone Concentrations, Station N9

Monitor Period	Concentration µg/m³
	4th Highest 8-hr
8/11 – 7/12	137
8/12 – 7/13	129
8/13 – 7/14	120
Mean	129

Note: NAAQS = 3-yr average of the 4th highest 8-hr average 147 µg/m³

Table C-8 Off-Site Monitored Background Concentrations for $PM_{2.5}$

Pollutant	Site ID	Station Address	Approx. distance from KMC	Year	Averaging Period	Rank	Concentration (µg/m³)
$PM_{2.5}$	35-045-0019	Farmington Environmental Department Office	192 km East	2011	24-hour	98th percentile	12.3
				2012	24-hour	98th percentile	11.0
				2013	24-hour	98th percentile	15.8
						3-yr mean	13.0
				2011	Annual		4.1
				2012	Annual		4.9
				2013	Annual		5.0
						3-yr mean	4.7

Table C-9 Off-Site Monitored Background Concentrations for SO_2

Pollutant	Site ID	Station Address	Approx. distance from KMC	Year	Averaging Period	Rank	Concentration (ppb)	Concentration (µg/m³)
SO_2	35-045-0009	SE Corner of NM Highway Department Yard	207 km East	2011	1-hour	99th percentile	9	23.6
				2012	1-hour	99th percentile	9	23.6
				2013	1-hour	99th percentile	8	21.0
						3-yr mean	9	22.7
				2011	3-hour	2nd High	6	15.7
				2012	3-hour	2nd High	7	19.1
				2013	3-hour	2nd High	7	19.1
						Highest 2nd	7	19.1
				2011	24-hour		2	5.8
				2012	24-hour		3	6.6
				2013	24-hour		3	6.8
						Highest 2nd	3	6.8
				2011	Annual		2	4.9
				2012	Annual		2	4.1
				2013	Annual		1	2.9
						Annual Max.	2	4.9

Table C-10 Off-Site Monitored Background Concentrations for CO

Pollutant	Site ID	Station Address	Approx. distance from KMC	Year	Averaging Period	Rank	Concentration (ppm)	Concentration (µg/m³)
CO	08-067-7001	Pine River Valley, the most densely populated area	246 km east/northeast	2011	1-hour	98th percentile	1.3	1,495
				2012	1-hour	98th percentile	0.8	920
				2013	1-hour	98th percentile	1.7	1,955
						Highest 2nd	1.7	1,955
				2011	8-hour		0.7	805
				2012	8-hour		0.6	690
				2013	8-hour		1.3	1,495
						Highest 2nd	1.3	1,495

Table C-11 Regional Ambient Background Concentrations

Pollutant	Averaging Period	Concentration (µg/m³)	Monitoring Site
Carbon Dioxide	8-hour	3,664	JGL Supersite
	1-hour	2,633.5	JGL Supersite
Lead	Rolling 3-mo	0.10	JGL Supersite
Nitrogen Dioxide	1-hour	Varies Seasonally	Hurricane
	Annual	6.0	Hurricane
PM2.5	24-hour	5.9	Glen Canyon
	Annual	20.8	Glen Canyon
PM10	24-hour	44.5	Glen Canyon
Sulfur Dioxide	1-hour	22.5	Glen Canyon
	3-hour	24.6	Glen Canyon

Note: PM2.5 annual background includes 0.26 µg/m³ secondary aerosol concentration generated by CAMx. PM2.5 24-hour background includes1.0 µg/m³ secondary aerosol concentration generated by CAMx

Table C-12 Visibility (Haziness) Records at IMPROVE Sites

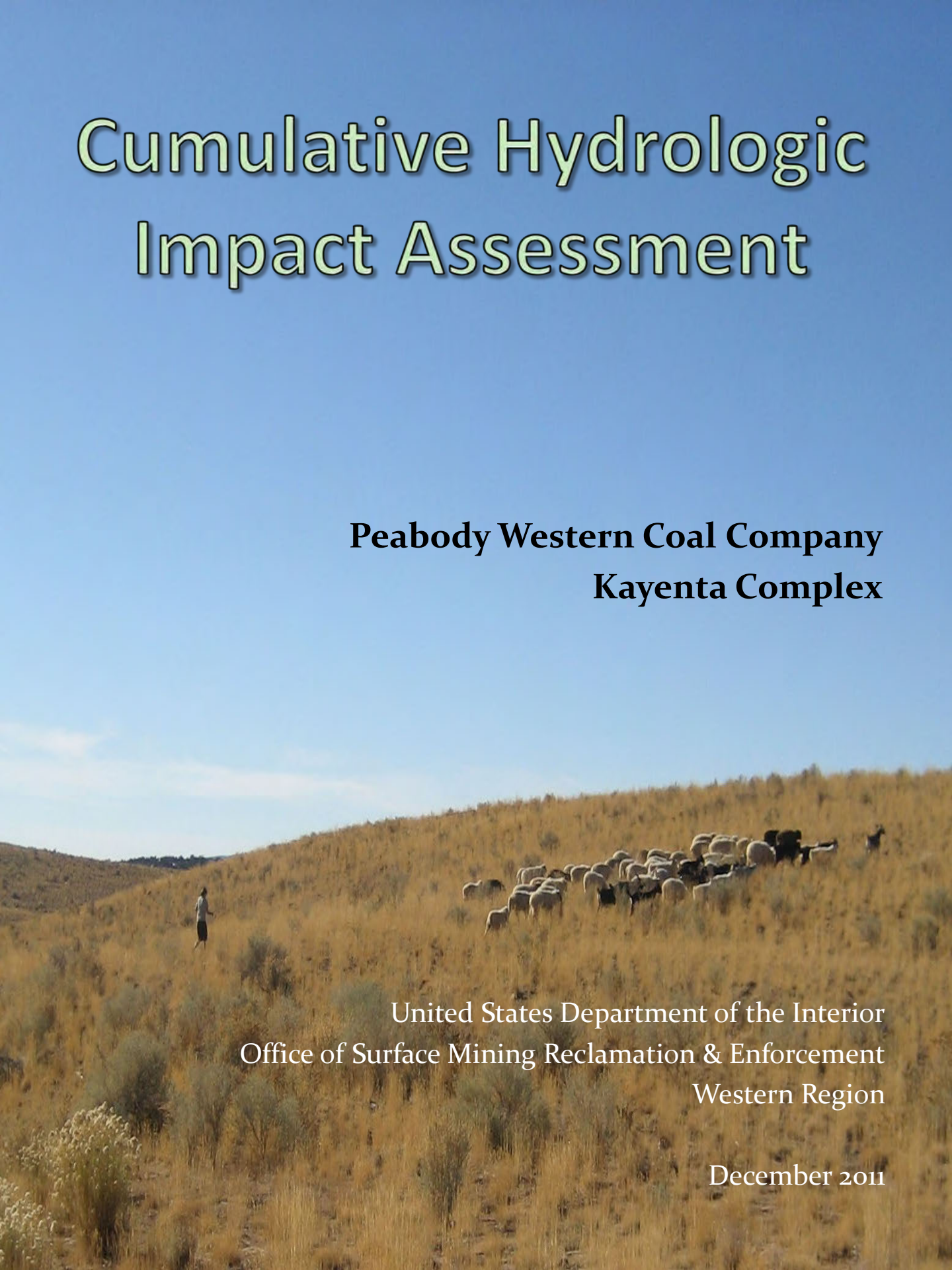
Parameter	Site	Visibility by Year (deciviews)				
		2010	2011	2012	2013	2014
Lowest 20% of days (Least hazy)	Bryce Canyon	1.66	2.00	1.67	1.40	1.16
	Canyonlands	2.74	2.74	3.20	3.37	2.60
	Capitol Reef	2.15	2.89	2.41	2.93	2.12
	Mesa Verde	3.03	3.18	2.73	2.91	2.44
	Grand Canyon	1.87	1.70	2.05	1.37	1.05
	Petrified Forest	4.27	4.03	4.24	3.63	3.37
Average of all days	Bryce Canyon	5.55	5.28	5.80	5.51	4.89
	Canyonlands	5.78	5.73	6.27	6.32	5.37
	Capitol Reef	5.90	5.83	6.36	6.21	5.38
	Mesa Verde	6.41	6.25	6.42	6.32	5.14
	Grand Canyon	5.43	5.48	5.73	5.13	4.49
	Petrified Forest	7.51	7.51	7.84	6.55	6.36
Highest 20% of days (Most hazy)	Bryce Canyon	9.39	10.77	10.46	9.16	8.49
	Canyonlands	10.70	9.91	11.61	10.40	9.14
	Capitol Reef	9.63	9.29	11.79	9.94	9.14
	Mesa Verde	11.78	10.47	11.57	10.58	9.52
	Grand Canyon	9.87	11.65	9.55	9.68	10.10
	Petrified Forest	11.49	11.90	12.10	10.07	10.56
Average	Lowest 20%	2.62	2.76	2.72	2.60	2.12
	Average	6.10	6.01	6.40	6.01	5.34
	Highest 20%	10.48	10.66	11.18	9.97	9.49

Appendix D

Cumulative Hydrologic Impact Assessment

Cumulative Hydrologic Impact Assessment

Peabody Western Coal Company
Kayenta Complex



United States Department of the Interior
Office of Surface Mining Reclamation & Enforcement
Western Region

December 2011

CUMULATIVE HYDROLOGIC IMPACT ASSESSMENT

of the

Peabody Western Coal Company

Kayenta Complex

United States Department of the Interior
Office of Surface Mining Reclamation and Enforcement
Western Region

December 2011

Cover:
Photograph of reclaimed area within the Kayenta Complex, northern Arizona. (OSMRE photograph taken by Paul Clark.)

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List of Acronyms and Abbreviations

3D Model	regional three-dimensional numerical flow model of D and N aquifers
ac-ft	acre-feet
AgL	agricultural livestock watering
AgI	agricultural irrigation water
AgWS	agricultural water supply
ALJ	administrative law judge
$A\&W_e$	aquatic and wildlife - ephemeral
A&WHbt	aquatic and wildlife habitat
BIA	Bureau of Indian Affairs
C aquifer	Coconino aquifer
cfs	cubic feet per second
CHIA	cumulative hydrologic impact assessment
CIA	cumulative impact area
CFR	Code of Federal Regulations
CG	crest gage
CWA	clean water act
D aquifer	Dakota aquifer
DWS	domestic water supply
EA	environmental assessment
EIS	environmental impact statement
EPA	Environmental Protection Agency
ft/sec	feet per second
FC	fish consumption
FR	federal register
gpd/ft	gallons per day per foot
GWR	groundwater recharge

HTWQS	Hopi Tribe water quality standards
HUC	hydrologic unit code
LW	livestock watering
MDL	method detection limit
mg/L	milligrams per liter
mi^2	square miles
N aquifer	Navajo aquifer
NNSWQS	Navajo Nation surface water quality standards
NPDES	National Pollutant Discharge Elimination System
OSMRE	Office of Surface Mining Reclamation and Enforcement
PAP	permit application package
PBC	partial body contact
PHC	Probable Hydrologic Consequences
PWCC	Peabody Western Coal Company
PWS	public water supply
ScHC	secondary human contact
SMCRA	Surface Mining Control and Reclamation Act
TDS	total dissolved solids
TSS	total suspended solids
µg/L	micrograms per liter
USEPA	United States Environmental Protection Agency
USGS	United States Geologic Survey

1 INTRODUCTION

The Office of Surface Mining Reclamation and Enforcement (OSMRE) is the regulatory authority for coal mining operations under the Surface Mining Reclamation and Control Act of 1977 that occur on Hopi Tribe and Navajo Nation surface. As such, OSMRE is responsible for the review and decisions on all permit applications to conduct surface coal mining operations. The Peabody Western Coal Company (PWCC) permit area, located on both Navajo Nation and Hopi Tribe surface area, is required to have a cumulative hydrologic impact assessment (CHIA), prepared by the regulatory authority, which assesses whether the proposed operation has been designed to prevent material damage to the hydrologic balance outside the permit area (30 Code of Federal Regulations (CFR) § 780.21(g)).

A CHIA is an assessment of the probable hydrologic consequences (PHC) of the proposed operation and all anticipated coal mining upon surface and groundwater systems in the cumulative impact area (CIA). The PHC is prepared by the applicant as required by 30 CFR § 780.21(f), and approved by the regulatory authority. Congress identified in the Surface Mining Coal and Reclamation Act (SMCRA) (U.S. Congress, 1977) that there is "a balance between protection of the environment and agricultural productivity and the Nation's need for coal as an essential source of energy" (SMCRA, 1977 Sec 102(f)). The hydrologic reclamation plan required by the rules at 30 CFR § 780.21(h) recognizes that disturbances to the hydrologic balance within the permit and adjacent area should be minimized, material damage outside the permit area should be prevented, applicable Federal, Tribal, and State water quality laws should be met, and the rights of present water users protected. Additionally, 30 CFR § 816.42 states "discharges of water from areas disturbed by surface mining activities shall be made in compliance with all applicable State and Federal water quality laws and regulations and with the effluent limitations for coal mining promulgated by the United States Environmental Protection Agency (USEPA) set forth in 40 CFR part 434." Discharges of disturbed area runoff at the Kayenta Complex are conducted in accordance with the terms and conditions of two separate National Pollutant Discharge Elimination System (NPDES) permits issued by the USEPA and certified by the Navajo Nation and Hopi Tribe under the Clean Water Act (CWA).

OSMRE considered USEPA approved water quality standards for the Hopi Tribe and Navajo Nation as part of the impact assessment. Additionally, protection of existing and foreseeable water uses within the various delineated cumulative impact areas was a focus of this assessment. The following summary table identifies water resources evaluated and approach for impact assessment (Table 1). It should be noted that OSMRE has identified material damage thresholds which are not enforceable, but provide a preliminary assessment level of material damage so that measures may be taken to prevent material damage to the hydrologic balance outside the permit area before occurring. Table 1 indicates that; (1) the hydrologic monitoring program is adequate for OSMRE's CHIA, (2) impacts within the permit area have been minimized, and (3) material damage outside the permit area has been prevented. This CHIA supersedes the CHIA prepared in 2008 (OSMRE, 2008) and 1989 (OSMRE, 1989).

Kayenta Complex – Material Damage Summary						
Water Resource	Assessment Approach	Material Damage Threshold	Material Damage Limit	Material Damage Outside Permit Area	Impact Minimization	Adequate Monitoring Program
Surface Water Quality	Downstream Comparison to Upstream Samples	4 of 4 Sample Events > WQS	Change Resource Use	No	Sediment Control Structures	Yes
Surface Water Quantity	Percent CIA Managed with Impoundments	30-Percent CIA	> 50-Percent CIA	No	Contemporaneous Reclamation	Yes
Alluvial Quality	Downstream Comparison to Upstream Samples	Agricultural Livestock Use WQS	Continued Monitoring	No	Mining Limited to Ephemeral Channels	Yes
Alluvial Quantity	Darcy's Law Flow Equation	Continued Monitoring	Continued Monitoring	No	Water Retention for Livestock and Wildlife	Yes
Wepo Quality	Backfill Spoil and Adjacent Area Monitoring	Continued Monitoring	Continued Monitoring	No	Water Supply Replacement	Yes
Wepo Quantity	Modeling , Monitoring, and Visual Observation	Continued Monitoring	Continued Monitoring	No	Water Supply Replacement	Yes
N-Aquifer Quality	USGS and PWCC NAV Well Data	4 of 4 Sample Events > MCLs	Drinking Water Quality Standards	No	Alternating Pumping Wells	Yes
N-Aquifer Quantity	USGS and PWCC Monitoring, and PWCC Model Lift Costs	26-Percent Lift Cost Increase at Supply Wells	> 50-Percent Lift Cost Increase at Supply Wells	No	System Recovery due to Reduced Pumping (70% Reduction After 2005)	Yes
N-Aquifer Baseflow	Approved PWCC Model and Model Verification	21-Percent Reduction In Modeled Baseflow	> 30-Percent Reduction In Modeled Baseflow	No		Yes - Predictions Modeled

Table 1. Kayenta Complex Material Damage Summary

The finding that the mining operation is designed to prevent material damage to the hydrologic balance outside the permit area is supported by the following chapters. The CHIA is organized as follows:

- Chapter 1
  - Describes the regulatory environment.
  - Describes general background of the Kayenta Complex.

- Chapter 2
  - Assesses cumulative impact potential with active coal mines.
  - Delineates the surface water CIAs.
  - Delineates the groundwater CIAs.

- Chapter 3 identifies water resource uses and designations in the CIAs.

- Chapter 4 provides a description of baseline surface and groundwater quantity and quality within the CIAs.

- Chapter 5 contains an impact assessment of the Kayenta Complex on surface water and groundwater quantity and quality, and includes a determination of:
  - The minimization of impacts within the permit area;
  - The prevention of material damage outside the permit area;
  - The adequacy of the monitoring program to assess potential impacts; and,
  - Establishes material damage thresholds and limits.

1.1 Regulatory Environment

Surface coal operations on Hopi Tribe and Navajo Nation surface are managed through the coordinated collaboration of several regulatory agencies. Depending on the permitting action, multiple regulatory agencies may be involved in the review, comment, and public participation process. Regulatory agencies that may have a permitting action or compliance interest on the PWCC permit include:

- OSMRE (regulatory authority for coal mining operations on Hopi Tribe and Navajo Nation surface)
- Bureau of Indian Affairs (protect and improve trust assets of the Tribes)
- Hopi Tribe Water Resources Program (develop and administer water quality standards)
- Navajo Nation EPA (develop and administer water quality standards)
- Navajo Nation Minerals Department (represent Tribal mineral interests)
- Navajo Nation Water Management Branch (implement Navajo Nation's Water Code)
- U.S. Environmental Protection Agency (issue and administer NPDES permits)
- U.S. Fish and Wildlife Service (ensure protection of threatened and endangered species)
- Bureau of Land Management (ensures maximum resource recovery)
- U.S. Army Corps of Engineers (issue permits and associated impact assessments for the discharge of fill material into waters of the United States, including wetlands under section 404 of the CWA)

The 2011 CHIA update was developed based on regulatory review and comment by the Bureau of Indian Affairs, Hopi Tribe Water Resources Program, Navajo Nation EPA, Navajo Nation Minerals Department, Navajo Nation Water Management Branch, and OSMRE peer reviews.

1.1.1 CHIA Revision Purpose

The CHIA is not updated at a specified interval. 30 CFR § 780.21(g)(2) states "an application for permit revision shall be reviewed by the regulatory authority to determine whether a new or updated CHIA shall be required." A revision to PWCC's permit application package (PAP) was submitted to OSMRE in September, 2010. Revision updates include additions to the PHC (PAP Chapter 18), the protection of the hydrologic balance (PAP Chapter 17), and the hydrologic monitoring program (PAP Chapter 16). The revisions were in response to reduced PWCC wellfield pumping within the permit area. Based on the factors below, OSMRE determined that an updated CHIA for the PWCC permit area was warranted.

Compared to the 2008 CHIA, the 2011 CHIA for PWCC operations:

1) Defines "material damage to the hydrologic balance" outside the permit area.
2) Updates hydrologic monitoring data sets through 2010.
3) Evaluates surface water using 2007 Navajo Nation Surface Water Quality Standards (NNSWQS).
4) Evaluates water resources using 2008 Hopi Tribe Water Quality Standards (HTWQS).
5) Identifies material damage thresholds that are less than material damage criterion.
6) Assesses recovery of the Navajo aquifer due to a reduction of pumping in 2006.

1.1.2 Cumulative Impact Area

A CIA is defined at 30 CFR § 701.5 as, ". . . the area, including the permit area, within which impacts resulting from the proposed operation may interact with the impacts of all anticipated mining on surface- and ground-water systems." The CIA is an area where impacts from the coal mining operation, in combination with additional coal mining operations, may cause material damage (OSMRE, 2002). The size and location of a given CIA will depend on the surface water and groundwater system characteristics,

the hydrologic resources of concern, and projected impacts from the operations included in the assessment (OSMRE, 2007). For this CHIA, two surface water CIAs and two groundwater CIAs are delineated to assess impacts associated within these distinct hydrologic resource areas.

1.1.3 Material Damage to the Hydrologic Balance

Sections 507(b)(11) and 510(b)(3) of SMCRA, and 30 CFR § 780.21(g) require OSMRE to determine that a mining and reclamation operation has been designed to prevent material damage to the hydrologic balance outside the permit area. "Hydrologic balance" is defined at 30 CFR § 701.5 as, "the relationship between the quality and quantity of water inflow to, water outflow from, and water storage in a hydrologic unit such as a drainage basin, aquifer, soil zone, lake or reservoir. It encompasses the dynamic relationships among precipitation, runoff, evaporation, and changes in ground and surface water storage."

"Material damage to the hydrologic balance" is not defined in SMCRA or at 30 CFR § 701.5. The intent of not developing a programmatic definition for "material damage to the hydrologic balance" was to provide the regulatory authority the ability to develop a definition based on regional environmental and regulatory conditions. Therefore, for the purpose of this CHIA;

> Material damage to the hydrologic balance outside the permit area means any quantifiable adverse impact from surface coal mining and reclamation operations on the quality or quantity of surface water or groundwater that would preclude any existing or reasonably foreseeable use of surface water or groundwater outside the permit area.

1.1.4 Material Damage Criteria and Thresholds

Except for water quality standards and effluent limitations required at 30 CFR § 816.42, the determination of material damage criteria is the discretion of the regulatory authority (48 Federal Register (FR) 43972-43973, 1983 and 48 FR 43956, 1983). Material damage criteria for both groundwater and surface water are related to existing standards, and based on the protection of water uses. The 2011 Kayenta Complex CHIA also provides material damage thresholds that are less than material damage criteria. The material damage criteria and thresholds are reviewed after submittal of the PWCC annual reclamation status report to OSMRE.

1.2 Kayenta Complex Background

The Kayenta Mine is located within the boundaries of the Hopi Tribe and Navajo Nation reservations and has operated since 1973. The Black Mesa Mine operated in a permit area adjacent to the Kayenta Mine and was active from 1970 through 2005. The two surface mine operations are collectively considered the Kayenta Complex. The Black Mesa Mine operated under Initial Program and Administrative Delay pursuant to 30 CFR 750.11(c). The Kayenta Mine operates under Permit AZ-0001D based upon the Permanent Program Permit Application submitted in 1985. In 1990, OSMRE approved an operation plan and granted Permit AZ-0001C under the Permanent Indian Lands Program, supported by an environmental impact statement (EIS) (OSMRE, 1990). OSMRE has renewed Permit AZ-0001C every five years and converted the permit number to AZ-0001D in 1995. OSMRE approved two revisions of Permit AZ-0001D in 2004 and 2005 to add N-11 Extension and N-9 to the mine plan sequence along with other operational approvals. In September 2010, PWCC submitted a permit revision "Revisions to Chapter 18, Probable Hydrologic Consequences; and Chapter 17, Protection of the Hydrologic Balance", upon which this CHIA is based. Since technical updates to the PAP are ongoing, reference to specific chapters in the PAP use the year 2011 as reference since the permit is complete and up to date at the publishing of this CHIA document.

The Kayenta Complex encompasses an area of 65,387 acres and is located in northeastern Arizona on Black Mesa, southwest of Kayenta, Arizona (Figure 1). The Navajo Nation has exclusive surface and mineral interests for 24,858 acres in the northern portion of the Kayenta Complex. In the remaining 40,529 acres of the Kayenta Complex, the Hopi Tribe and Navajo Nation have joint and equal interests in the mineral resources that underlie the land surface. Navajo Nation coal resource areas are identified as "N" areas, and joint coal resource interest areas are identified as "J" area (Figure 2). Active coal mining occurs in the N-9, J-19, and J-21 coal resource areas. Coal royalties are based on surface area, and water royalties for PWCC's wellfield pumping are paid equally to the Hopi Tribe and Navajo Nation based on metered wellfield production. Royalty payments for PWCC wellfield production averaged $1.86 million annually for each tribe during the 1988-2005 pumping period, and reduced to approximately $0.6 million per tribe annually after Black Mesa coal slurry pipeline operations discontinued and Kayenta Complex pumping reduced approximately 70-percent, averaging 1,243 acre-feet (ac-ft) per year from 2006 to 2009 (Macy and Brown, 2011).

From 1970 to 2005, coal mined at the Black Mesa mine was shipped approximately 273 miles to the Mohave Generating Station near Laughlin, Nevada via a coal slurry pipeline. The Mohave Generating Station consumed approximately four to five million tons of coal annually (PWCC, v.1, ch.2, 2011). Coal produced at Kayenta Mine is transported approximately 83 miles to the Navajo Generating Station near Page, Arizona via an electric railroad. The Navajo Generating Station consumes seven to eight million tons of coal annually (PWCC, v.1, ch.2, 2011).

PWCC uses the strip mining method to recover the coal resources at the Kayenta Complex. Strip mining involves the removal of overburden material covering the coal using blasting and draglines. The coal is then removed by shovels or front-end loaders and transported to coal preparation facilities using haulage trucks. After the coal removal, the overburden material is regraded to the approximate original topographic contours, conforming to topography to support the approved post-mining land uses. Stockpiled topsoil and other suitable material are then spread on top of the graded overburden material to support the re-establishment of approved post-mining vegetation. PWCC must then demonstrate the persistence of re-established vegetative cover sufficient to support post-mining land use.

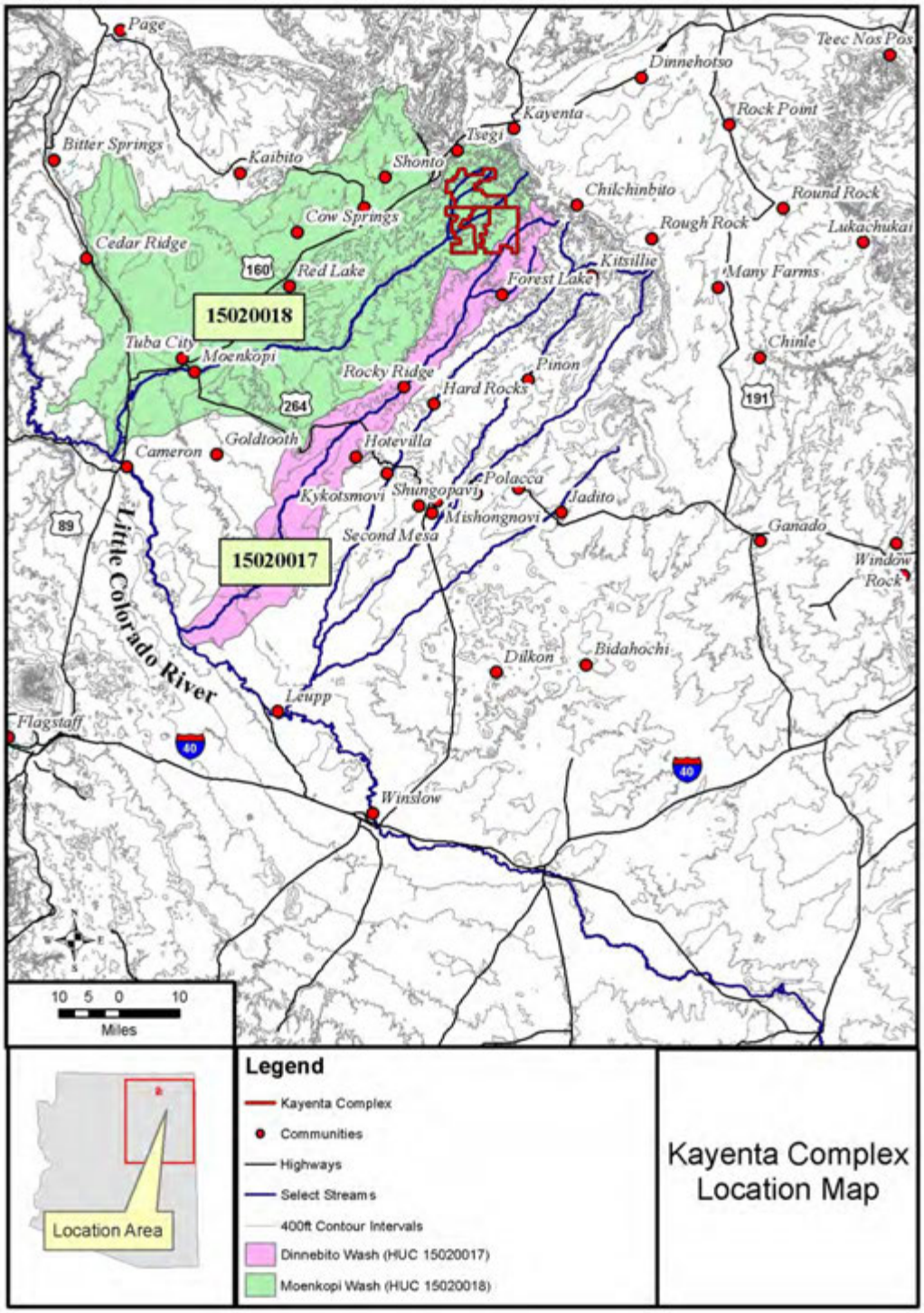


Figure 1: Kayenta Complex Location Map.

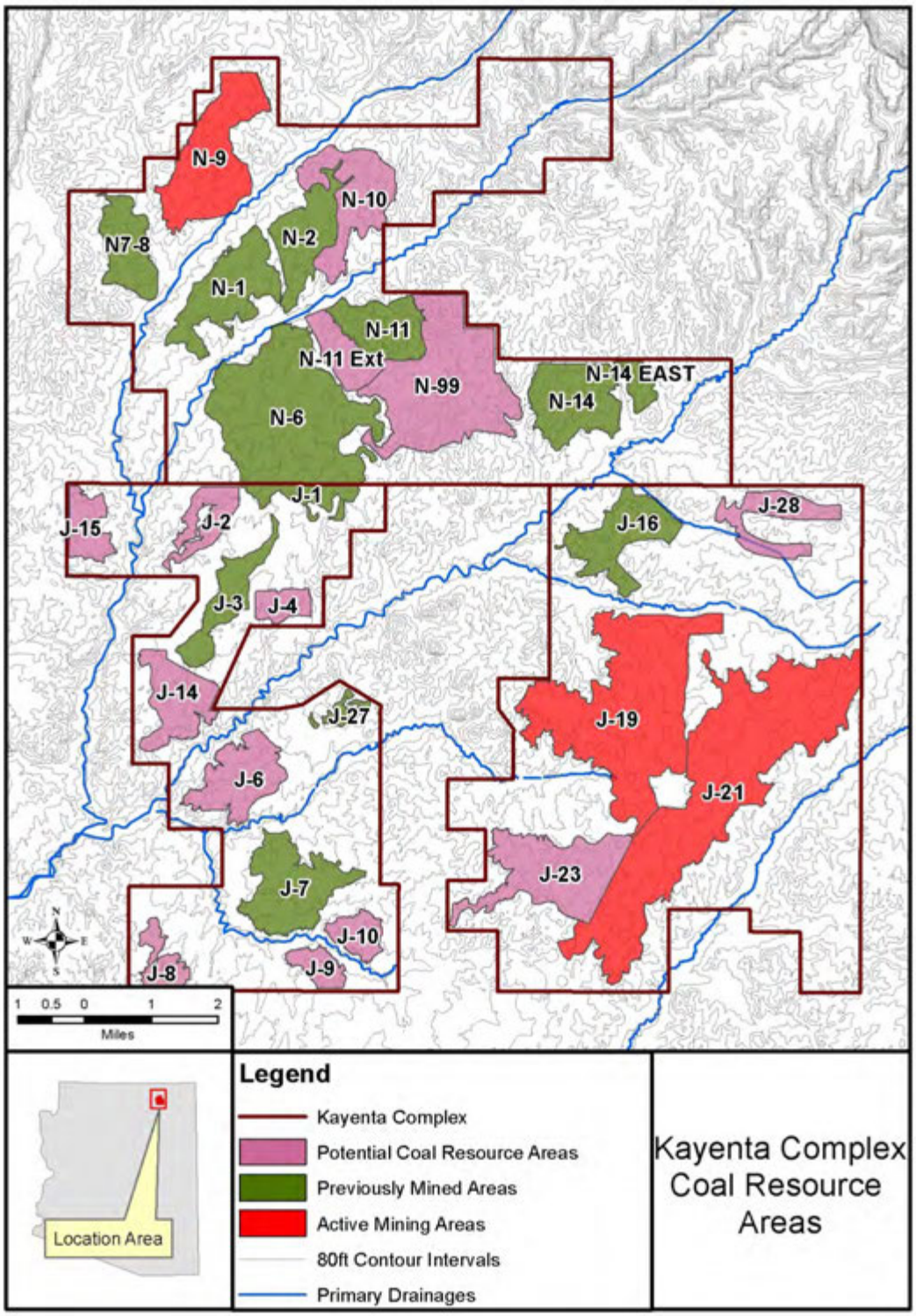


Figure 2: Kayenta Complex Coal Resource Areas.

2 DELINEATION OF CUMULATIVE IMPACT AREA

A CIA is defined at 30 CFR § 701.5 as, ". . . the area, including the permit area, within which impacts resulting from the proposed operation may interact with the impacts of all anticipated mining on surface- and ground-water systems." A CIA considers an area where impacts from the coal mining operation, in combination with additional coal mining operations, may cause material damage. Material damage considers quantifiable adverse degradation or reduction of surface or ground waters outside the permit area, resulting in the inability to utilize water resources for existing or reasonably foreseeable uses. CIA delineation for the Kayenta Complex consists of both surface water and groundwater delineations, with impact areas delineated for both surface and ground waters based upon the resource extent and potential use impacts.

2.1 Surface Water Cumulative Impact Area

The United States is divided into 21 surface water regions, and further sub-divided into 221 sub-regions (USGS, 1987). Sub-regions are further sub-divided into 378 hydrologic accounting units, and finally a fourth level of classification, 2264 cataloging units. The subdivisions provide a mechanism to classify each hydrologic unit by a unique hydrologic unit code (HUC) consisting of two to eight digits based on the four levels of classification in the hydrologic unit system. The Little Colorado River sub-region encompasses 29,900 square miles, and assigned a HUC of 1502. The Little Colorado River 1502 is sub-divided into 18 cataloging units. Kayenta Complex mining and reclamation operations occur in 2 of the 18 cataloging units: Dinnebito Wash (HUC 15020017) and Moenkopi Wash (HUC 15020018). Dinnebito Wash and Moenkopi Wash discharge to the Little Colorado River at two independent downstream locations (Figure 1). Since mining operations at the Kayenta Complex are the only existing or proposed coal operations in either Moenkopi Wash (HUC 15020018) or Dinnebito Wash (HUC 15020017), surface water impacts will not be cumulative with other coal mining operations unless the impacts extend to the Little Colorado River.

McKinley Mine, located in the Upper Puerco Watershed (HUC 15020006), and the Kayenta Complex are the only active coal mining and reclamation operations in the Little Colorado (HUC 1502) (Figure 3). McKinley Mine is approximately 190 stream miles from the first point McKinley Mine impacts could become cumulative with Kayenta Complex impacts at the confluence of the Little Colorado River and Dinnebito Wash. McKinley Mine ceased coal production in December 2009, and is currently completing final reclamation.

Figure 3 presents the mean annual flow measured on Dinnebito Wash (station 09401110), Moenkopi Wash (station 09401260), and the Little Colorado River (station 09402000). Compared to the mean annual flow at station 09402000, mean annual flow at stations 09401110 and 09401260 are 1.8- and 4.3-percent respectively, of the Little Colorado River flow measured at station 09401260. Based on the spatial separation of McKinley Mine from the Little Colorado River and Dinnebito Wash confluence, and the magnitude of mean annual surface flow on the Little Colorado River compared to contributing flow volumes, make it impracticable to distinguish potential coal mine water quality impacts at the confluence of the Little Colorado River and Dinnebito Wash. Therefore, the McKinley Mine is excluded from the Kayenta Complex CIA, and a smaller watershed area for assessment of probable hydrologic impacts attributed to the Kayenta Complex operations will be delineated.

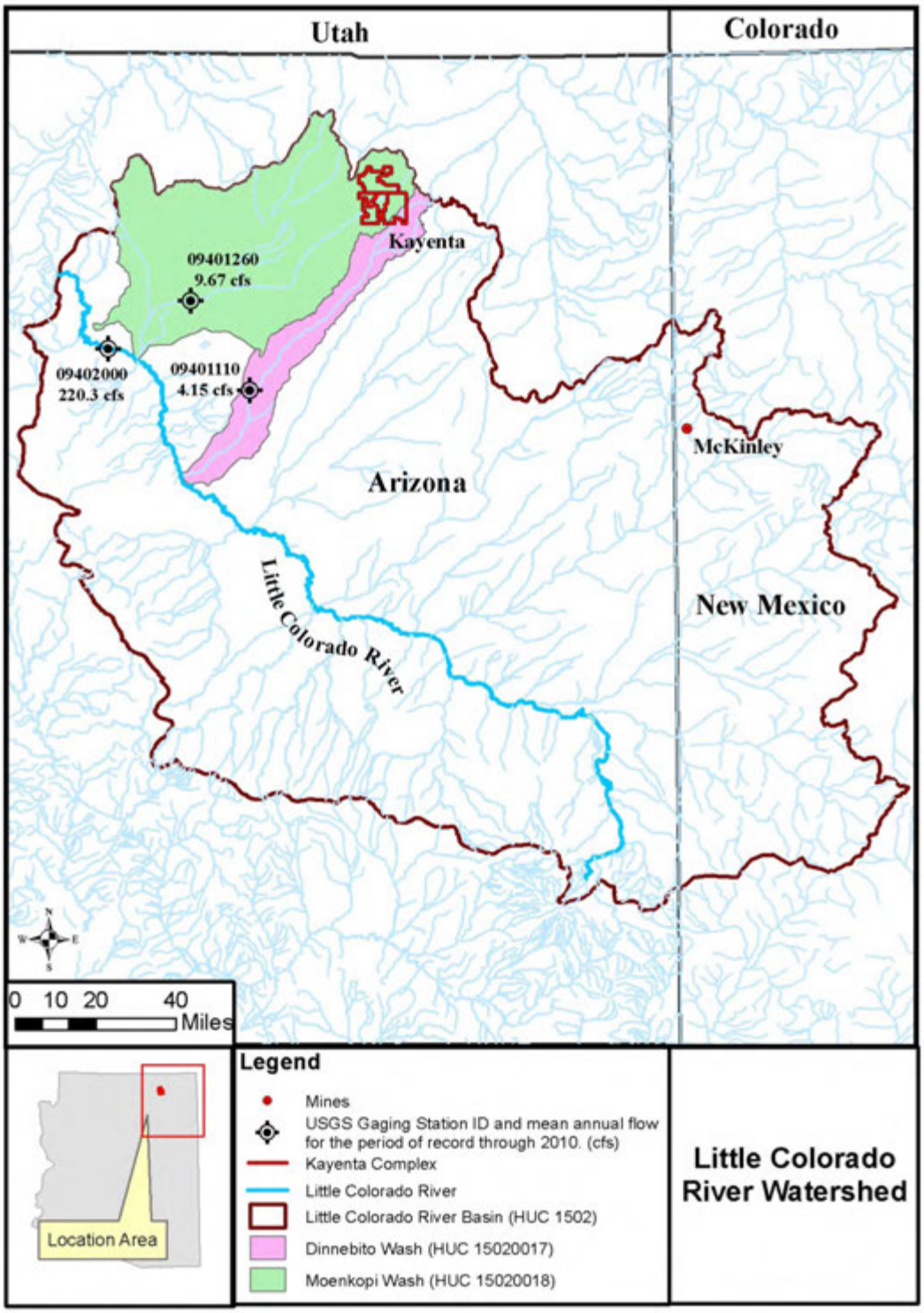


Figure 3: Mining Operations in the Little Colorado River Watershed

2.1.1 Downstream Impact Potential

Approximately 30 stream miles downstream of the Kayenta Complex, Rocky Ridge is the only community along the main channel of Dinnebito Wash. Historically, an attempt was made to dam Dinnebito Wash at Rocky Ridge and impound storm flow water for potential use. Currently, only remnants of the Dinnebito Dam remain, and there are no structures or equipment indicating Dinnebito Wash is utilized for irrigation water at Rocky Ridge (OSMRE, 2011a).

Moenkopi is the only community along the main channel of Moenkopi Wash, approximately 70 stream miles downstream of the PWCC permit area. At this area, Moenkopi residents may dig pits in the Moenkopi alluvium for agricultural irrigation on fields adjacent to Moenkopi Wash (OSMRE, 2011b). The pits are dug in the channel alluvium until the pits remain saturated. The shallow alluvial water may be pumped from in-channel pits during the growing season in order to reduce the amount of sediment extracted with the irrigation water. Suspended sediment generated during storm flow events precludes farmers in the Moenkopi area from utilizing flowing storm water directly on the crop fields. The high sediment loads transported during storm flow events create problems with the pumping equipment, as well as limits the productivity of the crop if the fine silt is applied over the field.

OSMRE recognizes that subflow in the Moenkopi Wash alluvium is part of the hydrologic balance and important to local farmers in the Moenkopi community, and potentially Rocky Ridge. Subflow in the alluvium is part of the flow system, and a decrease in surface water flow contribution to the hydrologic system may affect subflow and ultimately surface water use (OSMRE, 2011b).

2.1.2 Surface Water Impact Areas

Mining and reclamation operations on the Kayenta Complex occur in the headwater areas of Dinnebito Wash (HUC 15020017) and Moenkopi Wash (HUC 15020018), which are tributary to the Little Colorado River (Figure 3). Moenkopi Wash (HUC 15020018) drains an area of 2,635 square miles (mi^2), and Dinnebito Wash (HUC 15020017) drains an area of 743 mi^2 before discharging to the Little Colorado River. The United States Geological Survey (USGS) maintains a gaging station on both Moenkopi Wash (station No. 09401260) and Dinnebito Wash (station No. 09401110) (Figure 3). Gaging station 09401260 has a continuous period of record at the same location beginning in 1977, and the continuous period of record for gaging station 09401110 began in 1993. The Moenkopi Wash gaging station is located approximately 1-2 miles from the area local farmers dig pits in the alluvium. The Dinnebito Wash gaging station is approximately 30 stream miles downstream from Rocky Ridge.

USGS gaging stations 09401260 and 09401110 provide valuable information on the hydrology of the Moenkopi and Dinnebito watersheds. However, the watershed areas monitored by the two gaging stations cannot be used exclusively to assess surface water quantity and quality impacts of the Kayenta Complex due to the size of the watershed monitored. Surface water impacts from the Kayenta Complex are most effectively evaluated using monitoring information close to the permit area. PWCC collects surface water quality and quantity information at locations 25, 26, 34, and 155 (Figure 4). Therefore, OSMRE has delineated two surface water areas for hydrologic impact assessment: one for Moenkopi Wash (253 mi^2) one for Dinnebito Wash (51 mi^2) (Figure 5). The Moenkopi Wash CIA will use information from monitoring locations 25, 26, and 155 near the downgradient permit boundary on Moenkopi Wash for mine impact assessment. The Dinnebito Wash CIA will use information from monitoring location 34 near the downgradient permit boundary on Dinnebito Wash for mine impact assessment.

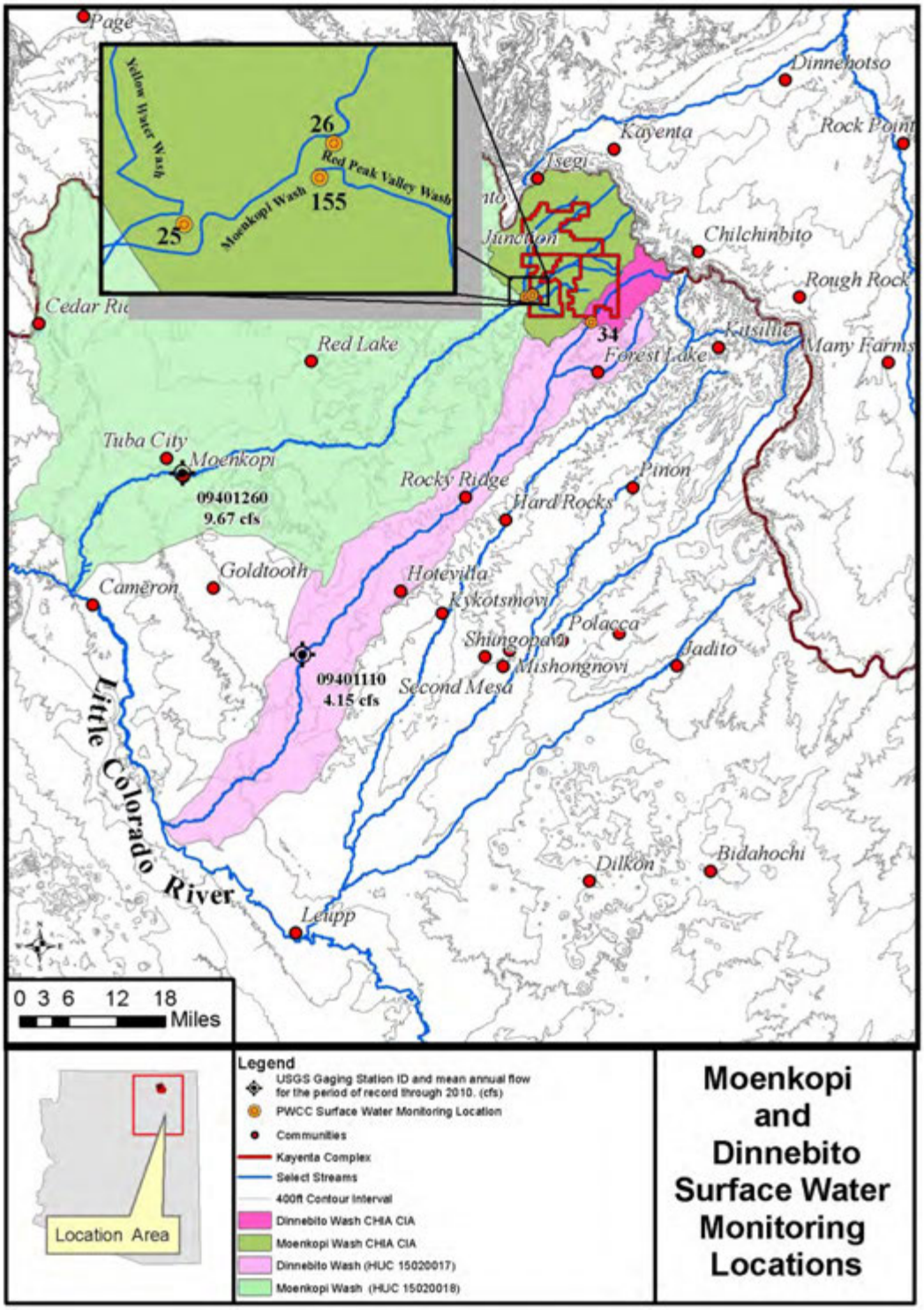


Figure 4: Moenkopi and Dinnebito Surface Water Monitoring Locations

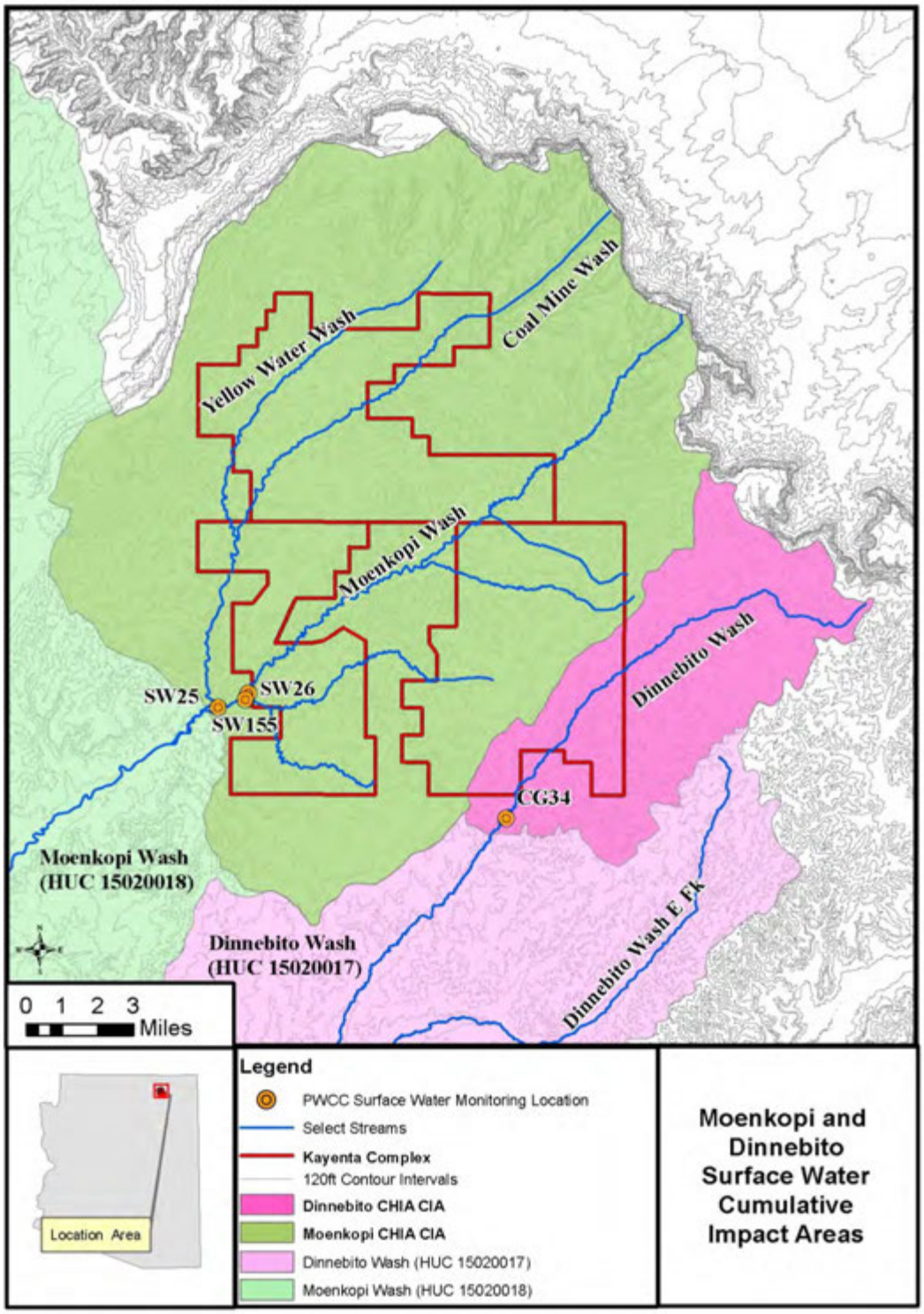


Figure 5: Moenkopi and Dinnebito Surface Water Cumulative Impact Areas, Kayenta Complex

2.2 Ground Water Cumulative Impact Area

Kayenta Complex mining operations occur in the Wepo Formation of the Mesa Verde Group (Figure 6). The Yale Point sandstone is above the Wepo Formation and present between the eastern boundary of the Kayenta Complex and the rim of Black Mesa. The Yale Point Sandstone is recharged by direct precipitation and will either discharge to stream channels above the Kayenta Complex or recharge the underlying Wepo Formation. The Toreva Formation of the Mesa Verde Group underlies the Wepo Formation. Geologic mapping indicates that the Wepo Formation is discontinuous over the areal extent of Black Mesa, varies in thickness from 130-740 feet where present, and intertongues with the overlying Yale Point Sandstone on the northeastern mesa rim and underlying Toreva Formation (Repenning and Page, 1956).

The Black Mesa area has three regional aquifer systems: Dakota aquifer (D aquifer), Navajo aquifer (N aquifer), and Coconino aquifer (C aquifer) (Figure 6). The D Aquifer is separated from the Mesa Verde Group by the Mancos Shale (Figure 7). The D aquifer and N aquifer are separated by the siltstone Carmel Formation. The PWCC water supply wellfield withdraws water from wells screened in the D aquifer and N aquifer systems. The N aquifer system is the deepest water bearing zone to be potentially affected by the mining operation water supply wellfield; confined below by the Chinle Formation. The Chinle Formation separates the N aquifer from the C aquifer.

2.2.1 Mesa Verde Group

The Yale Point sandstone may discharge at outcrop areas above the Kayenta Complex and will not be influenced by mining operations. There are no known use locations of water in the Yale Point sandstone northeast of the permit area. Lithologic drill logs of the Wepo Formation indicate water yielding units consisting of single sandstone beds, multiple sandstone beds which are hydraulically connected, fractured coal seams, and sandy shales of limited extent (PWCC, v.1, ch.4, 2011). Historical and existing use locations of Wepo Formation water have been identified within the permit and adjacent area (Figure 8). The Toreva Formation is not disturbed during mining operations, and there are no water use locations within the permit or adjacent area. Therefore, delineation of the CIA for the Mesa Verde Group will focus on the Wepo Formation.

The Wepo Formation is completely incised by Moenkopi Wash near the southwest corner of the permit area where the Mancos Shale is exposed at the surface. Therefore, water quantity and quality impacts cannot propagate past the exposed area prior to impact detection at surface water monitoring stations 25, 26, and 155. Additionally, a Wepo water level contour map indicates that the water level contours generally mimic the surface topography (PWCC, v.9, ch.15, 2011), flowing to discharge areas where the alluvial washes incise the Wepo Formation. Geologic and hydrologic mapping were applied to delineate the CIA for the Wepo Formation. Since the Wepo Formation is in hydrologic communication with the alluvial washes, alluvial aquifers are included in the CIA.

The Wepo Formation CIA is bound to the west by Yellow Water Wash, and to the southeast by Dinnebito Wash. The Wepo Formation CIA also includes the upgradient sides of mine areas N-7/8, N-9, N-11, N-14, J-21, and any historical or existing use location in the adjacent area. Water level contours for the Wepo Formation south of the Kayenta Complex indicate that ground water flow is from the east to the discharge zone in Moenkopi Wash west of the Kayenta Complex; therefore, the southern extent of the CIA has been delineated parallel to the Wepo flow paths (Figure 8).

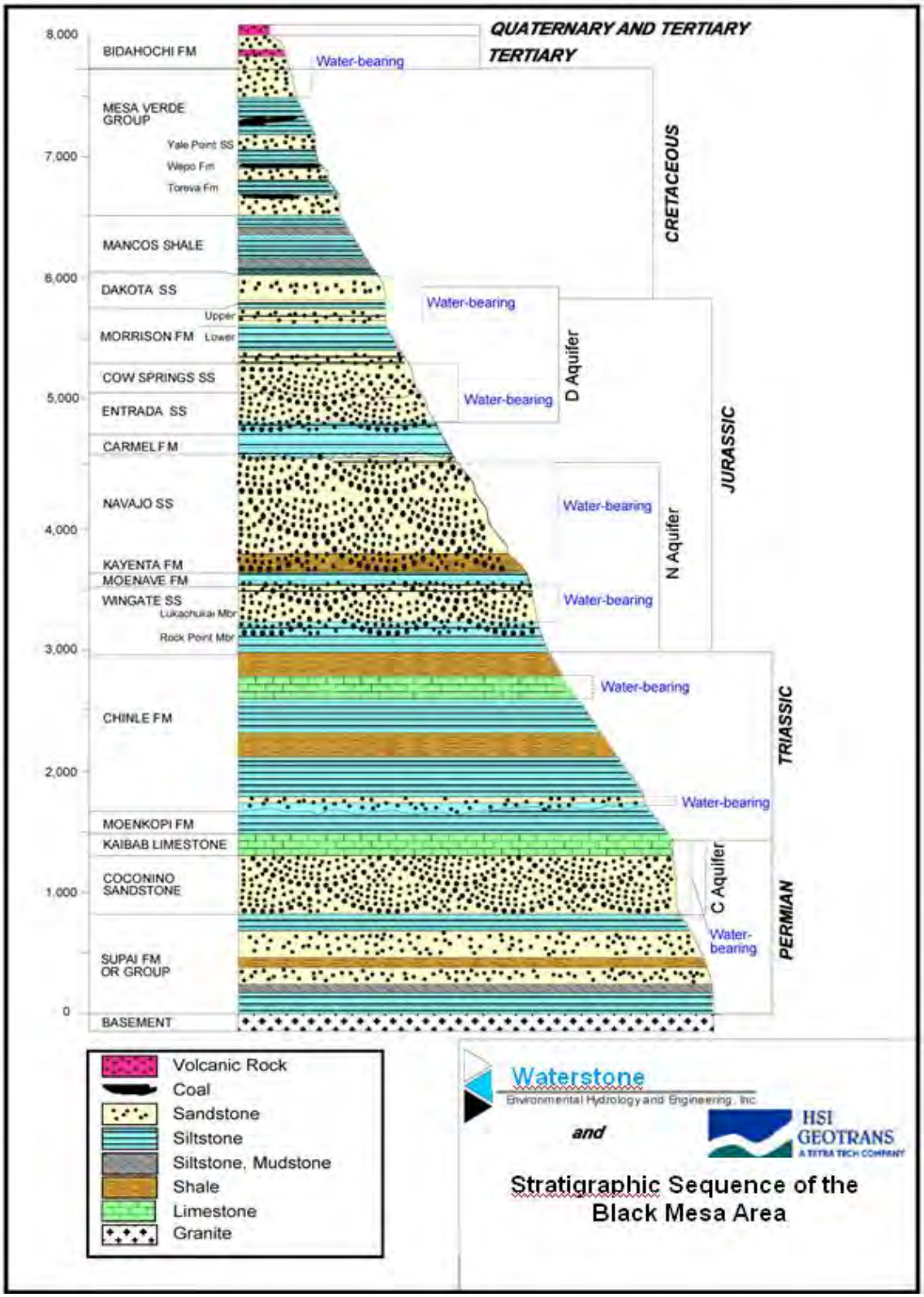


Figure 6: Stratigraphic Sequence of the Black Mesa Area (PWCC, 1999)

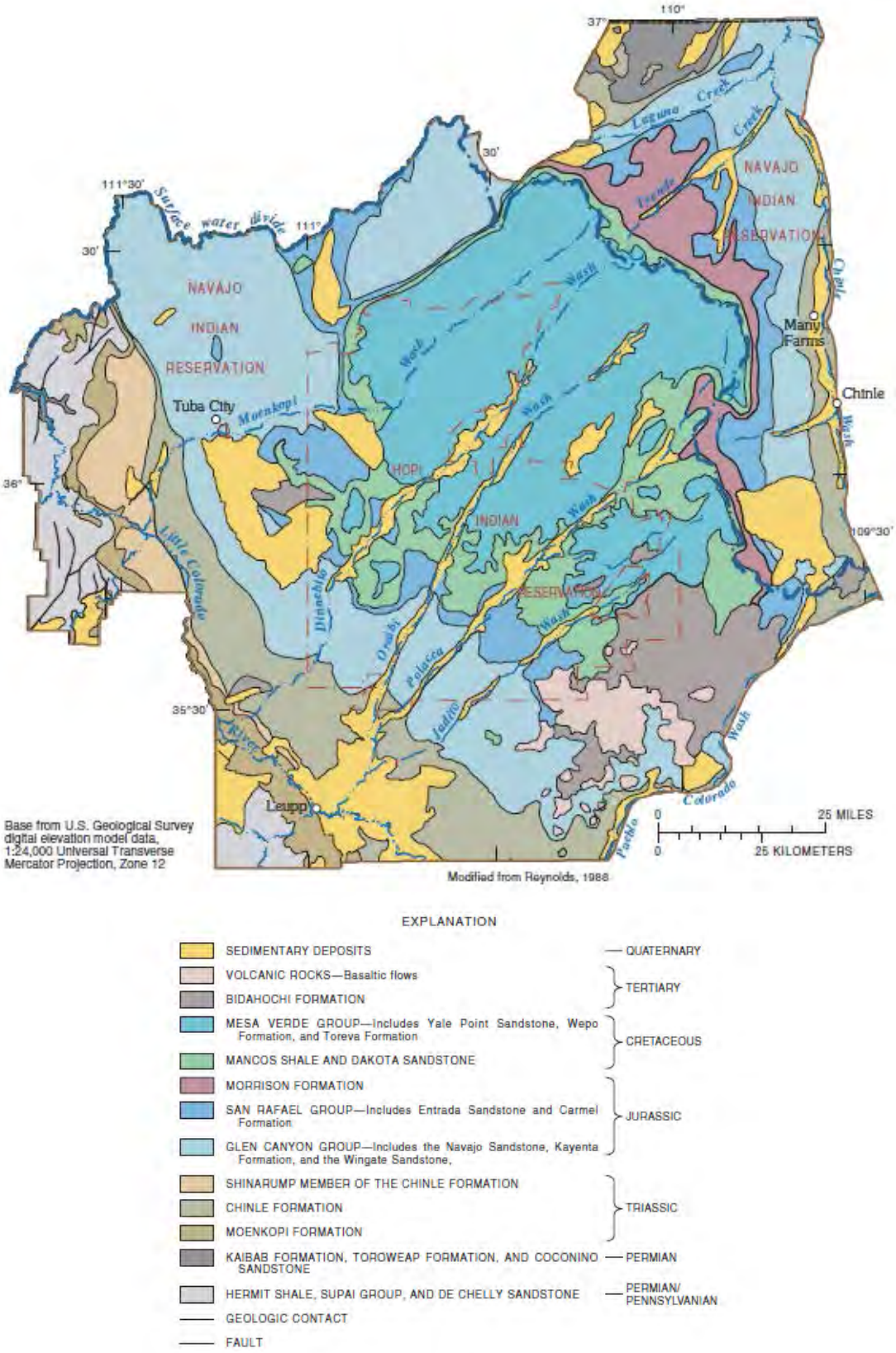


Figure 7: Black Mesa Area Surface Geology, Northeastern Arizona (Truini and Longsworth, 2003)

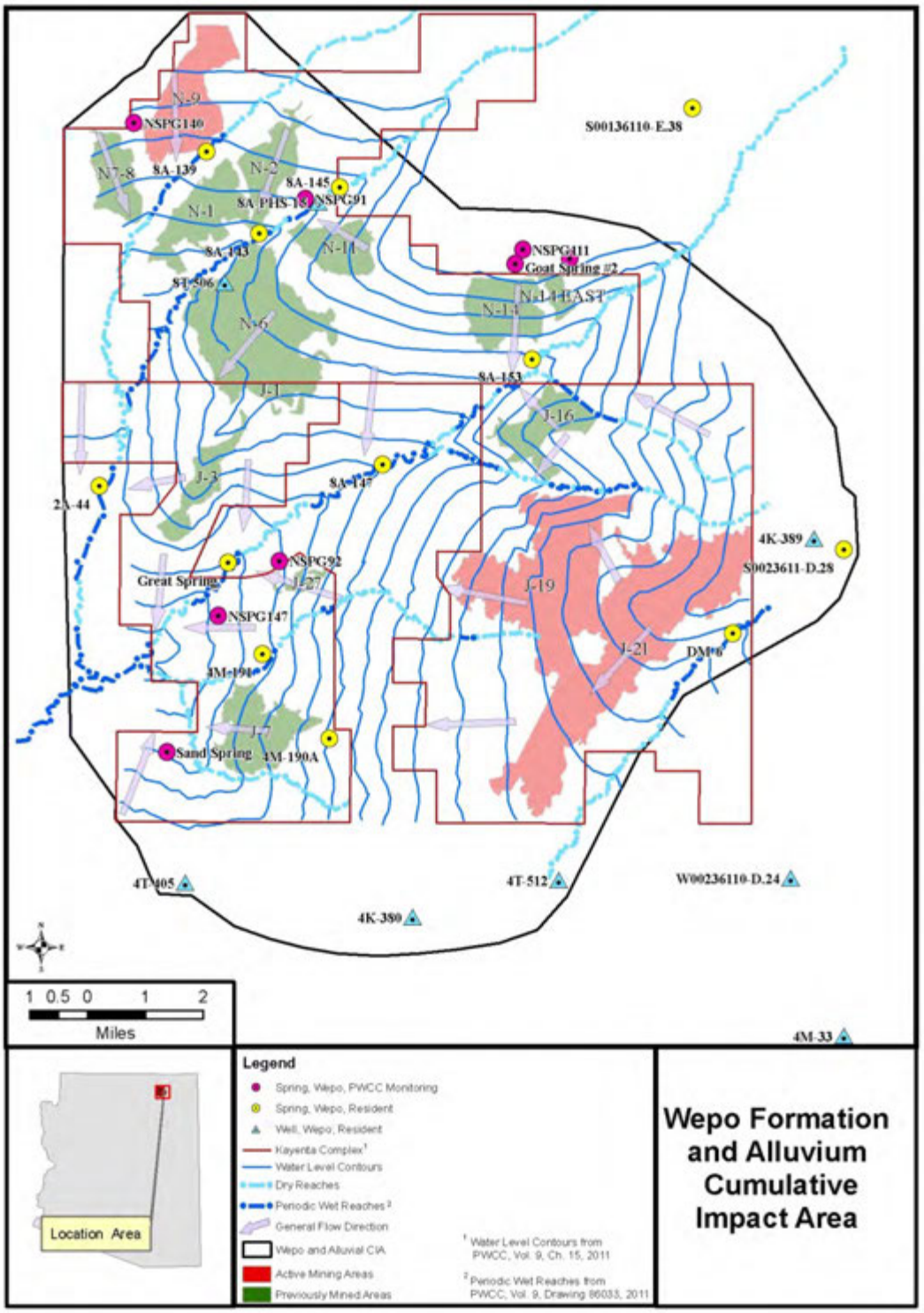


Figure 8: Wepo Formation and Alluvium Cumulative Impact Area, Kayenta Complex

2.2.2 D and N Aquifers

In 1999, PWCC completed a report that presented a regional three-dimensional numerical model of the Black Mesa Basin groundwater flow system (hereinafter, the "3D Model") (PWCC, 1999). The 3D Model represents the most comprehensive compilation and evaluation of geologic and hydrologic data for the purpose of evaluating the effects of PWCC pumping of the D and N aquifers. The 3D Model considers the cumulative effect of all groundwater use from PWCC, Navajo Nation, and Hopi community pumping centers on the aquifers and associated surface flows. The 3D Model was calibrated using data collected through 1996, and 3D Model predictions were validated against field measured water levels from 1996-2005, and again in 2010 including 2006-2009 data, which assists in determining the appropriateness of utilizing the 3D Model for predictive purposes (PWCC, v.11, ch.18, 2011). The model validation and previous calibrations to field data demonstrate that the 3D Model is an appropriate tool for assessing PWCC water quantity impacts from groundwater pumping at the PWCC wellfield. OSMRE relies on the 3D Model for water resource impact predictions, and will reference summary statements and conclusions throughout this assessment supported by the 3D Model report. The 3D Model boundary is considered the CIA for the D and N aquifers (Figure 9).

The 3D Model boundary is described in the 3D Model report (PWCC, 1999). It is based on the lateral extent of rocks comprising the N aquifer as well as hydrologic features. The lateral extent of the N aquifer bounds the 3D Model on the west, south, and southeast (Figure 7). From Cedar Ridge to near Bidahochi, north toward the vicinity of Round Rock; this boundary is a no-flow boundary (PWCC, 1999). East of the Kayenta Complex, Chinle Wash is a hydrologic boundary, and is a discharge area for flow both east and west of Chinle Wash (PWCC, 1999). "The northern boundary is placed along the interpreted groundwater divide that extends eastward from Cedar Ridge to Preston Mesa, northeastward to Skeleton Mesa east of Kaibito to the Shonto Plateau. The boundary then extends southeastward east of Tsegi Canyon to a point where it is defined by the northern extent of the Wingate hydrostratigraphic unit along the Comb Ridge monocline" (PWCC, 1999).

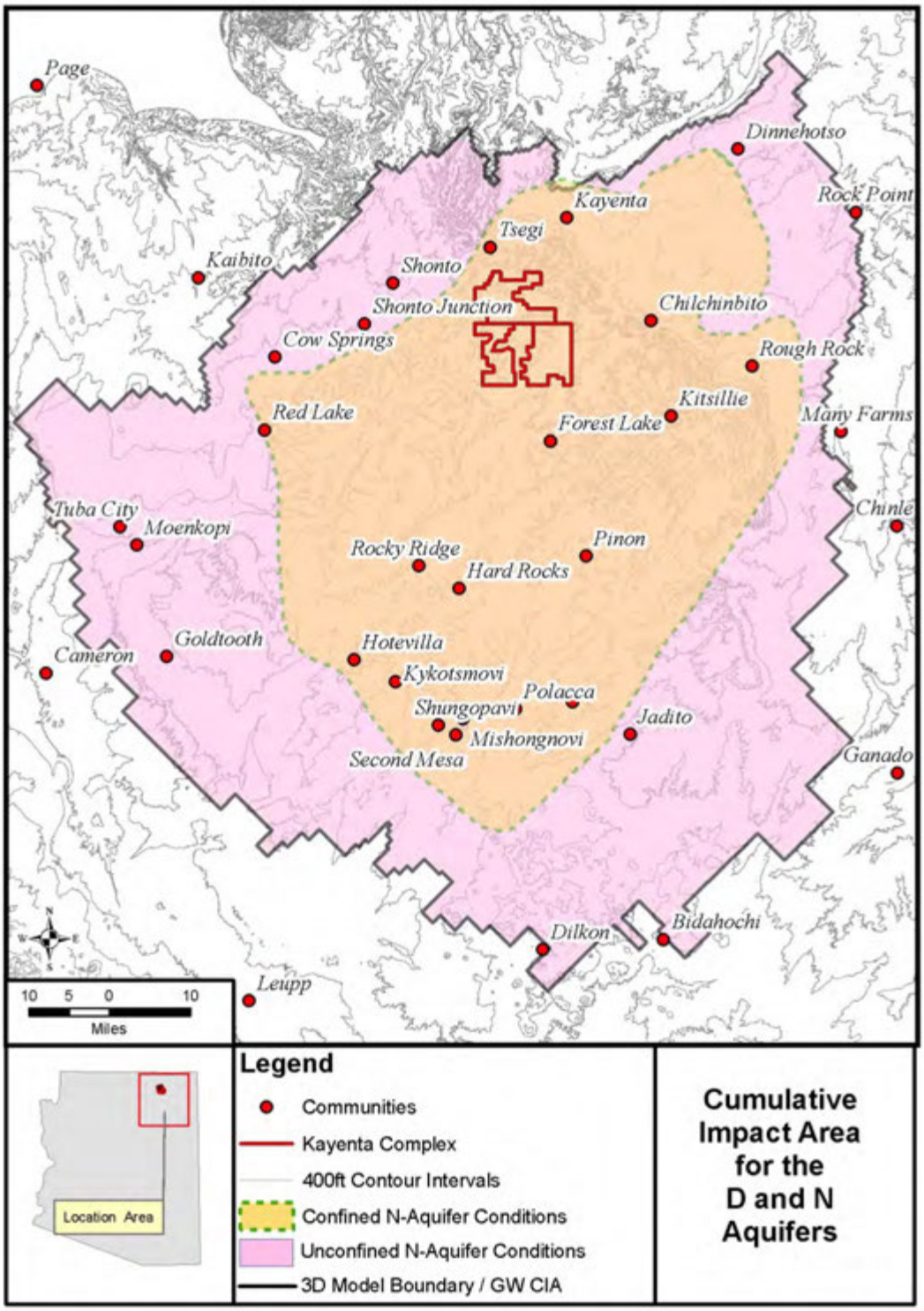


Figure 9: D aquifer and N aquifer Cumulative Impact Area, Kayenta Complex

3 WATER RESOURCE USES AND DESIGNATIONS

As the regulatory authority, OSMRE has the responsibility of assessing the potential impacts of the mining and reclamation operations on the hydrologic balance, and to provide a determination for the potential to materially damage the hydrologic balance outside the permit area. Material damage implies that a quantifiable adverse degradation or reduction of surface or ground waters outside the permit area has occurred, precluding the utilization of water resources for existing and foreseeable uses. The existing and foreseeable water uses within the surface water and groundwater CIA's include:

- Domestic Water Supply
- Industrial Water Supply,
- Agricultural Water Supply,
- Livestock Watering,
- Secondary Human Contact and Partial Body Contact,
- Aquatic & Wildlife Habitat and Fish Consumption.
- Primary Contact Ceremonial (Hopi Tribe), and
- Groundwater Recharge (Hopi Tribe).

3.1 Domestic Water Supply

Domestic water supply is a water body that supports the use of water as a potable water supply (Hopi Tribe, 2008; and NNEPA, 2007). The Hopi Tribe Water Resources Program has designated the N aquifer as a domestic water supply (DWS). The effect of PWCC pumping from the D aquifer and N aquifer on Hopi Tribe and Navajo Nation domestic water supply wells is a concern addressed in this assessment. Domestic water supply concern areas identified include all water supply wells within the groundwater CIA for the D aquifer and N aquifer. Figure 10 illustrates the location of water supply well systems and annual withdraw for calendar year 2009. Well systems may be comprised of more than one well at locations illustrated on Figure 10. Concern has been raised by the Hopi Tribe and Navajo Nation that drawdown from PWCC pumping will reduce the amount of water in water supply wells, increase electrical cost associated with lifting water an additional height to the wellhead, damage the stability of the aquifer matrix, and induce poorer quality D aquifer water to potentially degrade N aquifer water.

PWCC provides access to two public water supply standpipes as part of the PWCC distribution system. The water available for public supply meets compliance with public water supply (PWS) permit ID #NN0400287. The water accessed by the two public standpipes is hauled by area residents and used for both domestic water supply and livestock consumption. The two public water stands are located near the N-6 and N-14 mining areas, and account for approximately 61 ac-ft per year of the total use at the Kayenta Complex (PWCC, v.11, ch.18, 2011).

3.2 Industrial Supply Water

Kayenta Complex is the only location in the CIAs using water for industrial purposes. On February 1, 1964, Sentry Royalty (a wholly owned subsidiary of Peabody Coal Company at the time) entered into a coal lease agreement with the Navajo Tribe. The agreement provided approval "…to develop and utilize water for use in its mining operations, provided, however, that at the conclusion of mining operation all wells will be left properly cased and that any water not utilized in mining operations shall be made readily available for local Navajo use" (Sentry, 1964).

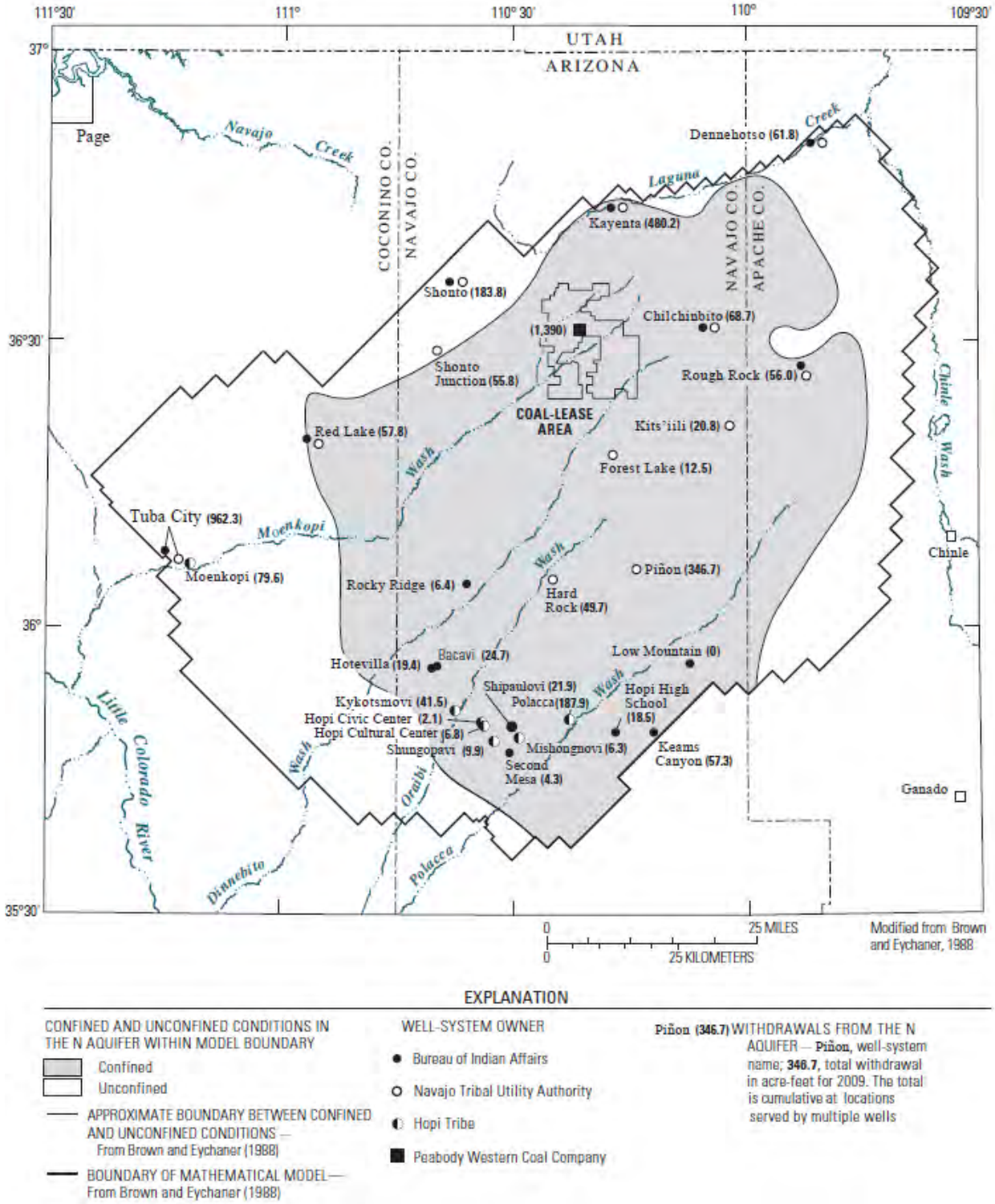


Figure 10: Well Systems Monitored, Black Mesa, Northeastern Arizona (Macy and Brown, 2011)

On June 6, 1966 the Grant of Right to Use Water was further clarified in separate lease agreements between Sentry Royalty and both the Hopi Tribe and Navajo Nation. The agreements established that Sentry Royalty would "…develop and utilize water obtained from wells located on the leased premises for use in its mining operations including the transportation by slurry pipeline of coal mined from the leased premises…" (Stetson, 1966), and royalty rates for water use were established. In 1987, new coal lease and royalty agreements were signed by Hopi Tribe, Navajo Nation, and PWCC, and received Secretarial approval by the Department of Interior (PWCC, 1987). Additionally, the Secretary of Interior reserves the right to require PWCC to provide water in quantity and quality equal to that formerly available or obtain water for its mining operation from another source if monitoring data indicate material damage to the hydrologic balance is occurring due to pumping.

PWCC began pumping in 1968 at 100 ac-ft per year (Macy and Brown, 2011). The water use rate increased to 3,680 ac-ft per year in 1972 (Macy and Brown, 2011). From 1972 to 2005 PWCC annual pumping fluctuated between 2,520 ac-ft and 4,740 ac-ft; averaging 3,980 ac-ft (Macy and Brown, 2011). Water pumped from the PWCC wellfield was utilized for the transportation of coal to the Mojave Generating Station, dust suppression, and potable water for mine facilities. Approximately 70-percent of the pumped water was used for transportation of coal via a coal slurry pipeline during this period. Coal was pulverized onsite into a powder and mixed with water to make a slurry consistency of approximately 50-percent coal and 50-percent water. The slurry was then transported approximately 273 miles through an underground pipeline to the Mojave Generating Station, the coal burned, and the water utilized as part of the cooling process at the power plant. The Mojave Generating Station and the coal slurry line are no longer operational. The coal slurry pipeline ceased operation on December 31, 2005. PWCC pumping has reduced by approximately 70-percent since 2005, averaging 1,243 ac-ft from 2006 to 2009 (Macy and Brown, 2011).

3.3 Agricultural Water Supply

Agricultural water supply means the use of water for irrigation of crops which could be used for human consumption (Hopi Tribe, 2008; NNEPA, 2007). Corn and bean fields are usually located at the foot of the mesas, on sand slopes, in small canyons, along alluvial plains in washes, and in the valleys between mesas in order to maximize the limited surface moisture available (Hopi Tribe, 2006). "Another method of cultivation involves gardening on self-irrigated terraces along the mesa walls below villages. Terrace irrigation is possible because of the perennial springs at each village that originally permitted settlement" (Hopi Tribe, 2006). In the southern area of Black Mesa, these springs emanate from the Toreva Formation and formations comprising the D aquifer system. In the Moenkopi and Tuba City area, the perennial springs used for irrigation purposes emanate from the unconfined N aquifer.

Additionally, as presented in section 2.2.1, during the growing season Hopi and Navajo farmers in the Moenkopi area may dig a pit in the Moenkopi channel alluvium until water is reached. The alluvial water is pumped from the pit and piped to the adjacent fields, providing supplemental irrigation water when necessary. HTWQS designate all aquifers as Agricultural Irrigation (AgI) water. NNSWQS designate Moenkopi Wash as Agricultural Water Supply (AgWS). HTWQS designate Moenkopi Wash and Dinnebito Wash as AgI.

3.4 Livestock Watering

Livestock watering means the use of water as a supply for consumption by livestock (Hopi Tribe, 2008; NNEPA, 2007). Livestock watering is a pervasive practice in the CIAs; with livestock typically accessing water at springs and in-channel pools when the opportunity is available. Windmills drilled into water bearing formations that are of suitable water quality for livestock watering provide a more reliable source for livestock watering. HTWQS designate all aquifers, Moenkopi Wash, and Dinnebito Wash as

Agricultural Livestock Watering (AgL). NNSWQS designate Moenkopi Wash and Dinnebito Wash as Livestock Watering (LW).

3.5 Secondary Human Contact and Partial Body Contact

Water designated to support secondary human contact (ScHC) means the "water body supports the use of water which may cause the water to come into direct contact with the skin of the body, but normally not the point of submergence, ingestion of the water, or contact of the water with membrane material of the body" (NNEPA, 2007). The Hopi Tribe provides a similar use designation for incidental and infrequent contact and defines as partial body contact (PBC). "Partial body contact means the use of a stream reach, spring, reservoir, and other water body in which contact with the water may, but need not, occur and in which the probability of ingesting water is minimal; examples are fishing and boating (Hopi Tribe, 2008). NNSWQS identify Dinnebito Wash and Moenkopi Wash as meeting ScHC designation. The HTWQS identify Dinnebito and Moenkopi Wash as meeting the PBC use designation.

3.6 Primary Contact Ceremonial

Within the ground water CIAs, 419 springs have been cataloged in a database developed by PWCC (PWCC, 1999). The database was compiled from a variety of sources; however, most spring and seep locations were identified from available maps without field verification. Of the springs cataloged, only 18 have more than two flow measurements or documented observations; four are monitored as part of the ongoing USGS Cooperators Monitoring Program, and of these, only Pasture Canyon has a continuous monitoring gage installed.

The HTWQS designate that primary contact ceremonial (PCC) means "the use of a spring, stream reach, lake, or other water body for religious or traditional purposes by members of the Hopi Tribe; such use involves immersion and intentional or incidental ingestion of water, and it requires protection of sensitive and valuable aquatic life and riparian habitat" (Hopi Tribe, 2008).

3.7 Aquatic Wildlife Habitat and Fish Consumption

Aquatic and Wildlife Habitat (A&WHbt) water means "the use of the water by animals, plants or other organisms, including salmonids and non-salmonids, and non-domestic animals (including migratory birds) for habitation, growth or propagation" (NNEPA, 2007). Similarly, the Hopi Tribe establish Aquatic and Wildlife Habitat (ephemeral) ($A\&W_e$) as "a stream reach, lake, or other water body where water temperature and other characteristics are periodically suitable for support and propagation of animals, plants, or other organisms" (Hopi Tribe, 2008). Fish consumption (FC) supports "the use of water by humans for harvesting aquatic organism for consumption. Harvestable aquatic organisms include, but are not limited to fish, shell-fish, turtles, crayfish, frogs, and salamanders" (NNEPA, 2007).

3.8 Groundwater Recharge

"Groundwater recharge (GWR) use means any surface water that recharges an aquifer. Surface waters designated as groundwater recharge must meet the standards for the aquifer being recharged as well as surface water standards" (Hopi Tribe, 2008). Additionally, the Hopi Tribe Water Resources Program may designate water as "unique waters". The Moenkopi Wash watershed from Blue Canyon Springs to the confluence of Begashibito Wash has been classified as a unique Hopi surface water area (Hopi Tribe, 2008). The N aquifer and all areas recharging the N aquifer are classified as unique groundwater (Hopi Tribe, 2008).

4 BASELINE HYDROLOGIC CONDITIONS

The issuance SMCRA established that surface coal mining operations are to be conducted as to protect the environment, and to assure that a balance between the protection of the environment and the production of coal as a source of energy is maintained (SMCRA, Section 102(d) and (f), 1977). Therefore, as presented in OSMRE's guidance document for the preparation of PHC's and CHIA's, the goals in establishment of baseline hydrologic conditions are to characterize the local hydrology, understand the regional hydrologic balance, and identify any water resource or water use that could be affected by the mining operation (OSMRE, 2002). The guidance document is consistent with 30 CFR 780.21. However, mining operations at the Kayenta Complex commenced prior to the issuance of SMCRA, making quantification of baseline conditions for impact assessment challenging for some hydrologic resources due to the absence of pre-mining information since it was not required prior to 1977.

In compliance with the issuance of SMCRA, PWCC initiated an extensive hydrologic monitoring program documenting the interaction between the surface water system and alluvial and Wepo groundwater systems within the permit area. Additionally, the USGS began regional monitoring assistance in the mid 1970's. The continued monitoring conducted by the USGS in the Black Mesa area is designed to track the effects of industrial and municipal pumpage on ground water levels, stream and spring discharge, and ground water chemistry (Macy and Brown, 2011).

Although the majority of hydrologic information was collected after mining operations began at the Kayenta Complex, the data collected from the mid 1970's to present provide insight on water quality and quantity. The groundwater models that have been developed also greatly assist with assessing hydrologic conditions and quantifying recovery and other changes within the CIAs.

4.1 Surface Water

The drainages in the surface water CIAs are considered ephemeral and intermittent based on OSMRE definitions at 30 CFR 701.5. An ephemeral stream is when a stream flows only in direct response to precipitation in the immediate watershed or in response to the melting of a cover of snow and ice, and which has a channel bottom that is always above the local water table. An intermittent stream is considered a stream, or reach of a stream, that is below the water table for a least some part of the year, and obtains its flow from both surface runoff and groundwater discharge. PWCC refers to reaches of channels whose channel beds are located periodically below the local water table as wet reaches (PWCC, v.9, ch.15, 2011). OSMRE further defines intermittent at 30 CFR 701.5 as a stream, or reach of stream, that drains a watershed of a least one square mile.

4.1.1 Surface Water Regulatory Requirements

Water Quality

Surface water runoff from areas disturbed by mining operations is required to be managed in a manner that prevents additional contribution of suspended solids to stream flow outside the permit area to the extent possible with the best technology currently available, and otherwise prevents surface water pollution (30 CFR 816.41(d)). PWCC complies with 30 CFR 816.41(d) by designing, constructing, and maintaining siltation structures, impoundments, diversions, and designating stream buffer zones within the permit area. Additionally, PWCC complies with 30 CFR 816.41(d) by monitoring in-stream surface water quality according to the approved monitoring plan in the PAP. The Moenkopi surface water CIA includes 253 mi^2 of the 2,635 mi^2 Moenkopi Wash (HUC 15020018), and the Dinnebito surface water CIA includes 51 mi^2 of the 743 mi^2 Dinnebito Wash (HUC 15020017). However, all water in the

Moenkopi and Dinnebito surface water CIA's does not pass through siltation structures or impoundments due to the absence of mining disturbance in some areas.

PWCC is required to submit a quarterly report to the USEPA regarding NPDES Permit #NN0022179. The NPDES reports document the water quality and quantity of discharge to the washes when high runoff events exceed the storage capacity design of the structure and surface water discharge to the wash occurs. Additionally, PWCC may dewater ponds in order to ensure sufficient design capacity by either transferring water to nearby ponds with available capacity, or by discharging water into the downstream wash in accordance with the NPDES permit.

Water Quantity

PWCC is required to reclaim lands disturbed by mining so the lands may be returned to the appropriate land management agency in a condition compatible with and capable of supporting the approved post-mining land uses. The approved post-mining land uses on the Kayenta Complex are livestock grazing and wildlife habitat, which are consistent with the pre-mining land uses. Therefore, PWCC "has designed its reclamation efforts to return mined lands to the land use of livestock grazing and wildlife habitat" (PWCC, v.8, ch.14, 2011). In order to support the livestock grazing and wildlife habitat post-mining land uses, and after consultation with the Navajo Nation, Hopi Tribe, and the Bureau of Indian Affairs (BIA), PWCC proposed the construction and retention of 51 permanent surface water structures to ensure an adequate distribution of post-mining water resources in order to promote a greater viability of post-mining land use success. The reclamation plan has been previously agreed to by the BIA and the Hopi Tribe and Navajo Nation.

The retention of surface water impounded by temporary and permanent impoundments was contested by the Hopi Tribe in 1991, and presented before Administrative Law Judge (ALJ) John R. Rampton, Jr. (Rampton, 1991). ALJ Rampton's decision concluded that trust responsibilities are owed equally to both the Hopi Tribe and the Navajo Nation, who dispute each other's water rights claims. ALJ John H. Kelly reaffirmed ALJ Rampton's decision on June 5, 1992 (Kelly, 1992). To date, these water rights claims have not been adjudicated. Therefore, OSMRE cannot determine which tribe holds adjudicated water rights that require protection until the water claims are adjudicated.

While OSMRE does not have the authority to make determinations of possible violations of adjudicated water rights between the Hopi Tribe and Navajo Nation, OSMRE evaluates surface water quantity and related to existing and foreseeable downstream uses and the impact of the mining operation on the overall hydrologic balance.

4.1.2 Surface Water Baseline Quantity

Precipitation that does not infiltrate into the subsurface, or return to the atmosphere by evapotranspiration, flows in the washes as surface water. The nature of the surface water flow depends on the type of precipitation and behavior of the storm. "Forty-six percent of the annual precipitation is received in the months of July, August and September, and sixty-four percent is received in the period April through September" (PWCC, v.8, ch.11, 2011). The majority of surface runoff results from precipitation from April through September. A much smaller amount of runoff occurs in other months, such as snowmelt derived runoff in February and March.

The average channel gradient in the permit area is approximately 1%, which induces high velocities during runoff events (PWCC, v.9, ch.15, 2011). The high velocity is reflected in most hydrographs by a short time to peak and a quick reduction in flow after the storm ends. Velocities measured by PWCC personnel using current meters commonly exceed 5 feet per second (ft/sec) and have been as high as 10 ft/sec or greater during large flow events. PWCC monitoring also indicates that it is not uncommon to

have a time to peak of two to three minutes at the various monitoring stations (PWCC, v.9, ch.15, 2011). Multiple peak hydrographs are a characteristic observed during monitoring of the Black Mesa hydrology. The multiple peaks are likely the result of the localized nature, movement, and varying intensity of the thunderstorms that cause runoff. PWCC observations indicate that a thunderstorm cell might produce intense rain in a small upper tributary, move to other tributaries within the same watershed, and may change intensity as the thunderstorm cell migrates over the area, producing multiple runoff surges at downstream monitoring stations (PWCC, v.9, ch.15, 2011).

Fourteen stream monitoring sites were established to characterize the surface water regime related to surface water quantity (Figure 11). Above-mining and below-mining monitoring sites were selected on the primary drainages in the CIA: Yellow Water Wash, Coal Mine Wash, Moenkopi Wash, Red Peak Valley Wash, and Dinnebito Wash. The flow monitoring provides information on the hydrograph characteristics representing a range of drainage areas, watershed shapes, slopes, channel densities, and vegetative characteristics. Once the flow hydrographs are characterized for the snowmelt, convective and frontal storm events, the information provides reasonable flow volume estimates from the peak flow measurements. The flow quantity estimates are based on a strong correlation identified during regression analysis between peak flow and flow volume for the various type of flow event (PWCC, v.9, ch.15, 2011).

PWCC demonstrated through the use of upstream and downstream flow hydrographs for a storm event occurring entirely in the watershed above the upstream site that the upstream hydrographs only provide information on the channel transmission losses and the dampening effects these losses will have on the shapes and peaks of the downstream hydrographs (PWCC, 2001). Therefore, in 2002, OSMRE approved the reduction of continuous flow monitoring at upstream monitoring locations since PWCC demonstrated characterization of the surface water quantity and quality regime and the potential for surface water impacts. Additionally, no significant mining-related disturbance is present upgradient of the Kayenta Complex and the distinct geographic edge of Black Mesa.

PWCC currently monitors surface water at downstream monitoring locations 155 (Red Peak Valley Wash), 25 (Coal Mine Wash), 26 (Moenkopi Wash), and 34 (Dinnebito Wash). Locations 155, 26, and 25 collect continuous flow stage levels during storm flow events using ultrasonic gages mounted to a platform over the wash at established channel control sections. Location 34 is a crest gage (CG) used to measure peak flow, and the peak measurement can be applied to the appropriate hydrograph type to approximate the total discharge event. In 2010, PWCC installed monitoring location 34 near CG34, which has the same continuous monitoring design capabilities as locations 25, 26, and 155. These gaging locations continue to provide useful surface water quantity information during the evaluation of potential impact to the hydrologic balance outside the permit area.

Monitoring locations 25, 26, and 155 measure surface water runoff that does not pass through PWCC dams, ponds, or impoundments; with the exception of overflow quantities that periodically occur due to discharges from sediment control structures and are reported as part of compliance with the NPDES permit. During the NN0022179 permit term (2005-2009), discharges from precipitation events ranged from 0 ac-ft in 2009 to 57.81 ac-ft in 2007, averaging 21.28 ac-ft per year over the 5-year period. Combined measured surface flow at monitoring locations 25, 26, and 155 varies annually for the period of record (1987-2008). Total combined runoff for these three locations was a low (124.1 ac-ft) in 1991, and a maximum (4,105.8 ac-ft) in 2006; averaging 1,488.5 ac-ft from 1987-2008 (PWCC, v.11, ch.18, 2011). Based on the combined drainage area for the three locations (253 mi^2), less the total PWCC impounded area during each calendar year, an average annual runoff of 0.15-inches was calculated for the Moenkopi surface water CIA (PWCC, v.11, ch.18, 2011).

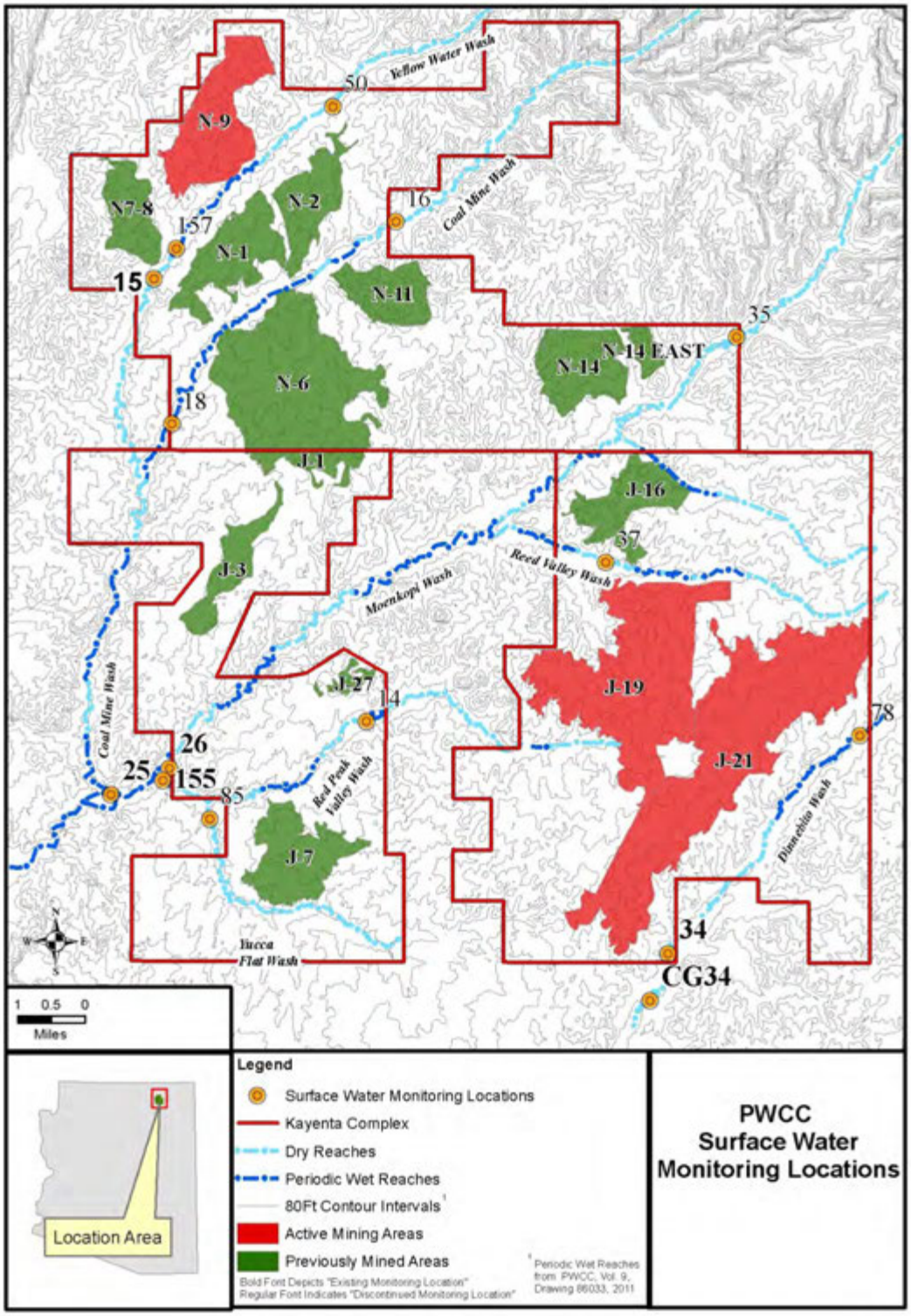


Figure 11: PWCC Surface Water Monitoring Locations

4.1.3 Surface Water Baseline Quality

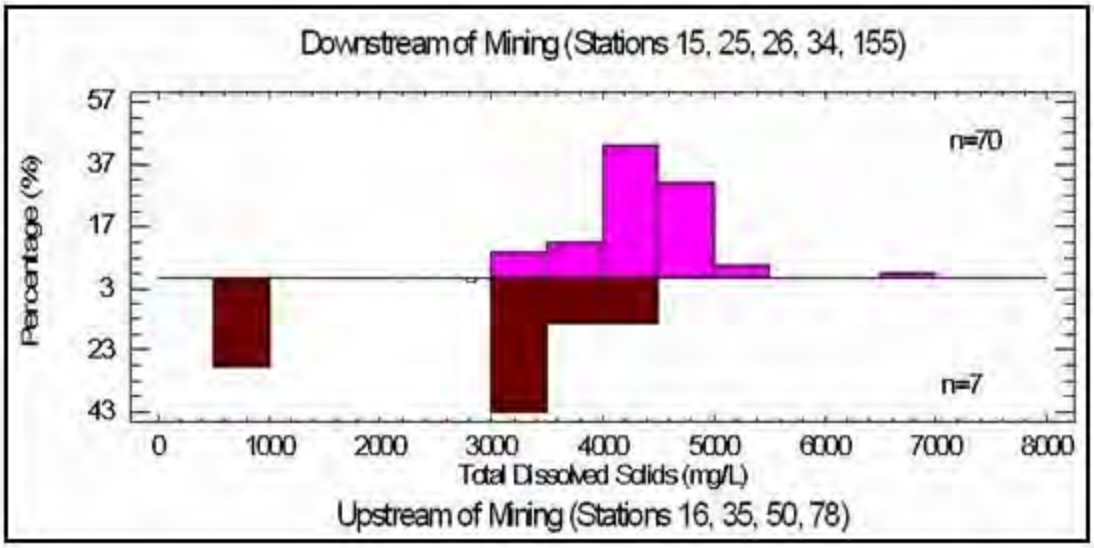
Surface water quality varies based on the type of runoff: storm water runoff, snowmelt runoff, or baseflow runoff (PWCC, v.9, ch.15, 2011). Data collected from surface water monitoring locations from September 1980 to June 1985 indicates that the dominant dissolved ions are calcium, magnesium, sometimes sodium, bicarbonate and sulfate (PWCC, v.9, ch.15, 2011). Dominant water types are calcium-magnesium sulfate and calcium-magnesium bicarbonate (PWCC, v.9, ch.15, 2011). Surface water flows in the Dinnebito Wash and Moenkopi Wash CIAs primarily originate from storm water runoff. "Resulting flows can be classified as flash floods of varying magnitude" (PWCC, v.9, ch.15, 2011). Storm water runoff in the CIAs can entrain the channel wash sediment. The amount of entrained sediment can be expressed as total suspended solids (TSS). The PWCC monitoring program established that as the flow discharge increases, TSS concentrations will increase (PWCC, v.9, ch.15, 2011). A maximum TSS concentration of 994,000 milligrams per liter (mg/L) was recorded during the 1980 to 1985 monitoring period (PWCC, v.9, ch.15, 2011).

The USGS collected surface water quality samples in December 1973 and then quarterly through the second half of 1975 in Moenkopi Wash approximately one mile downstream of the permit boundary (retired Station No. 09401240). Samples collected at retired USGS station 09401240 had mean sulfate concentrations of 1,600 mg/L and total dissolved solids (TDS) concentrations of 2,691 mg/L. The USGS also periodically collected water quality samples throughout the mid 1970's in Moenkopi Wash, Yellow Water Canyon Wash, and Coal Mine Wash within and adjacent to the Kayenta Complex.

The Kayenta Complex CHIA considers TDS a valuable indicator of water quality conditions in surface water flow. TDS is a broad measure of the overall quality of surface water. Figure 12 compares baseflow and storm flow TDS values between stations located upstream and downstream of mining activity. The data indicate that upstream baseflow TDS is consistent with downstream baseflow TDS concentrations. However, the upstream baseflow TDS data is limited. The Wepo Formation outcrops, and sub-crops in the alluvium, across the permit area; trending northwest to southeast. Therefore, baseflow is more prevalent on the downstream channels. Storm flow TDS is consistent when comparing upstream and downstream locations. Concentrations of TDS and other constituents are greater at downstream sampling locations compared to upstream sampling locations, likely attributed to the overlying Yale Point Sandstone. The Wepo Formation is present adjacent to the stream channels, but approximately 80% of the surface area between the eastern Kayenta Complex boundary and the rim of the mesa has been map at Yale Point sandstone (Repenning and Page, 1956). The Yale Point does not contribute as much of a dissolved load to the surface water compared to the Wepo. Within the Kayenta Complex, the land surface is dominated by the Wepo Formation, and the Yale Point is present only in the northeastern extension of the permit area. Therefore, within the permit area, runoff has a higher dissolved load, and the Wepo-influenced water recharges the alluvium in stream channels with higher TDS water. A review of sulfate data indicates that the distribution relationship is consistent with the TDS baseflow – stormflow relationship.

Table 2 provides summary information for upstream surface water monitoring locations for the Dinnebito Wash and Moenkopi Wash CIAs of the Kayenta Complex. Surface water monitoring location 78 represents upstream water quality for the Dinnebito Wash CIA. Surface water monitoring locations 16, 35, and 50 represent the upstream water quality for the Moenkopi Wash CIA. Storm flow water quality data collected between 1986 and 2010 is presented relative to the most protective WQS considering HTWQS (Hopi Tribe, 2008) and NNSWQS (NNEPA, 2007).

Baseflow TDS



Stormflow TDS

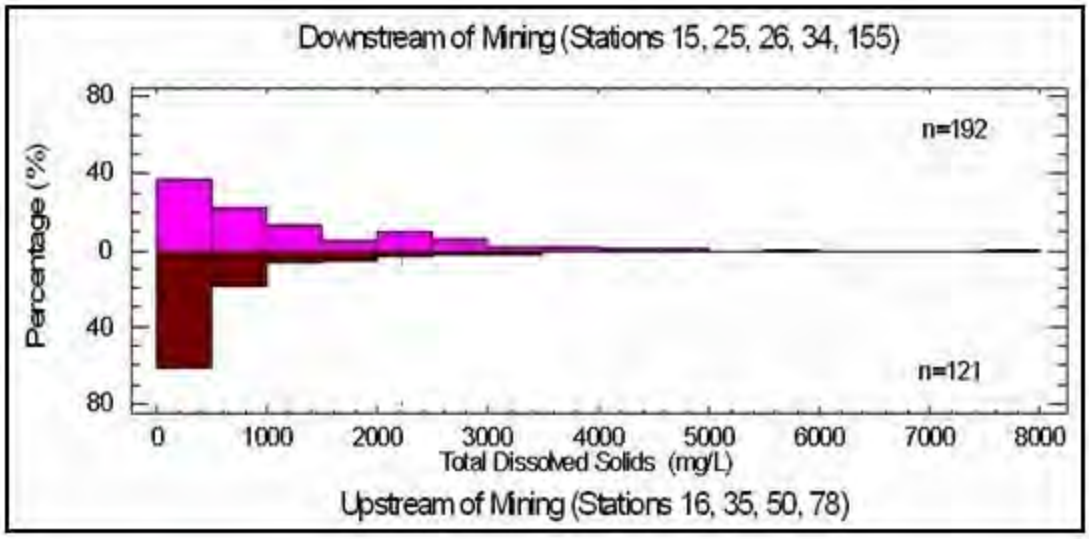


Figure 12: Comparison of Upstream and Downstream TDS Surface Water Quality Data for Baseflow and Stormwater flow (1986-2004).

					Dinnebito Wash CIA				Moenkopi Wash CIA			
					Location 78 Storm Water Samples				Locations 16, 35, and 50 Storm Water Samples			
Chemical Parameter	Most Protective WQS	WQS	Units	Type	# Samples	Low	Median	High	# Samples	Low	Median	High
Aluminum	Aquatic (NN)	0.75 (T)	mg/L	Dissolved	n=20	0.03	0.1	0.5	n=45	0.05	0.5	1.1
Antimony	Aquatic (NN)	88	µg/L	Dissolved	n=15	1	200	485	n=38	1	200	860
Arsenic	Aquatic (HT)	230	µg/L	Dissolved	n=20	1	20	30	n=45	1	20	30
Barium	Secondary Contact (NN)	98000 (T)	µg/L	Dissolved	n=17	90	195	500	n=44	20	250	1500
Bicarbonate	NNS	NNS	mg/L	Dissolved	n=34	39	95	390	n=86	26.8	94	1022
Boron	Agricultural (NN)	1000 (T)	µg/L	Dissolved	n=35	20	100	500	n=87	10	10	10
Calcium	NNS	NNS	mg/L	Dissolved	n=35	32	173	570	n=88	14	60	580
Cadmium	Fish Consumption (NN)	8 (T)	µg/L	Dissolved	n=18	3	5	20	n=42	10	100	504
Chloride	Aquatic (HT)	230 (T)	mg/L	Total	n=34	1	17.9	282	n=88	2	5	15
Chromium	Agricultural (HT)(NN)	1000 (T)	µg/L	Dissolved	n=18	10	20	50	n=41	1	7	69
Copper	Agricultural (NN)	200	µg/L	Dissolved	n=20	10	10	30	n=45	10	20	50
Fluoride	Secondary Contact (NN)	56 (T)	mg/L	Total	n=34	0.1	0.5	1.9	n=88	0.1	0.3	0.8
Iron	NNS	NNS	mg/L	Total	n=27	1.57	444.5	3871.0	n=76	7.75	352	4125
Lead	Secondary Contact (NN)	15 (T)	µg/L	Dissolved	n=18	20	20	540	n=41	20	20	280
Magnesium	NNS	NNS	mg/L	Dissolved	n=35	7	78.7	1300	n=88	2.7	13	247
Manganese	Agricultural (HT)	10 (T)	mg/L	Total	n=28	0.12	16	84	n=76	0.2	10	79
Mercury	Aquatic (HT)	0.01	µg/L	Dissolved	n=18	0.1	1	2.0	n=42	0.1	1	20
Molybdenum	Agricultural (HT)	0.01	µg/L	Dissolved	n=15	1	200	500	n=40	1	200	500
Nickel	Fish Consumption (NN)	4600 (T)	µg/L	Dissolved	n=15	20	20	300	n=40	10	50	300
Nitrate as N	Secondary Contact (NN)	1493 (T)	mg/L	Total	n=33	0.0	0.96	82.9	n=88	0.01	0.9	7.5
Nitrite as N	Secondary Contact (NN)	93.3 (T)	mg/L	Total	n=33	0.00	0.05	0.9	n=88	0.00	0.04	1
NO3+NO2	Livestock Watering (NN)	132	mg/L	Total	n=33	0.24	1.29	83	n=70	0.02	0.99	8.5
pH	All Uses	< 9.0	s.u.	Total	n=33	6.2	7.3	8.0	n=88	6.8	7.4	8.2
Selenium	Aquatic (HT)	2 (T)	µg/L	Dissolved	n=20	1	5	50	n=46	1	10	50
Silver	Secondary Contact (NN)	4670 (T)	µg/L	Dissolved	n=15	10	20	30	n=40	5	20	40
Sodium	NNS	NNS	mg/L	Dissolved	n=35	7.2	87	1740	n=88	1	4	108
Sulfate	Aquatic (HT)	250 (T)	mg/L	Total	n=34	48	900	9096	n=88	10	150	3060
TDS	Aquatic (HT)	500	mg/L	Total	n=34	170	1444	13250	n=88	72	440	6620
Vanadium	Agricultural (HT)(NN)	100 (T)	µg/L	Dissolved	n=20	5	20	500	n=45	5	100	1000
Zinc	Agricultural (HT)(NN)	10 (T)	mg/L	Dissolved	n=20	0.01	0.02	0.10	n=45	0.01	0.02	0.5

NNS - No Numeric Standard
WQS - Water Quality Standard
mg/L - milligrams per liter
µg/L - micrograms per liter
NN - Navajo Nation
HT - Hopi Tribe
CIA - Cumulative Impact Area
T- Total

Table 2. Storm water sample ranges for upstream locations, Kayenta Complex (1986-2010).

4.2 Groundwater

The proposed mining effect on groundwater quantity and quality is a hydrologic impact consideration related to the Kayenta Complex. The coal resource areas mined at the Kayenta Complex are in the Wepo Formation of the Mesa Verde Group, and the alluvial channels are locally connected to the formations of the Mesa Verde Group. PWCC utilizes groundwater from eight water supply wells within the Kayenta Complex. The wells withdraw groundwater from the N aquifer, and a portion is withdrawn from screened intervals of the overlying D aquifer. The N aquifer is utilized regionally by Hopi and Navajo communities for domestic supply water, and the D aquifer is utilized only in isolated areas where the water quantity and quality supports domestic or livestock water supply use. A third regional aquifer system, C aquifer, exists below the N aquifer and is confined from the N aquifer by siltstone, mudstone, and claystone comprising the Chinle Formation.

4.2.1 Groundwater Regulatory Requirements

30 CFR 816.41(h) states that a water supply of an owner of interest used for domestic, agricultural, industrial, or for other legitimate use that is adversely impacted by contamination, diminution, or interruption proximately resulting from surface mining activities shall be replaced. PWCC use of water for mining operations is authorized based on previous and current permit agreements. The coal leases from the Navajo Nation and Hopi Tribe state that Peabody may "develop and utilize water obtained from wells located on the leased premises for use in its mining operations including the transportation by slurry pipeline of coal mined from the leased premises…" (Stetson, 1966). PWCC commits to proper protection and maintenance of the production wells in accordance with the leases. PWCC will seal and properly abandon all monitoring wells in the alluvial and Wepo aquifers and remove the surface installations and instrumentation, unless the Tribes request retention of specific wells in the groundwater monitoring program.

4.2.2 Alluvium

Geomorphic mapping of the alluvium and colluvium along the principal washes and tributaries in the permit and adjacent area in 1980 identified that Dinnebito, Reed Valley, lower Coal Mine, and lower Moenkopi (2-mile segment downstream from permit boundary) washes have the largest amount of alluvium and saturated material (PWCC, v.11, ch.17, 2011). During 1980, PWCC conducted studies to determine the presence of alluvial valley floors. The studies concluded that the potential for agricultural practices in alluvial areas on and adjacent to the Kayenta Complex is limited, and alluvial valley floors do not exist on or immediately adjacent to the Kayenta Complex (PWCC, v.11, ch. 17, 2011). The headwater reaches of all washes, and side tributaries, contain little to no alluvial water. PWCC has installed 89 wells, and replacement wells when necessary to characterize and monitor the hydrogeologic conditions of the alluvium (Figure 13). Seismic refraction surveys were completed to evaluate alluvium thickness and saturation (Figure 14). This section will assess baseline water quantity and agricultural livestock use quality with information from the alluvial monitoring well program of the primary washes and tributaries within the surface water CIAs. The surface water CIAs will be used for evaluation of the alluvium due to the shallow and variable alluvial thickness and high infiltration rates in the channel alluvium, which provide a mechanism for the surface water system and alluvial ground water system to interact with each other.

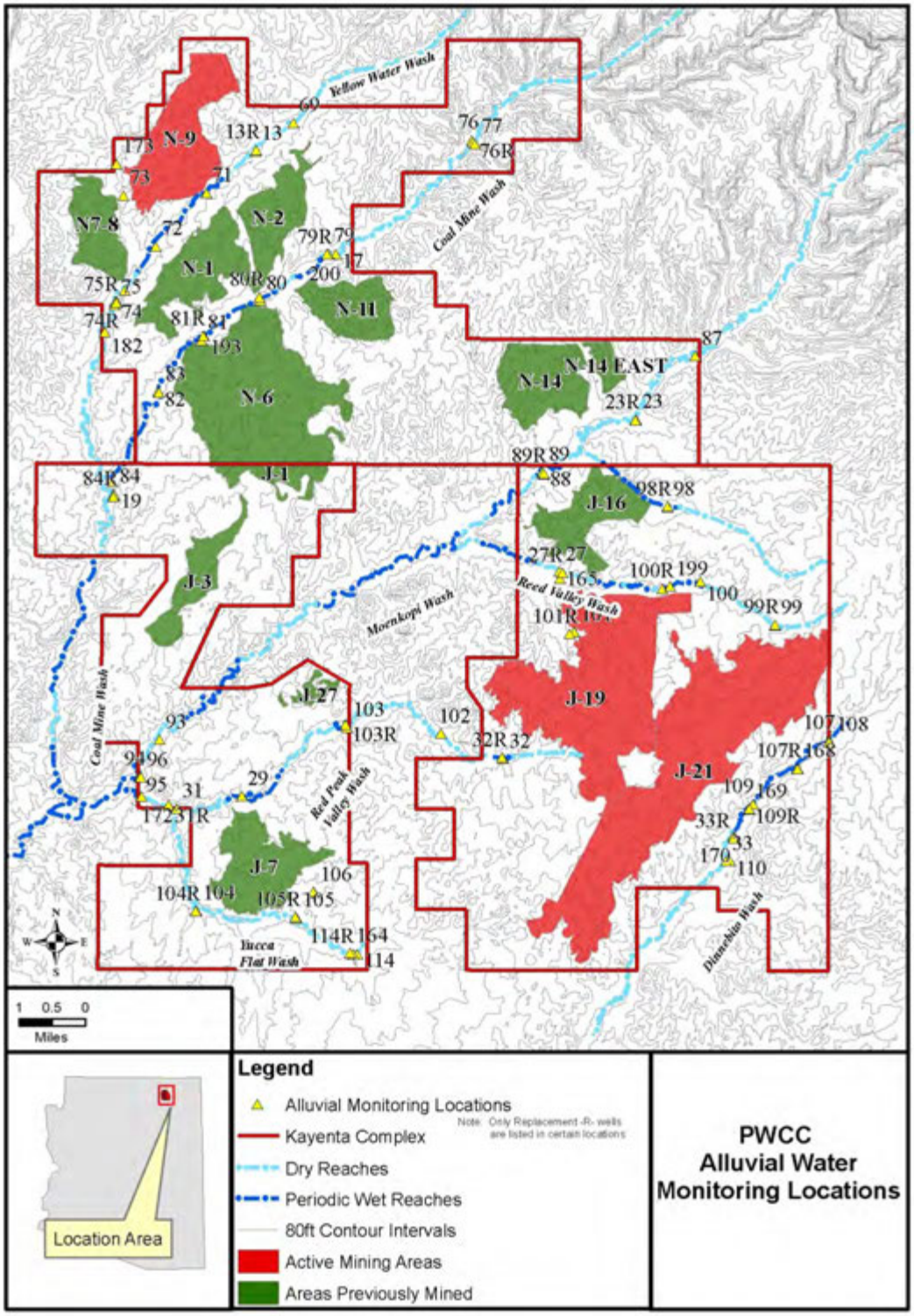


Figure 13: PWCC Alluvial Water Monitoring Locations, Kayenta Complex.

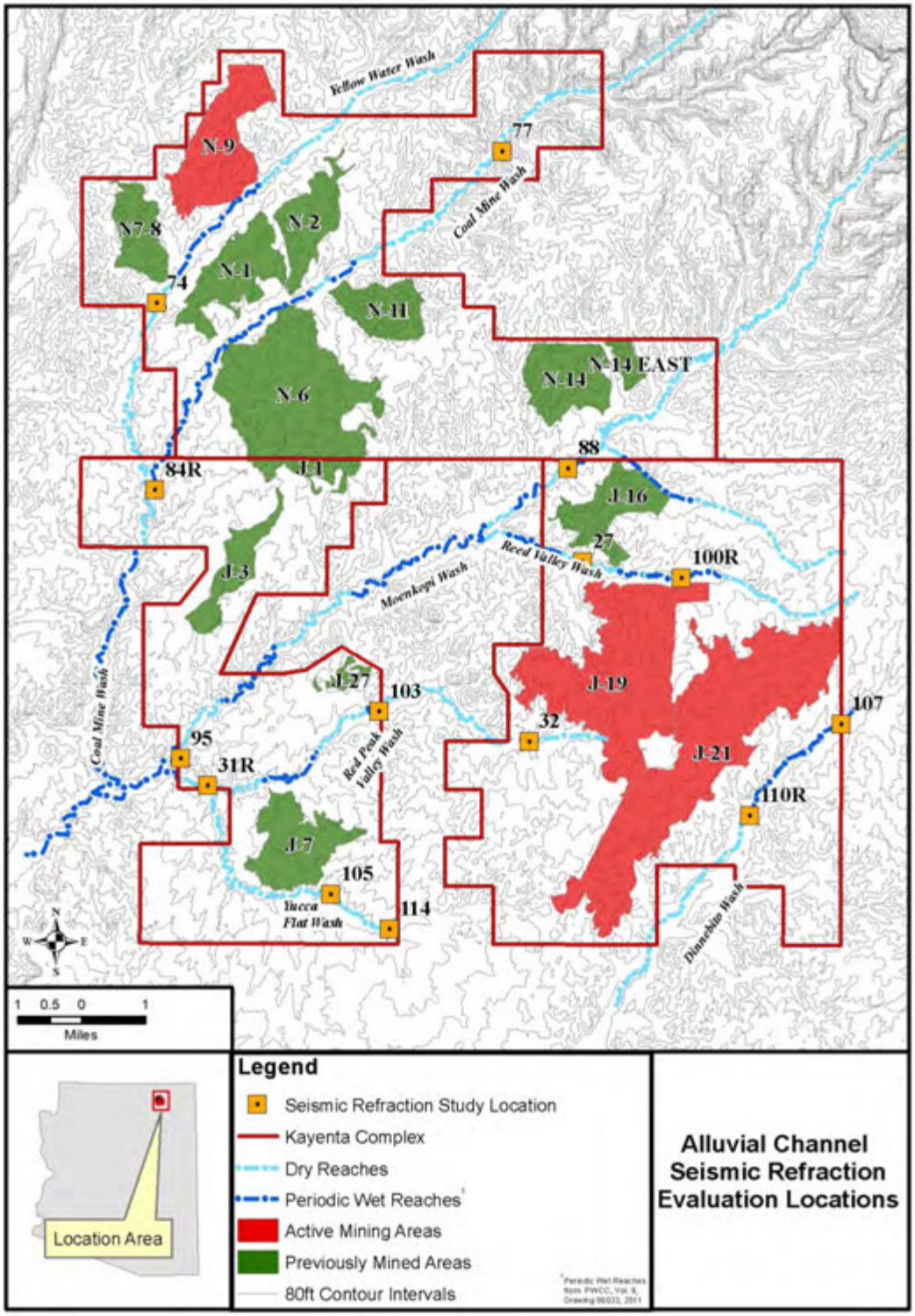


Figure 14: Seismic Refraction Evaluation Locations for Alluvium, Kayenta Complex.

4.2.2.1 Alluvial Baseline Quantity

Saturated thicknesses and saturated cross-sectional areas were determined for the primary washes within the permit area using borehole lithology, groundwater monitoring wells, and the geophysical technique of seismic refraction. The major washes investigated include Reed Valley Wash, Red Peak Valley Wash, Yellow Water Canyon Wash, Coal Mine Wash, Yucca Flat Wash, Moenkopi Wash, and Dinnebito Wash.

Seismic evaluation at 14 locations within the Kayenta Complex and at select adjacent areas resulted in average saturated thicknesses ranging from 3-34 feet, while saturated cross-sectional areas ranged from 900-40,000 square feet (Figure 14). Thinnest saturated thicknesses within the permit area are present at Upper Red Peak Valley Wash, Upper Yellow Water Canyon Wash and Upper Yucca Flat Wash, while greatest saturated thicknesses were found at Lower Yellow Water Canyon Wash, Lower Coal Mine Wash, Lower and Upper Dinnebito Wash, and Middle Reed Valley Wash. Greatest saturated cross-sectional areas are found along Dinnebito, Lower Moenkopi and Coal Mine Washes (PWCC, v.9, ch.15, 2011).

Ground water gradients were also evaluated on both micro-scale (180-foot length) and macro-scale (lengths of several thousand feet) along the alluvial channels using seismic refraction and water levels in the alluvial ground water monitoring wells. Gradients on a macro-scale ranged from 0.007-0.025 feet/feet, and 0.002-0.028 feet/feet on a micro-scale (PWCC, v.9, ch.15, 2011).

Additionally, a review of borehole lithology identified that the alluvium consists of poorly sorted sediments ranging from clays to cobbles. The alluvium varies in width and depth within the same wash and compared to other washes. The variation is a result of previous channel scour and associated sediment deposition. Subsequent events of channel scour and sediment deposition further add to the heterogeneity and anisotropy of the alluvial system. The variations in alluvial material influence the hydraulic conductivity of the saturated material throughout the various washes, and ultimately the transmissivity which is the product of hydraulic conductivity and saturated thickness. "The ability of an aquifer to transmit water is described by its hydraulic conductivity. The hydraulic conductivity is integrated in the vertical dimension to give an average transmission characteristic known as transmissivity, or hydraulic conductivity times the aquifer's saturated thickness" (Anderson and Woessner, 1992).

Transmissivity for the alluvial washes was evaluated in the permit area at 19 locations using time-distance drawdown aquifer tests in pits excavated into the alluvium or slug injection tests in the alluvial well bores (Figure 15). Time-drawdown pit tests were performed when meaningful drawdown responses could not be obtained in the alluvial wells prior to depleting all the water from the well bores. Therefore, where alluvial water levels were shallow and hydraulic conductivity high, pit pumping tests were performed. Transmissivity values from pit pumping tests near alluvial wells 74, 84, 88, and 95 ranged from 1870-5100 gallon per day per foot (gpd/ft), and transmissivity values derived from slug injection tests ranged from 21-1517 gpd/ft (PWCC, v.9, ch.15, 2011). The heterogeneity of the channel alluvium identified during review of the borehole lithology is evident in the transmissivity results for the various washes, which typically vary an order of magnitude within the same wash.

The alluvium is recharged from infiltration of surface water runoff from direct precipitation, and from groundwater emanating from saturated areas of the Mesa Verde Group in communication with the valley alluvium. The alluvial channels have not downcut to elevations in the permit area where the channels truncate the Toreva Formation of the Mesa Verde Group. Therefore, the groundwater portion of recharge is predominantly derived from saturated areas of the Wepo Formation of the Mesa Verde Group truncated by alluvial channels, and minor contribution from the Yale Point Sandstone Formation of the Mesa Verde Group in the northern and northeastern areas of Black Mesa above the permit area (PWCC, v.9, ch.15, 2011). Recharge to the alluvium from the truncated saturated areas of the Wepo Formation account for the maintenance of alluvial water levels during extended dry periods.

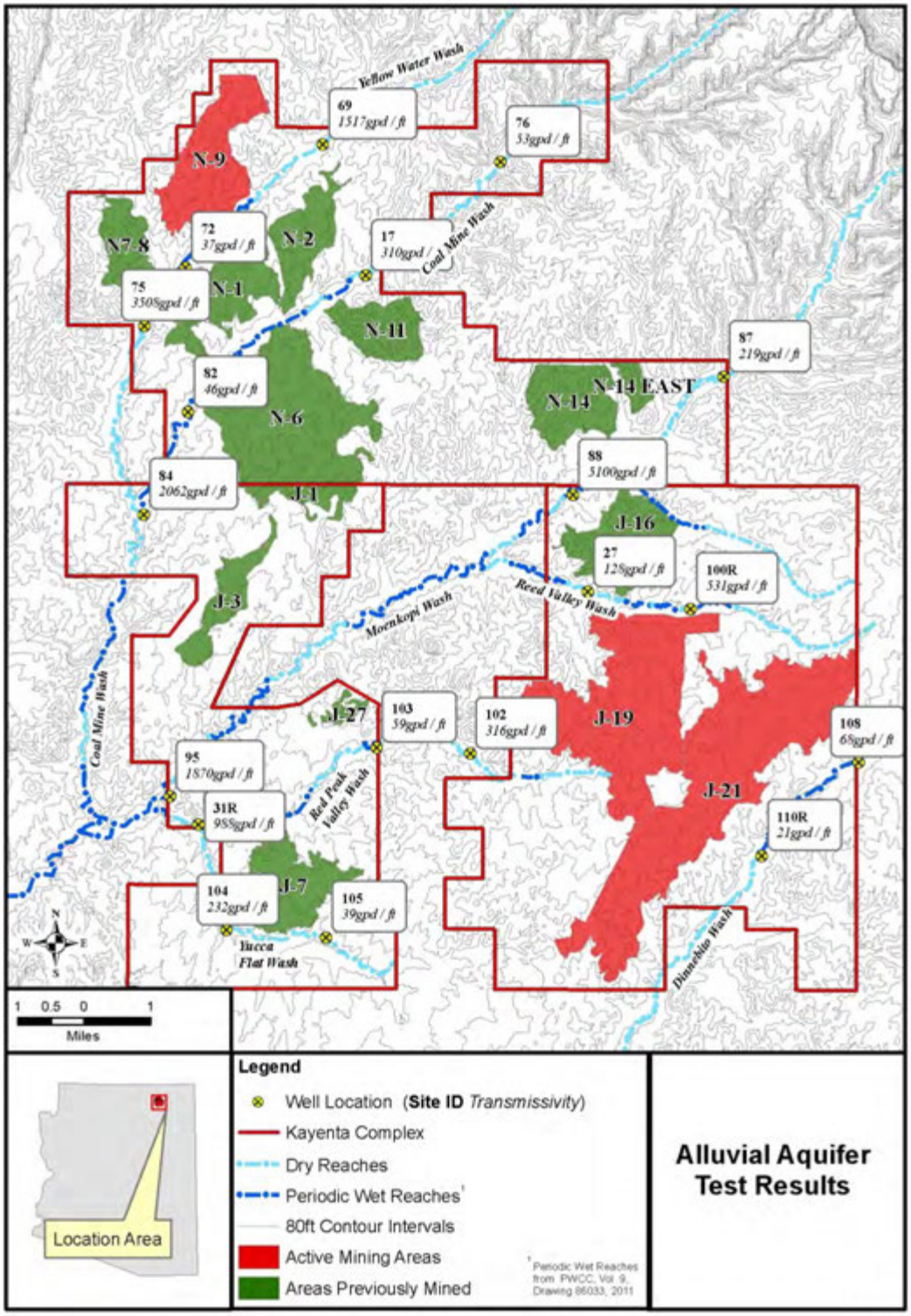


Figure 15: Alluvial Aquifer Test Results, Kayenta Complex.

Seismic refraction surveying noted the occurrence of water level gradients from the Wepo Formation to the alluvium at alluvial monitoring locations 31R, 77, 100R, 103, 107, and 110R (PWCC, v.9, ch.15, 2011). Typically, alluvial monitoring well hydrographs show gradual water level declines in the spring and late fall, and water level rises during the summer monsoon period and during wet winters in response to the infiltration of surface water runoff.

Alluvial ground water flow rates are driven by local hydrologic gradients, which vary depending on magnitude, frequency, and duration of the surface runoff and subsequent infiltration rates. Alluvial water discharge to the atmosphere by transpiration of phreatophytes along the alluvial channels is a factor at localized areas. Within the permit area, water level fluctuations during the spring and summer months have been observed at alluvial monitoring wells 33R, 83, 84, and 95 near tamarisk phreatophytes (PWCC, v.11, ch.18, 2011).

4.2.2.2 Alluvial Baseline Quality

Water quality of the alluvial drainages was evaluated for agricultural livestock watering use with the alluvial monitoring well network (Figure 13). Table 3 presents water quality summary statistics for upstream alluvial monitoring wells for the Dinnebito Wash CIA and Moenkopi Wash CIA related to Agricultural Livestock Watering WQS.

The nature of recharge to the alluvium varies depending on the season of the year. The majority of alluvial recharge occurs during the monsoon season of July, August, and September when surface water flow events infiltrate into the channel alluvium. Recharge to the alluvium also occurs as a result of surface water runoff generated from snowmelt events typically occurring in February and March. When surface water runoff is not recharging the alluvium from downward infiltration of surface water, the dominant recharge process occurs from horizontal flow of the Wepo Formation discharging into the adjacent alluvium, typically during April and May. Therefore, the nature of recharge may potentially have seasonal influence on alluvial water quality.

In order to assess the potential seasonal influence on alluvial water quality within the primary alluvial washes, the statistical analysis of sulfate was evaluated for time periods when the alluvium is recharged by storm water flow, snow melt runoff, or contribution from the Wepo Formation. The first part of the analysis evaluated the entire group of sulfate concentrations within each major wash broken down by dominant recharge mechanism, determined by sample collection date, and compared recharge mechanisms. The second part of the analysis evaluated the differences in sulfate concentrations between the monitoring locations within each wash after grouping the data by recharge mechanism, and compared location differences. Parametric and non-parametric statistical methods were applied to evaluate the statistical significance of the means and medians of the data grouped by recharge mechanism. Normality of the data distribution was also considered. If the data were normally distributed, then ANOVA, Cochran, Barlett, Hartley, and Levene analyses were considered. If the data were not normally distributed, then the Kruskal-Wallis method was considered.

The results, which are not included in this assessment, indicate that differences in alluvial water quality based on comparing recharge mechanism are not statistically significant at the 95% confidence interval for the four primary alluvial drainages. However, statistical differences are apparent when comparing concentrations in alluvial wells from different locations within the same alluvial drainage. Location based statistical differences are also apparent in all sampled alluvial drainages when comparing the different recharge mechanisms. The local seasonal influences of the different recharge mechanisms may effect on the water quality variability at any location, but not significantly compared to the water quality variability from location to location. Therefore, OSMRE evaluated upstream alluvial monitoring wells and downstream alluvial monitoring wells for comparison. If impacts are identified at downstream alluvial monitoring locations, evaluation of specific stream reaches may be necessary.

					Dinnebito Wash CIA				Moenkopi Wash CIA			
					Location 108R				Locations 69, 77, and 87			
Chemical Parameter	Agricultural Livestock Watering WQS	WQS	Units	Type	# Samples	Low	Median	High	# Samples	Low	Median	High
Aluminum	HT	5	mg/L	Dissolved	n=37	0.03	0.05	0.5	n=129	0.03	0.05	2
Arsenic	HT and NN	200	µg/L	Dissolved	n=37	0.5	1	32	n=99	0.5	1	20
Bicarbonate	NNS	NNS	mg/L	Dissolved	n=36	242	305	354	n=132	193	338	827
Boron	NN	5000	µg/L	Dissolved	n=37	10	100	160	n=129	20	110	500
Calcium	NNS	NNS	mg/L	Dissolved	n=37	479	561	666	n=132	106	214	604
Cadmium	HT and NN	50	µg/L	Dissolved	n=37	3	5	50	n=132	3	5	300
Chloride	NNS	NNS	mg/L	Total	n=37	30	59	77	n=129	3	26	230
Chromium	HT and NN	1000	µg/L	Dissolved	n=37	10	10	90	n=129	5	10	500
Copper	HT and NN	500	µg/L	Dissolved	n=37	10	10	60	n=129	5	10	500
Lead	HT and NN	100	µg/L	Dissolved	n=37	20	20	200	n=129	1	20	400
Magnesium	NNS	NNS	mg/L	Dissolved	n=37	201	242	289	n=132	21	205	1470
Mercury	HT	10	µg/L	Dissolved	n=37	0.1	0.2	0.5	n=132	0.1	0.2	1
Selenium	HT and NN	50	µg/L	Dissolved	n=37	1	1	10	n=132	1	2	10
Sodium	NNS	NNS	mg/L	Dissolved	n=37	260	314	401	n=132	78	165	1570
Sulfate	NNS	NNS	mg/L	Total	n=37	2390	2774	3005	n=132	175	1470	9410
TDS	NNS	NNS	mg/L	Total	n=37	4058	4311	4640	n=132	460	2312	15100
Vanadium	HT and NN	100	µg/L	Dissolved	n=37	5	10	50	n=129	5	10	500
Zinc	HT and NN	25	mg/L	Dissolved	n=37	0.01	0.01	0.12	n=129	0.01	0.01	0.5

NNS - No Numeric Standard
WQS - Water Quality Standard
mg/L - milligrams per liter
µg/L - micrograms per liter
NN - Navajo Nation
HT - Hopi Tribe
CIA - Cumulative Impact Area
T- Total

Table 3. Alluvial water quality sample ranges for upstream locations, Kayenta Complex (1986-2010).

PWCC also evaluated seasonal water quality using TDS in the alluvial wells to evaluate the water quality variability in the PHC demonstration (PWCC, v.11, ch.18, 2011). The data were grouped into dominant recharge mechanisms based on seasonal recharge characteristics to the alluvium: snowmelt recharge, Wepo recharge, and rainfall recharge. TDS concentrations are typically lower in alluvial wells during rainfall recharge as the infiltrated rain water has a diluting effect on alluvial water quality. When Wepo recharge is dominant during the dry period, Wepo Formation water having typically elevated TDS concentrations is the major recharge source water. The elevated TDS concentrations are reflected in the alluvial monitoring wells. Similarly, elevated TDS concentrations are observed in alluvial monitoring wells during the snowmelt period. Higher TDS concentrations during the snowmelt period in the alluvial wells may be attributed to a combination of the increased residence time for snowmelt to interact with mineral facies, or recharge from the Wepo still acting as the dominant recharge mechanism. Therefore, seasonality of the recharge water adds to the variability in the data, but the water quality variability between monitoring locations is most significant for impact evaluation regardless of recharge mechanism.

Due to the statistical variability in between locations, trend analysis was performed at each location. A time series plot of each parameter of interest was developed and fit with a least squares trend line best fitting the data for trend analysis. The slope of the trend line was determined to have either a positive or negative trend, and whether the slope of the trend was statistically different from zero at the 95% confidence interval (PWCC, v.11, ch.18, 2011). The trends identified will be further discussed in the impact evaluation in Chapter 5. However, the trends for the monitoring well furthest upstream of all mining impacts in the sampled drainages will be presented in this baseline discussion.

Monitoring well 69 is located in Yellow Water Canyon Wash, and upstream of all mining activities. Negative trends for sulfate, calcium, sodium, and magnesium, and positive trends in bicarbonate and TDS were identified at location 69 based on the period of record; however, no trend has a slope significantly different than zero. Monitoring well 77 is located in Coal Mine Wash, upgradient of all mining activities. Negative trends for sulfate, calcium, sodium, magnesium, and TDS were identified at location 77; however, none of the negative slopes are significantly different than zero. Location 77 does have a positive trend for bicarbonate that is significantly different than zero. Monitoring well 87 is located on Moenkopi Wash upstream of all mining activities and has a negative sulfate trend slope not significantly different than zero, a negative trend for calcium, sodium, magnesium, TDS, and a positive trend slope for bicarbonate. Monitoring location 108R located in Moenkopi Wash upstream of all mining activities has mixed trend slope results for the primary parameters of interest. Sulfate and calcium trends are not significantly different than zero at location 108R. Positive trends for sodium, bicarbonate, and TDS, and a negative trend for magnesium are apparent at location 108R for the period of record. Overall, the upstream background locations typically have a signature of elevated sulfate concentrations, with the exception of the upper reach of Coal Mine Wash, and the upstream water quality is not changing appreciably.

4.2.3 Wepo Formation

The Mesa Verde Group is the uppermost lithology on Black Mesa and includes the Yale Point Sandstone, Wepo Formation, and Toreva Formation. The Wepo Formation consists of the coal mined at the Kayenta Complex, and the mining operations may intercept local areas of groundwater from the Wepo Formation. Therefore, this section will characterize the nature of water quantity and quality for the Wepo Formation within Wepo Formation CIA delineated in Section 2.2.1 using information collected at PWCC Wepo sampling locations (Figure 16).

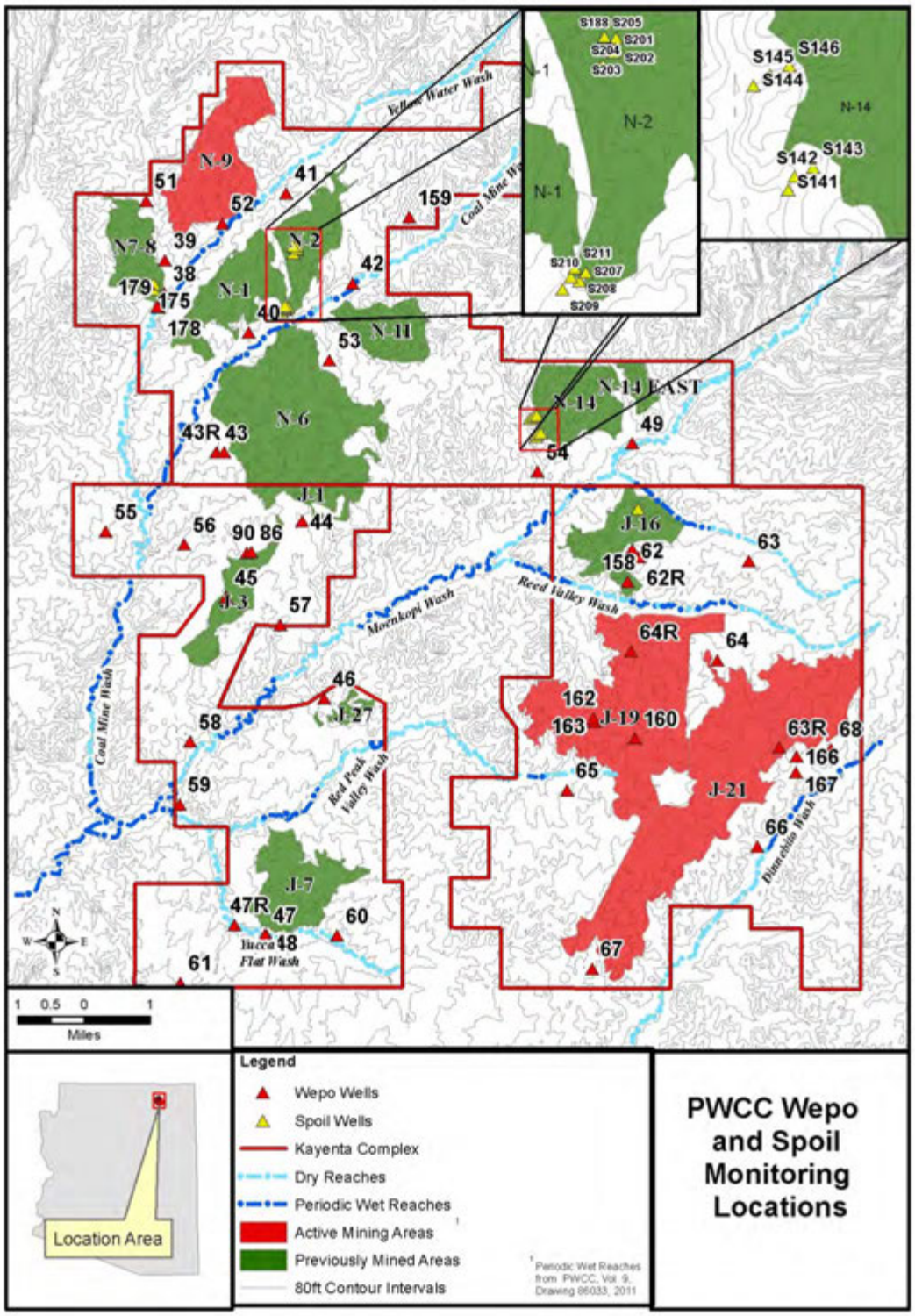


Figure 16: PWCC Wepo Formation and Spoil Monitoring Locations, Kayenta Complex.

4.2.3.1 Wepo Formation Baseline Quantity

Wepo Formation monitoring wells were primarily located on the downgradient side existing and potential surface mine areas. Additional Wepo Formation wells were installed upgradient from mine areas, within reclaimed mine pits, and in areas where mining is not anticipated to occur to provide further characterization of the Wepo aquifer and use potential. Forty-six Wepo wells were installed to characterize the heterogeneity of the Wepo Formation throughout the CIA delineated in Section 2.2.1 (Figure 8). The Wepo Formation contains low yielding perched aquifers that pinch out or are vertically displaced by minor structural deformation identified within the Kayenta Complex (PWCC, v.11, ch.18, 2011). Figure 17 illustrates the coal bed sequence mined at pit N-6. The coal deposits are typically five to fifteen feet thick and separated by interburden deposits. Some minor geologic structural deformation has been identified in the permit area identified by small stratigraphic offsets in the Wepo Formation.

Figure 17: Wepo Formation in N-6 with minor offset (photos by Paul Clark, 5-25-2005).

The primary alluvial drainages (Yellow Water Canyon Wash, Coal Mine Wash, Moenkopi Wash, and Dinnebito Wash) and associated tributaries truncate the Wepo Formation in areas within the CIA. Throughout the permit area, the Wepo Formation receives direct recharge from surface precipitation since it is exposed at the surface (Repenning and Page, 1956). Infiltrated precipitation source water flows towards areas of lower elevation until the water discharges to the surface as surface flow, or the alluvial drainages as baseflow. Therefore, the groundwater flow paths for water in the Wepo Formation are typically oriented towards the primary alluvial drainages and towards the mine pits when Wepo Formation water is intercepted (Figure 8). Since the flow paths are oriented toward the alluvial drainages, the groundwater contours generally mimic the surface topography.

The surface topography is highest to the northeast of the permit area and lowest to the southwest. Since the water level contours generally mimic the surface topography, regional Wepo Formation groundwater flow is toward the southwest and locally toward the alluvial drainages. Therefore, groundwater impact to the Wepo Formation will not extend significantly north of the mined coal resource areas. The eastern boundary of the CIA is defined by coal resource area J-21 and Dinnebito Wash. Similar to the northern coal resource areas, potential groundwater impacts will not propagate in the opposite direction of the flow path near J-21, which defines part of the eastern CIA boundary. Dinnebito Wash provides a hydrologic boundary to Wepo groundwater impacts. Dinnebito Wash has incised the Wepo Formation, allowing Wepo Formation water to discharge to the wash. The discharged water to Dinnebito Wash is monitored as part of the alluvial monitoring program. The southern CIA boundary crosses two surface water drainages: Moenkopi Wash and Dinnebito Wash. Therefore, some Wepo Formation water discharges to Dinnebito Wash and some discharges to Moenkopi Wash. The southern boundary was delineated to mimic surface topography divides. The western boundary of the CIA was delineated considering Yellow Water Canyon Wash and Coal Mine Wash as hydrologic boundaries. Downcutting of surface water in Yellow Water Canyon Wash and Coal Mine Wash have incised the Wepo Formation and allows discharge of Wepo water to these two washes.

Twenty-three Wepo wells were tested to characterize the water production potential of the Wepo Formation within the CIA. The Wepo Formation transmissivity values in the CIA, which relate the water production potential, vary four orders magnitude; from 0.01 gpd/ft at well 62, to 666 gpd/ft at well 51 (Figure 18). The median transmissivity is 40 gpd/ft.

Where the Wepo Formation is in hydrologic communication with the alluvium, the Wepo may receive recharge from surface water that has infiltrated into the alluvium. When the alluvium is saturated during surface flow events, the hydraulic gradient may temporarily reverse until the surface flow event and water in alluvial bank storage dissipates. Temporary and localized influence of the surface water and alluvial groundwater on the Wepo monitoring system has been observed shortly after surface flow events in several Wepo monitoring wells in close proximity to the alluvium (PWCC, v.9, ch.15, 2011).

4.2.3.2 Wepo Baseline Quality

Table 4 presents water quality summary statistics for parameters with an Agricultural Livestock Watering WQS, and major cations and anions, for the wells screened in the Wepo Formation within the Kayenta Complex. The major cations and anions include TDS, sulfate, magnesium, calcium, bicarbonate, sodium, and chloride. The following Wepo wells are considered background wells due to significant distance from area disturbed by mining: 47, 55, 56, 57, 59, 61, 65, and 67. Additional monitored Wepo wells may also be representative of background conditions based on the water quality results from the monitoring period, but OSMRE has identified the above listed wells as representative of background for this assessment.

The TDS concentrations in the selected background Wepo Formation wells range from 446 mg/L at well 61 to 2,000 mg/L at well 59. The median TDS concentration for all of the background Wepo Formation wells is 779 mg/L. Sulfate concentrations in background Wepo Formation wells range from 2 mg/L at well 55 to 1,200 mg/L at well 59. The median sulfate concentration for all background Wepo wells is 121 mg/L. Magnesium concentrations in background Wepo Formation wells range from 0.3 mg/L to 91 mg/L with a median concentration of 2.1 mg/L. Calcium concentrations in background Wepo Formation wells range from 1 mg/L to 188 mg/L with a median concentration of 9.8 mg/L. Sodium concentrations range from 160 mg/L to 744 mg/L with a median concentration of 270 mg/L. Chloride concentrations range from 3 mg/L to 48 mg/L in background Wepo Formation wells with a median concentration of 11 mg/L.

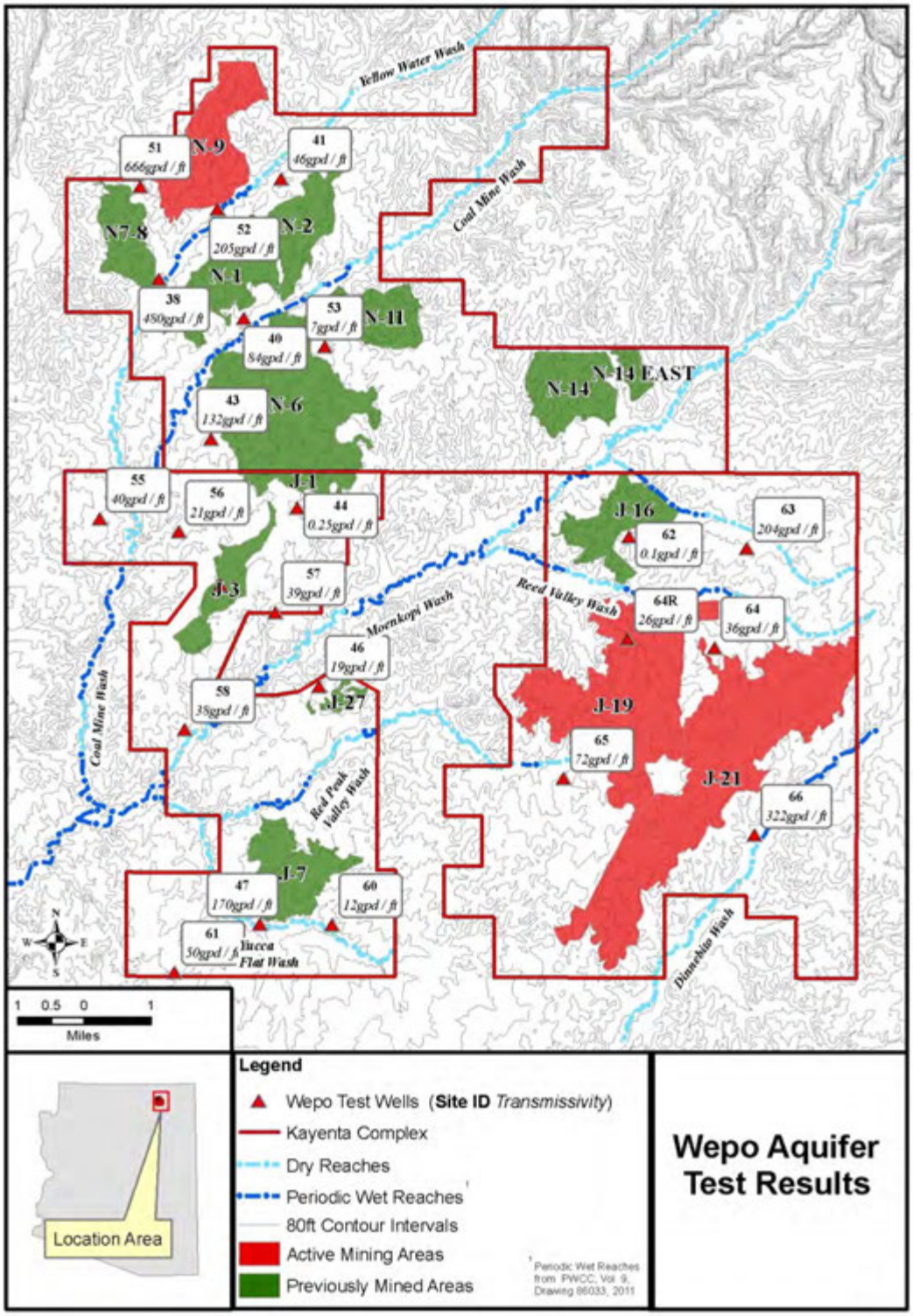


Figure 18: Wepo Aquifer Test Results, Kayenta Complex.

					Background Wepo Wells			
					Locations 47, 55, 56, 57, 59, 61, 65, 67			
Chemical Parameter	Agricultural Livestock Watering WQS	WQS	Units	Type	# Samples	Low	Median	High
Aluminum	HT	5	mg/L	Dissolved	n=212	0.03	0.05	1.69
Arsenic	HT and NN	200	µg/L	Dissolved	n=212	0.1	1	20
Bicarbonate	NNS	NNS	mg/L	Dissolved	n=212	200	434	2228
Boron	NN	5000	µg/L	Dissolved	n=212	20	200	1200
Calcium	NNS	NNS	mg/L	Dissolved	n=212	1	9.8	188
Cadmium	HT and NN	50	µg/L	Dissolved	n=212	3	5	20
Chloride	NNS	NNS	mg/L	Total	n=212	3	11	48
Chromium	HT and NN	1000	µg/L	Dissolved	n=212	5	10	30
Copper	HT and NN	500	µg/L	Dissolved	n=212	5	10	50
Lead	HT and NN	100	µg/L	Dissolved	n=212	1	40	200
Magnesium	NNS	NNS	mg/L	Dissolved	n=212	0.3	2.1	91
Mercury	HT	10	µg/L	Dissolved	n=212	0.1	0.2	1
Selenium	HT and NN	50	µg/L	Dissolved	n=212	1	1	11
Sodium	NNS	NNS	mg/L	Dissolved	n=212	160	270	744
Sulfate	NNS	NNS	mg/L	Total	n=212	2	121	1200
TDS	NNS	NNS	mg/L	Total	n=369	446	779	2000
Vanadium	HT and NN	100	µg/L	Dissolved	n=212	5	5	500
Zinc	HT and NN	25	mg/L	Dissolved	n=212	0.005	0.01	0.08

NNS - No Numeric Standard
WQS - Water Quality Standard
CIA - Cumulative Impact Area

mg/L - milligrams per liter
µg/L - micrograms per liter
T- Total

NN - Navajo Nation
HT - Hopi Tribe

Table 4. Wepo Formation water quality sample ranges for background locations, Kayenta Complex (1986-2010).

4.2.4 D Aquifer

The D aquifer is areally extensive throughout the Black Mesa area (Figure 19), and water is withdrawn from the D aquifer system by PWCC, communities in the area, and windmills. The D aquifer is composed, in order of oldest to youngest, of the Entrada Sandstone of the Summerville Formation, the Cow Springs Sandstone, the sandstone members of the Morrison Formation and the Dakota Sandstone. The Entrada Sandstone consists of three members, represented by two facies: a clean sandstone facies in the upper and lower members, and a silty facies in the middle member. The Summerville Formation is comprised of an upper sandy facies and a lower silty facies. The thickness of the Summerville Formation is variable where tongues of the Cow Springs Sandstone constitute part of the formation. The Cow Springs sandstone deposits are extensive, ranging from 230 feet to 449 feet in the southwest portion of the CIA. The tongues of the Cow Springs sandstone also intertongue extensively with members of the Morrison Formation. In the northeast part of the CIA, the Cow Springs sandstone is hydraulically connected with the Recapture and Salt Wash Members of the Morrison Formation. In the southwestern CIA area, the Cow Springs is hydraulically connected to the Entrada Sandstone and Dakota Formation, as the Morrison is absent in this area. The Dakota sandstone ranges in thickness from 40 feet to 150 feet, regionally thinning to the south and southwest on Black Mesa. Additional detail of the D aquifer lithology can be found in the documentation for the regional three-dimensional numerical model of the Black Mesa Basin (3D Model) (PWCC, 1999).

The D aquifer system is a complex hydraulic interconnection of several formations and members. However, an evaluation of D aquifer water level and water chemistry data indicates that the Mancos shale confining unit above, and the Carmel Formation below, allows these interconnected formations to behave as a regional aquifer system.

4.2.4.1 D aquifer Baseline Quantity

Water quantity for the D aquifer system is based on the hydraulic properties of the formations comprising the system. Hydraulic properties of horizontal and vertical hydraulic conductivity, saturated thickness, flow gradients, and aquifer storage of the D aquifer formations assist in the evaluation of water quantity. Stetson (1966) installed a test well in the permit area as part of a wellfield development feasibility study for the Kayenta Complex. Isolating and stressing the saturated 1,050 feet of Entrada, Morrison, and Dakota Formations comprising the D aquifer system at this location for 700 minutes, at a rate of 23 gallons per minute, produced 59 feet of drawdown in the pumping well (Stetson, 1966). Using the Theis recovery test for hydraulic property analysis, a transmissivity of 440 gallons/day/foot (hydraulic conductivity of 0.056 ft/day) was calculated for the D aquifer system based on the natural rate of recovery (Stetson, 1966).

GeoTrans developed similar horizontal conductivity values as Stetson (1966) for the formations comprising the D aquifer system through steady state calibration of the 3D Model (PWCC, 1999). Steady state calibration involves adjusting hydraulic conductivity and storage values until model simulated D aquifer water levels generally agree with regional measured water level elevations in D aquifer wells prior to significant pumping. For the 3D Model, steady state conditions occurred prior to 1956; however, hydraulic head measurements up through the end of 1969 were included as calibration targets for equilibrium conditions to increase the areal coverage due to the limited measurements made prior to 1956. The inclusion of hydraulic head water levels from 1956-1969 for equilibrium conditions is appropriate since community pumping effects were very localized at Kayenta, Kykotsmovi, Rocky Ridge, and Rough Rock prior to 1969, and significant pumping at the PWCC wellfield did not begin until 1970 (Macy and Brown, 2011).

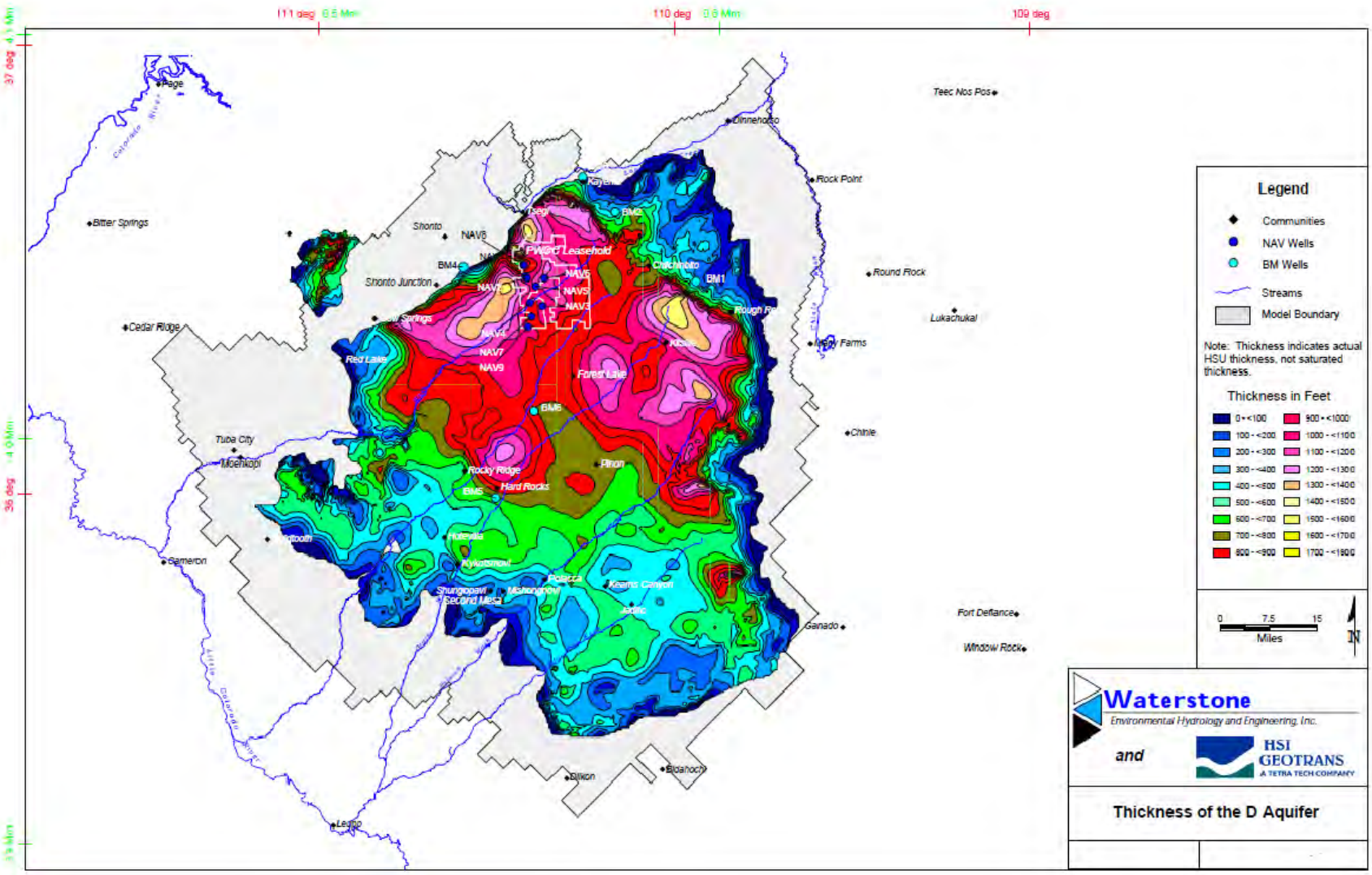


Figure 19: Thickness of the D aquifer, Black Mesa, Arizona (PWCC, 1999).

After review of well log information, water level measurements, water chemistry, geologic structure information, and spring elevations, water level data from 118 wells and springs were used as D aquifer steady state calibration targets for the 3D Model pre-pumping simulation (Figure 20). The steady state model was calibrated to horizontal hydraulic conductivity values of 0.0984 ft/day (Dakota Formation), 0.0197 ft/day (Morrison Formation), 0.0656 ft/day (Sandy Entrada Formation), and 0.0131 ft/day (Silty Entrada Formation) through calibration with measured water levels. The formation specific horizontal hydraulic conductivity values yielded from model calibration approximate the bulk value of 0.056 ft/day for the D aquifer system.

The resultant steady state potentiometric surface map for the D aquifer is illustrated as Figure 21. The D aquifer system is recharged from direct precipitation on ephemeral streams in areas where D aquifer formations are exposed at the surface or covered by permeable veneer of unconsolidated sediments. Steady state (pre-significant pumping) D aquifer flow occurred from the recharge area in the southeast and east predominantly toward the west and southwest and through the center of the basin. Steady state D aquifer discharge occurred northeast to Laguna Creek and along downcut washes intercepting the D aquifer formations near the southern Hopi communities.

4.2.4.2 Dakota Aquifer Baseline Quality

As water recharging the D aquifer flows toward the discharge areas, water-rock reactions dissolve formation constituents changing the groundwater chemistry along the flow path. Thin section analysis of rocks comprising the D aquifer reveal the persistence of alkali and plagioclase feldspars, clays, iron oxides, chert, and calcium-carbonate cement (GeoTrans Inc., 1993). The dissolution of feldspar contributes calcium, sodium, potassium, aluminum, and silicon into solution along the flow path. Then, the exchange of calcium and sodium ions in the clays and lignites found in the Dakota Sandstone contribute to the formation of sodium bicarbonate type water along the flow path (Truini and Longsworth, 2003). Additionally, the dissolution of sulfate from gypsum and lignite stringers contributes to increases in sulfate along the D aquifer flow paths. The overall quality of the D aquifer tends to have higher dissolved concentrations of boron, chloride, sodium, and sulfate compared to N aquifer water, resulting in elevated TDS concentrations (Truini and Longsworth, 2003). The elevated ion concentrations and TDS often limit the use and development of the D aquifer in the region.

Groundwater will flow from areas of high potential energy to areas of lower potential energy, and follow the path of least resistance. Therefore, since the D aquifer is confined above by the Mancos Shale, and below by the Carmel Formation having a low hydraulic conductivity compared to the formations comprising the D aquifer, flow is generally horizontal from east to west along the D aquifer flow paths. However, measured water levels defining the D aquifer potentiometric surface are typically higher than measured water levels of the underlying N aquifer potentiomentric surface in the area of the confined D aquifer. Figure 22 illustrates the hydraulic head differences between the D- and N aquifers. Therefore, a vertical flow potential exists for poorer quality D aquifer water to flow through the Carmel Formation to the underlying N aquifer.

The baseline vertical flow potential from the D aquifer to the N aquifer was investigated by the USGS using geochemical and isotopic analysis (Truini and Longsworth, 2003). The findings indicate that vertical flow leakage from the D aquifer to the N aquifer has been occurring for thousands of years, and has a higher likelihood of occurring in the southern part of Black Mesa (Truini and Longsworth, 2003). Truini and Macy (2006) related the thickness and lithology of the Carmel Formation to groundwater leakage in the southern part of Black Mesa using borehole-geophysical data and lithologic descriptions from drill logs. Figure 23 illustrates the approximate area where groundwater leakage likely occurs.

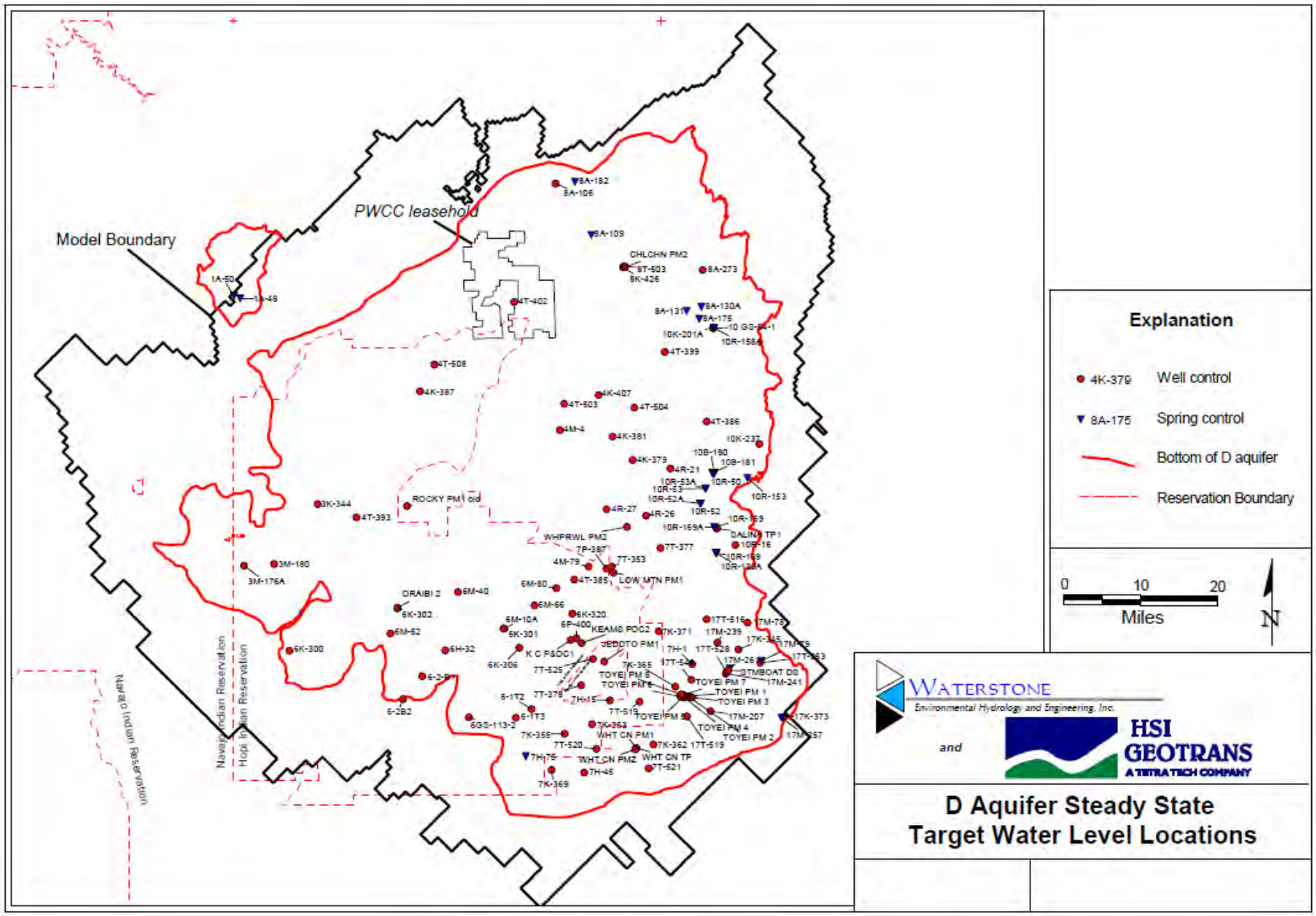


Figure 20: D aquifer Steady State Target Water Level Locations, Black Mesa, Arizona (PWCC, 1999).

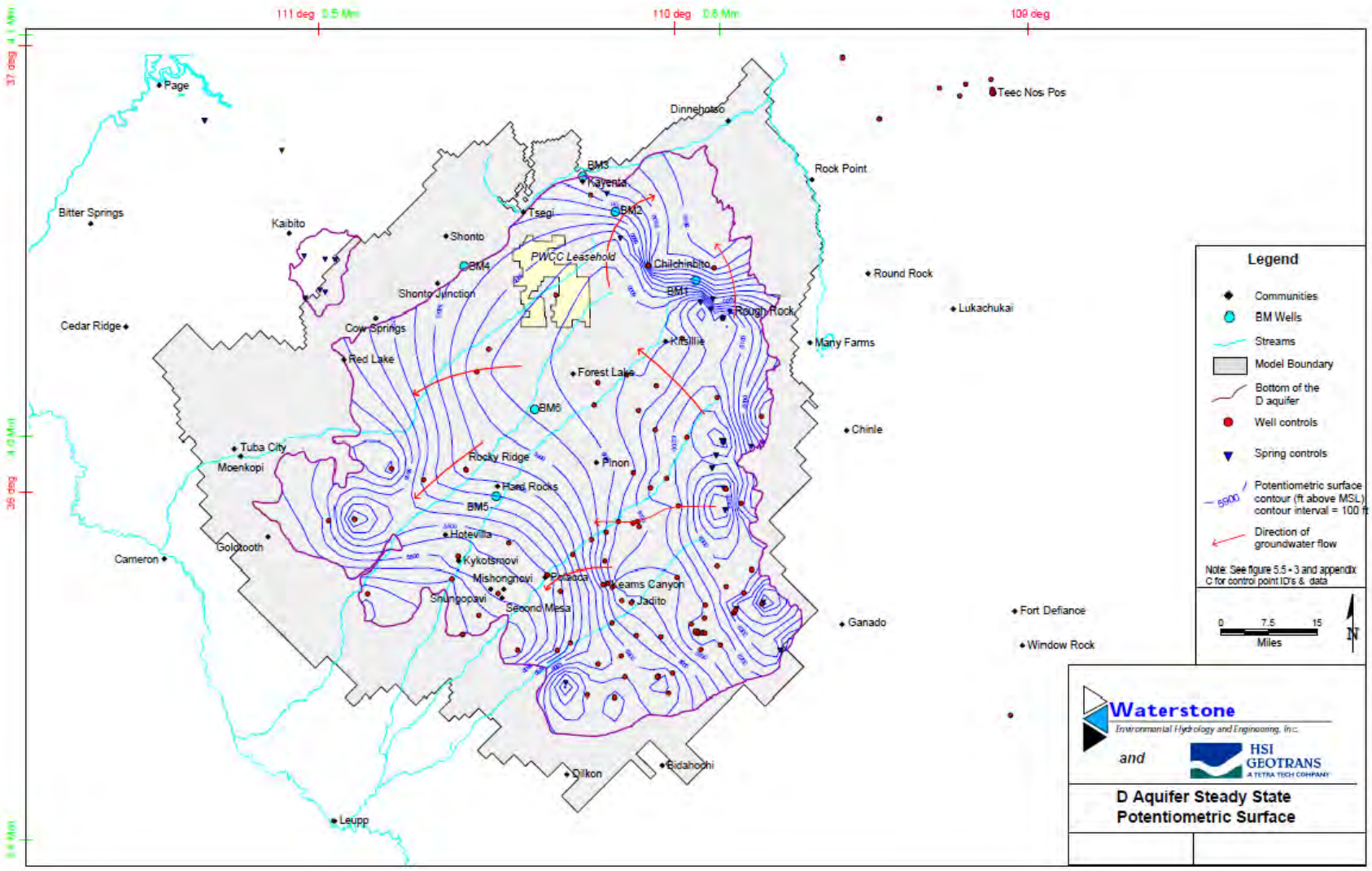


Figure 21: D aquifer Steady State Potentiometric Surface, Black Mesa, Arizona (PWCC, 1999).

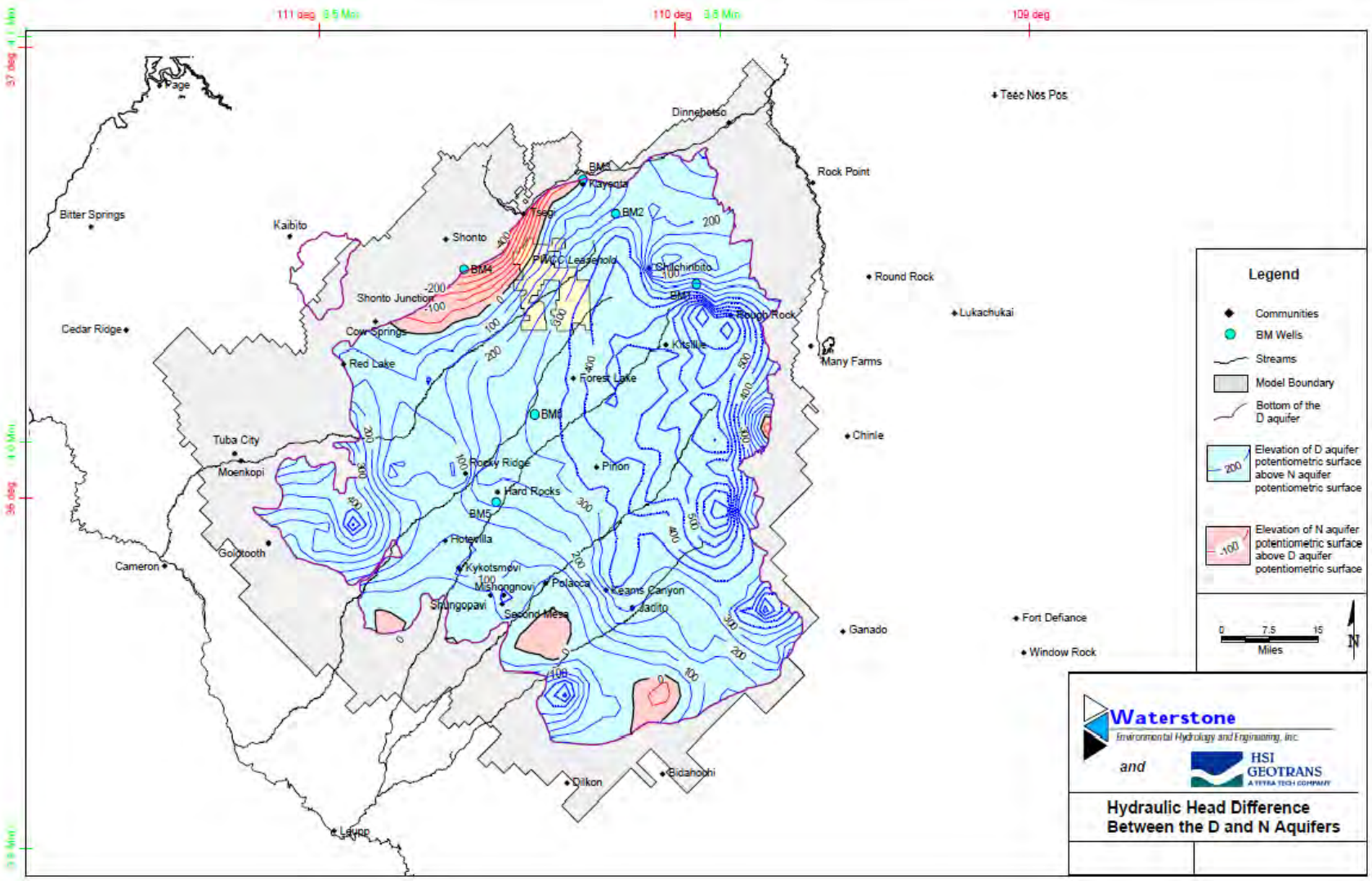


Figure 22: Hydraulic Head Difference Between the D and N Aquifers, Black Mesa, Arizona (PWCC, 1999).

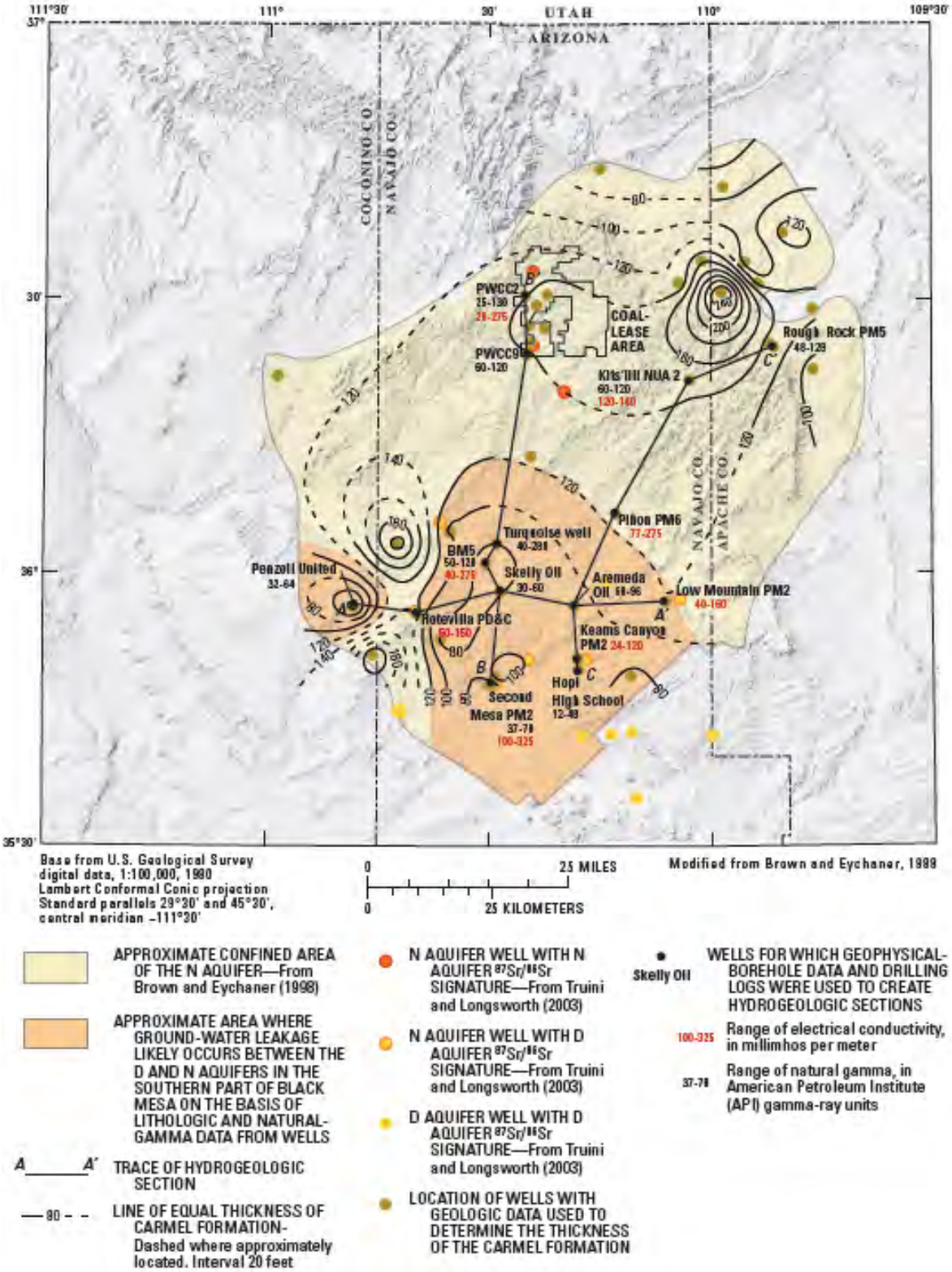


Figure 23: Approximate area where groundwater leakage likely occurs between the D and N aquifers in the southern part of Black Mesa (Truini and Macy, 2006).

4.2.5 N Aquifer

The N aquifer is known for its well sorted massive sandstone matrix, high water production potential, and drinking quality water. The N aquifer is comprised of (in ascending stratigraphic order) the Wingate Sandstone, Moenave Formation, Kayenta Formation, and the Navajo Sandstone. The combination of these hydrologically connected formations range in thickness from less than 100 feet around the perimeter of Black Mesa to approximately 1700 feet in the center of the Black Mesa Basin (Figure 24). In the center of the groundwater CIA, the stratigraphy of the N aquifer dips steeply into a synclinal basin, facilitating confined aquifer conditions. The N aquifer is separated from the C aquifer below by the low permeability Chinle Formation and is effectively confined from the D aquifer above by the Carmel Formation over much of the Black Mesa area (Figure 23). The Carmel Formation is discontinuous in some areas, and leakage between the D and N aquifers likely occurs in these discontinuous areas via vertically oriented fractures (PWCC, 1999).

4.2.5.1 N Aquifer Baseline Quantity

N aquifer is recharged by rainfall infiltrating on exposed formations of the N aquifer system around the perimeter of Black Mesa (Figure 25), and leakage from the overlying D aquifer. Before extensive pumping of the N aquifer, the hydrologic system was approximately in equilibrium, or steady state. A system is in equilibrium when the inflow equals the outflow, and aquifer storage remains constant. Prior to significant pumping in 1970, aquifer storage was essentially constant; therefore, the volume of water infiltrating into the N aquifer system as recharge equaled the volume discharged as springs and baseflow into washes.

After review of well log information, water level measurements, water chemistry, geologic structure information, and spring elevations, water level data from 263 wells and springs were used as N aquifer steady state calibration targets for the 3D Model pre-pumping simulation (Figure 26). The resultant steady state potentiometric surface map for the N aquifer is illustrated as Figure 27. N aquifer recharge occurs in areas to the north and northwest near Tsegi and Shonto on exposed outcrop areas east of Black Mesa. N aquifer flow during steady state conditions was predominantly towards the southwest and northeast from a ground water divide through the center of the basin; discharging to Laguna Creek to the northwest and along downcut washes intercepting the N aquifer formations to the southwest.

4.2.5.2 N Aquifer Baseline Quality

Since 1971, the USGS has been jointly funded by PWCC, BIA, and the Hopi Tribe and Navajo Nation to perform monitoring of wells, springs, and stream flows outside the permit area. The primary N aquifer water types are calcium bicarbonate and sodium bicarbonate. Calcium bicarbonate water is generally found in the recharge areas of the N aquifer, and sodium bicarbonate water in the confined area of the N aquifer. Figure 28 illustrates the N aquifer water type distribution collected annually by the USGS as part of the ongoing regional monitoring program (Macy and Brown, 2011). The N aquifer water quality for USGS monitored wells typically meet water quality standards for domestic water supply, except for locations on the eastern edge of the mesa where TDS and sodium concentrations are elevated.

The USGS evaluated the geochemistry of Black Mesa using geochemical and isotopic analysis (Truini and Longsworth, 2003). The USGS evaluation identifies that downward leakage is most likely to occur in the southern part of Black Mesa based on the geologic and hydrologic environment in that area (Truini and Longsworth, 2003). In the northern part of Black Mesa, isotopic analysis revealed significant statistical differences between the D aquifer and N aquifer water (Truini and Longsworth, 2003). The statistical difference in the northern area suggests that the leakage potential under natural pre-pumping conditions was not as great compared to the southern area.

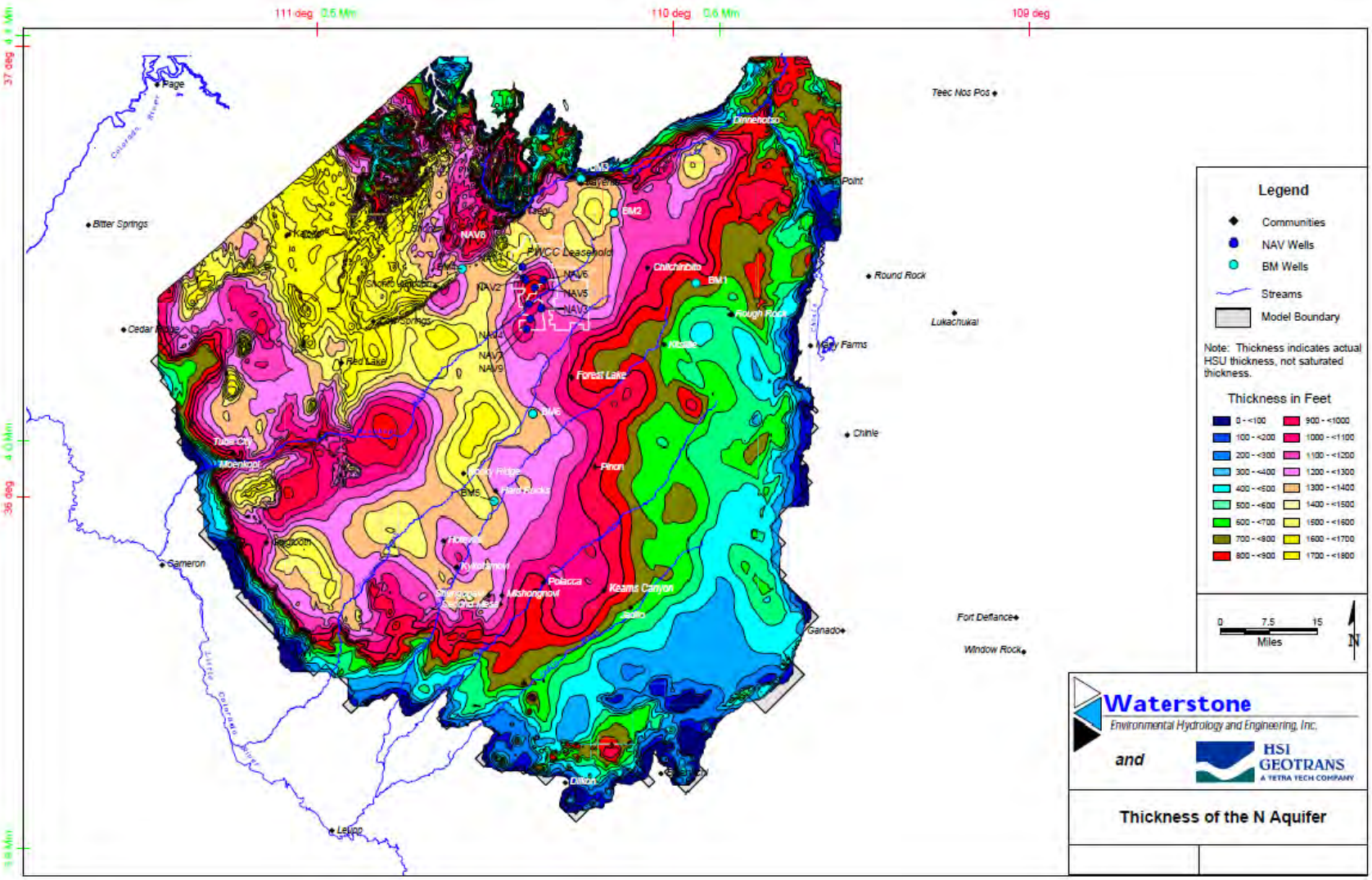


Figure 24: Thickness of the N aquifer, Black Mesa, Arizona (PWCC, 1999).

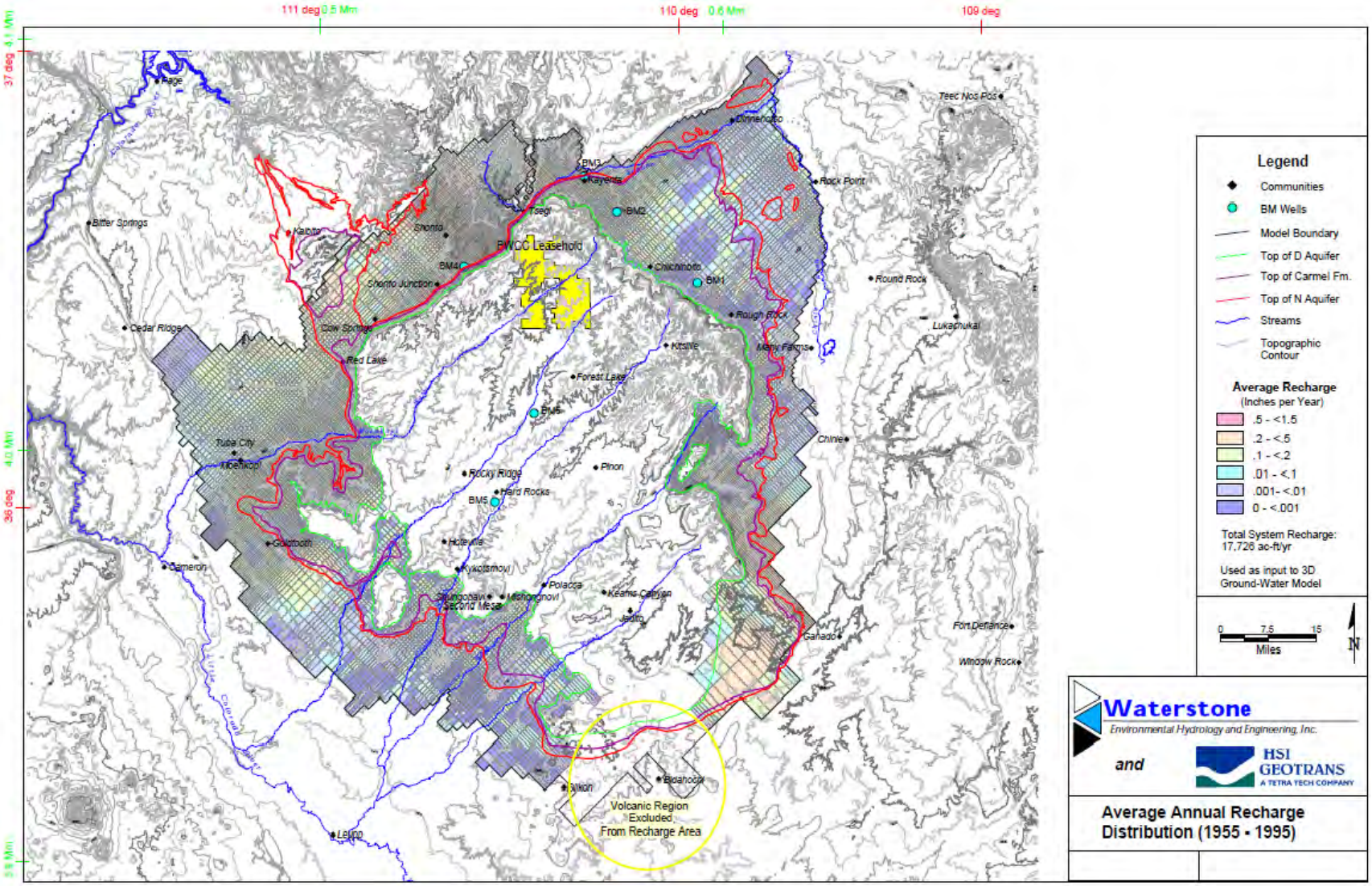


Figure 25: Average Annual Groundwater Recharge, Black Mesa, Arizona (PWCC, 1999).

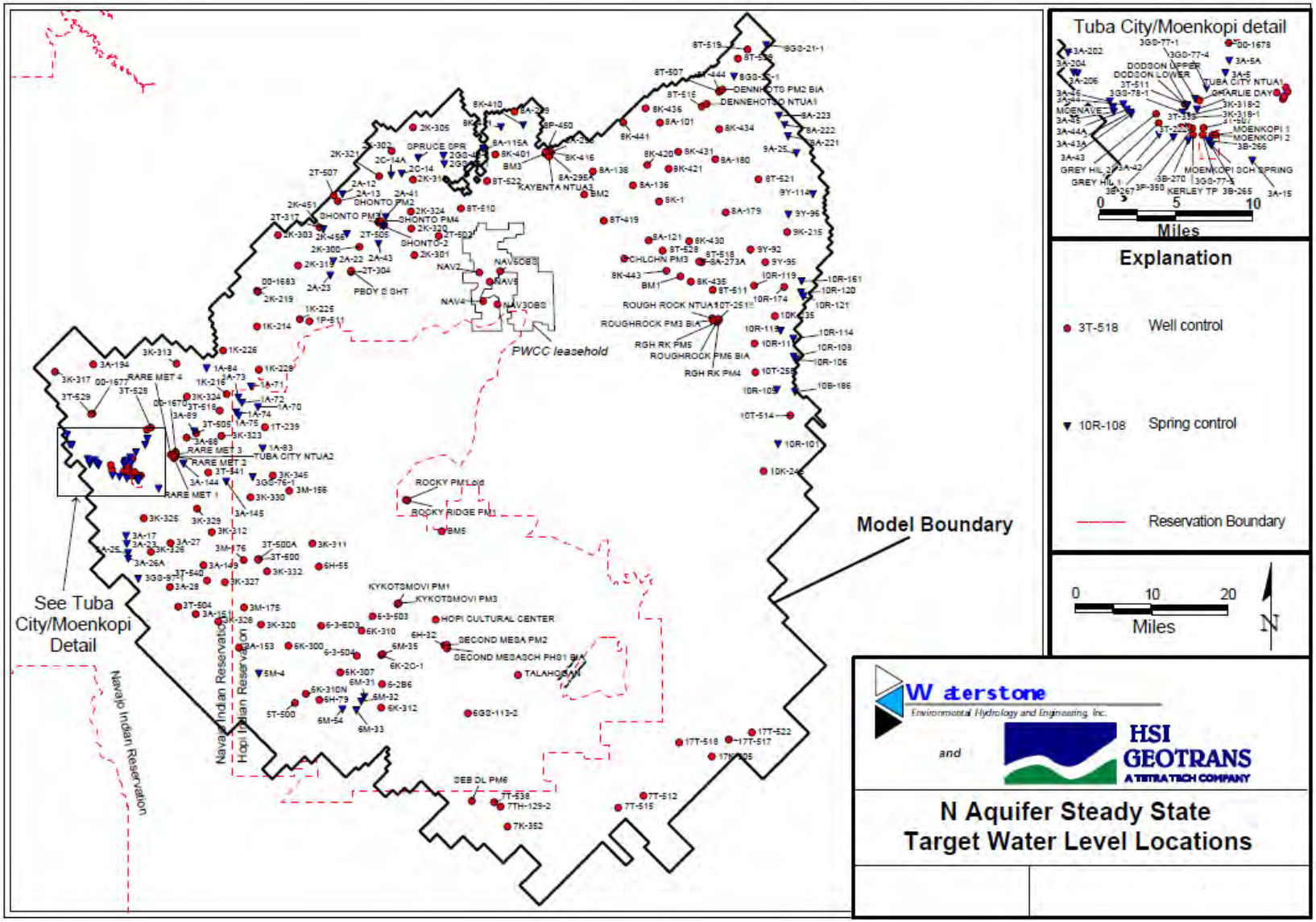


Figure 26: N aquifer Steady State Target Water Level Locations, Black Mesa, Arizona (PWCC, 1999).

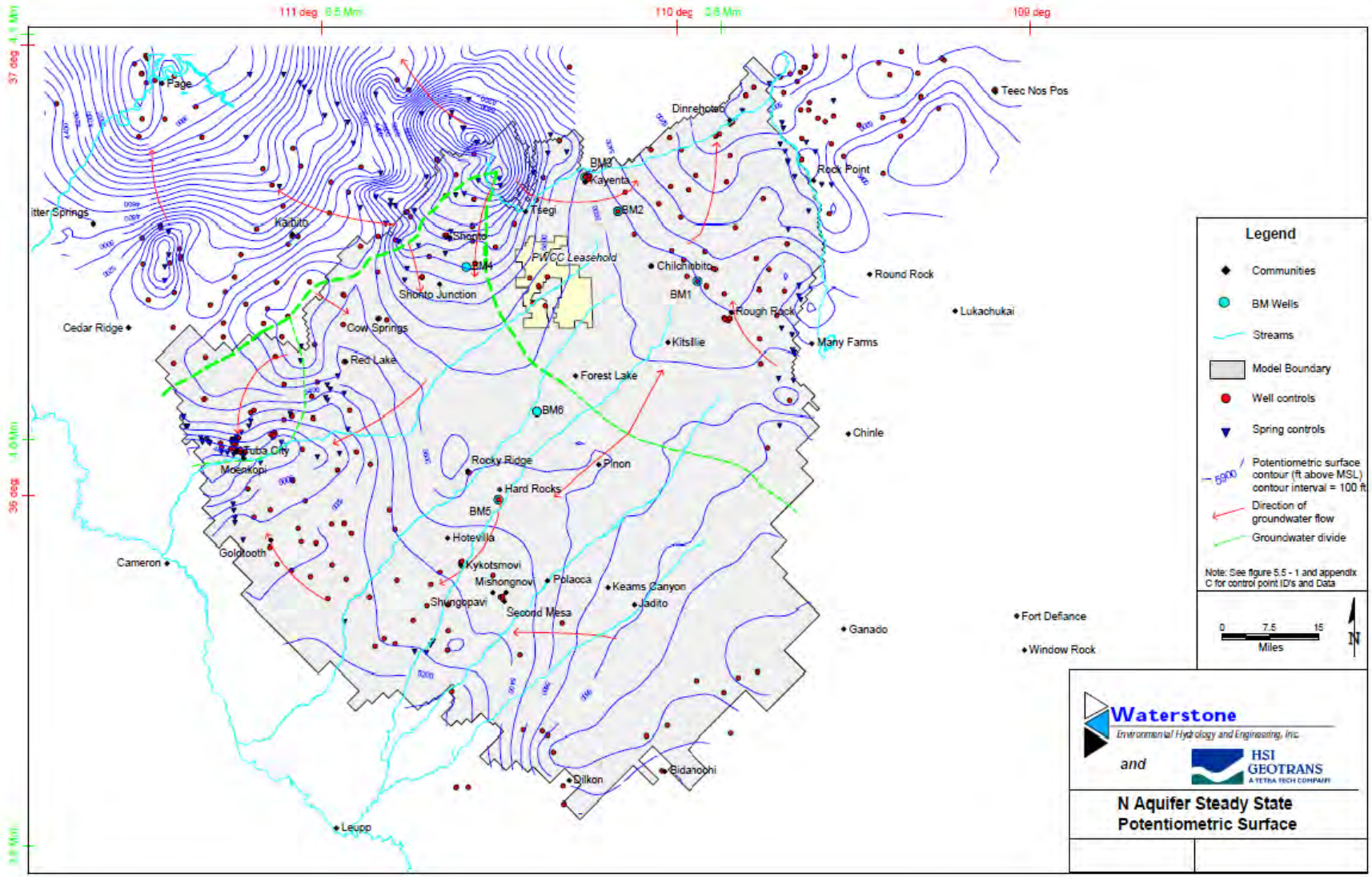


Figure 27: N aquifer Steady State Potentiometric Surface, Black Mesa, Arizona (PWCC, 1999).

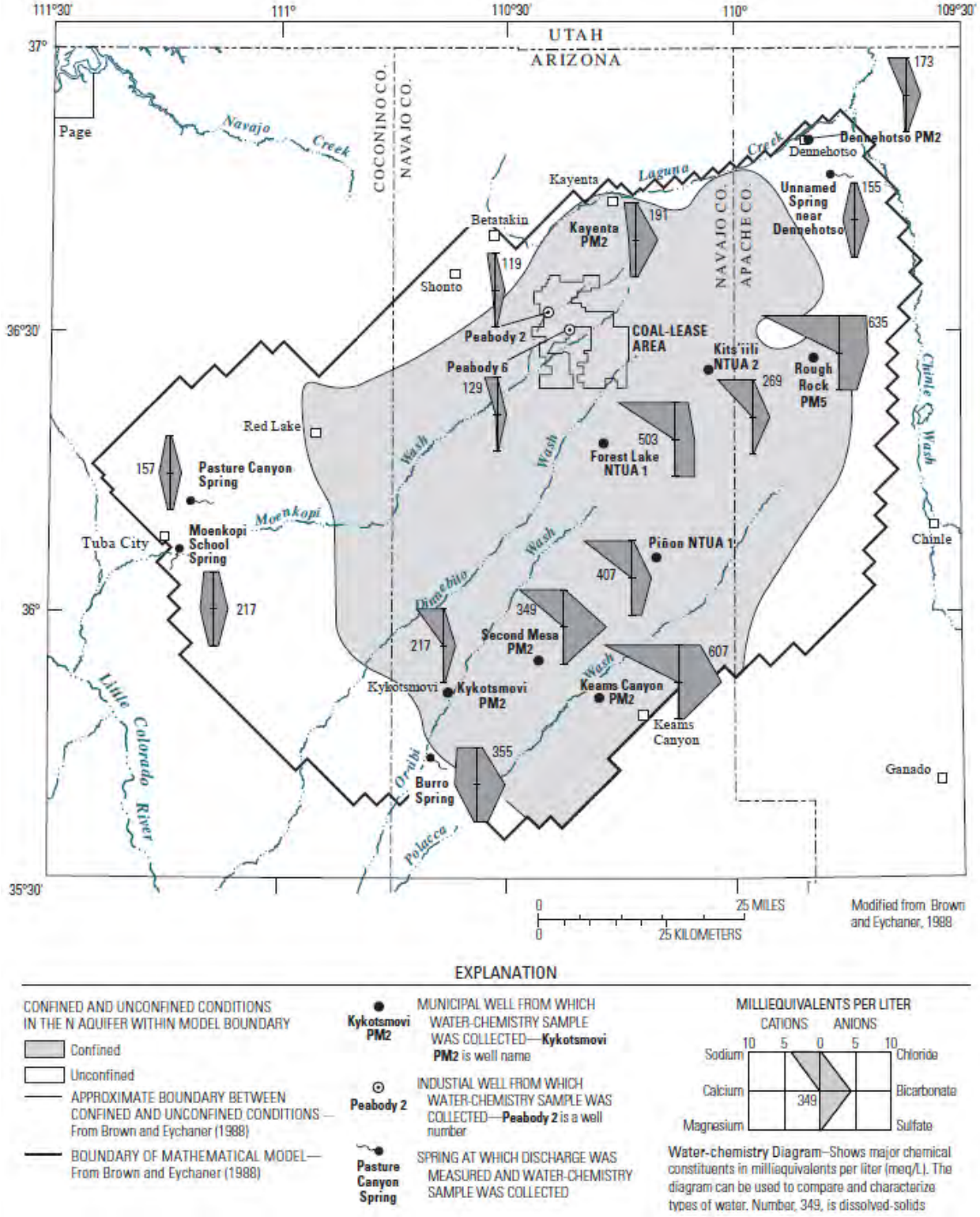


Figure 28: N aquifer Water Quality Type (Macy and Brown, 2011).

In 2006, the USGS applied the results of the geochemical and isotope analysis to a study that evaluated the Carmel Formation, which confines the N aquifer and separates the overlying poorer quality D aquifer water from the better quality N aquifer. The results indicate that thickness and lithology of the Carmel Formation are factors influencing groundwater leakage between the D aquifer and N aquifer. Areas where the Carmel Formation is 120 feet thick or less coincide with areas where $^{87}Sr/^{86}Sr$ isotope analysis indicate that overlying D aquifer water has historically mixed with underlying N aquifer water under natural conditions (Truini and Macy, 2006). In the vicinity of the PWCC wellfield, the Carmel Formation has a thickness greater than 120 feet.

5 HYDROLOGIC IMPACT ASSESSMENTS

Required by 30 CFR 780.21(g), as the regulatory authority, OSMRE shall provide an assessment of the probable cumulative hydrologic impacts of the mining operation upon surface water and groundwater systems in the cumulative impact area. After assessing the PHC presented in the PAP for the operation, and considering cumulative hydrologic impacts from all mining operations, OSMRE shall make a determination of whether or not the mining operation has been designed to minimize disturbances to the hydrologic balance within the permit and adjacent areas, and to prevent material damage to the hydrologic balance outside the permit area.

The assessment presented in Chapter 5 of this document considers available quantity and quality information related to surface water and groundwater potentially affected by the Kayenta Complex operation. The assessment will determine if the potential exists for the operation to create material damage to the hydrologic balance outside the permit area. If the potential exists for material damage to the hydrologic balance outside the permit area, then OSMRE will identify material damage criterion, and precursor material damage thresholds to ensure material damage to the hydrologic balance outside the permit area does not occur.

5.1 Surface Water

OSMRE will evaluate surface water quantity and quality related to the overall hydrologic balance and potential impact of the Kayenta Complex on stream uses and considering in-stream water quality standards (WQS). OSMRE must also evaluate that the operation has been appropriately designed to provide the surface water quantity and quality information necessary to assess potential impacts per 30 CFR 780.21(g). Potential offsite surface water quality impacts are related to WQS for irrigation, livestock, aquatic and wildlife habitat, fish consumption, and secondary human contact.

5.1.1 Surface Water Monitoring Program

Above-mining and below-mining locations were selected on the primary washes transecting the Kayenta Complex (Yellow Water Canyon Wash, Coal Mine Wash, Moenkopi Wash, Dinnebito Wash) in order to identify above-mining and below-mining relationships. Additionally, major tributaries to Moenkopi Wash within the Moenkopi Wash CIA (Reed Valley Wash, Red Peak Valley Wash, and Yucca Flat Wash) were monitored to evaluate potential contributing impacts to Moenkopi Wash. The primary washes, Moenkopi tributaries within the permit area, and corresponding monitoring locations are displayed on Figure 11.

A variety of monitoring techniques and instrumentation were utilized to characterize the surface water hydrologic regime. Surface water quantity monitoring techniques included the use of current meters, slope-area methodology, pulse generators coupled with stilling wells and data loggers, crest-stage gages, portable cutthroat flumes, and visual estimates when flow conditions precluded the use of other measuring devices (PWCC, v.11, ch.16, 2011).

PWCC may request modification to the surface water monitoring program after baseline is defined, surface water and groundwater interaction is characterized, and the magnitude of seasonal or natural variability is documented. When the magnitude and extent of potential impacts exceed hydrologic consequence projections identified in the PHC, the data collection frequency or geographic monitoring locations may need to be expanded. Conversely, when the monitoring program has sufficiently established background conditions and natural or seasonal variability, the frequency and data collection localities may be relaxed. As such, OSMRE approved the reduction of all above-mining and tributary

surface water monitoring locations in July of 2001 and July of 2002 since the provided data adequately fulfilled the monitoring objectives. Therefore, above-mining and tributary surface water monitoring locations 14, 16, 18, 35, 37, 50, 78, 85, and 157 were removed from the active monitoring program. PWCC continues to collect surface water quantity information at locations 15, 25, 26, 155, and 34.

Based on the surface water quantity monitoring information collected before the approved monitoring reduction, coupled with the continued monitoring at locations 15, 25, 26, 34, and 155, OSMRE finds that the surface water quantity program is currently sufficient for OSMRE to make the required evaluation for material damage potential in this CHIA. Continued surface water quantity monitoring at locations 15, 25, 26, 34, and 155 is necessary to reinforce hydrologic impact conclusions presented in the PHC of the permit application, and assess potential material damage impact.

5.1.2 Surface Water Quantity

Information from 14 monitoring locations determined multiple peak hydrographs are a characteristic of the area hydrology. PWCC calculated an average annual runoff of 0.15-inches in the Moenkopi CIA (PWCC, v.11, ch.18, 2011). Applying the runoff factor to the area of the Moenkopi CIA yields an estimated average annual baseline runoff of 1,972 ac-ft, and 402 ac-ft for the Dinnebito CIA. Baseline runoff was determined using measured flow data from undisturbed area, and applying the runoff factor to the entire assessment area. Average annual measured surface flow in the Moenkopi CIA from 1987-2008 was 1488 ac-ft. During the 2005 – 2009 monitoring period, discharges reported for NPDES permit #NN0022179 averaged 21.28 ac-ft from surface water impoundments.

5.1.2.1 Impact Potential to Existing and Foreseeable Uses

SMCRA requires that all surface mining and reclamation activities be conducted to minimize disturbance of the hydrologic balance within the permit and adjacent areas, and prevent material damage to the hydrologic balance outside the permit area. In order to protect the surface water hydrologic balance, and following 30 CFR 816.41(d)(1), PWCC shall prevent additional contribution of suspended solids to stream flow outside the permit area to the extent possible using the best technology currently available. Therefore, PWCC constructs surface water impoundment structures adjacent to areas disturbed by mining to capture suspended solids transported during runoff events. Nine Mine Safety and Health Administration (MSHA) sized structures have been constructed on tributaries confluent to Moenkopi Wash, and the PHC predicts that portions of the stream channel above and below the structures will be affected (PWCC, v.11, ch.18, 2011). “The reach immediately above a dam will gradually aggrade headward as more and more water is impounded until a pool level is reached that is in equilibrium with water gains and losses. Channel reaches below the dams will become incised by smaller active meandering channels whose widths are a function of drastically reduced runoff potential, channel gradients and sediment load particle size ranges” (PWCC, v.11, ch.18, 2011). “It is estimated that more than 320 sediment ponds and several permanent internal impoundments have been or will be constructed during the life of the mining operation” (PWCC, v.11, ch.18, 2011). The construction of sediment control structures, and the coordinated removal of temporary structures, assists in minimizing mining impacts. However, the construction of surface water impoundments potentially reduces surface water quantity outside the Moenkopi CIA and Dinnebito CIA during runoff events compared to baseline conditions when only a few local impoundments existed.

Figures 29 and 30 illustrate the total annual acreage potentially generating runoff to impoundments in the Moenkopi and Dinnebito CIAs. The annual acreage generating runoff to impoundments may vary from year to year based on mining and reclamation schedules. The contributing acreage to impoundments reaches a maximum of 47,321 acres for the Moenkopi CIA in 2021, and 3,651 acres for the Dinnebito CIA in 2011. The graphs are scaled to the size of the Dinnebito CIA (33,087 acres) and Moenkopi CIA

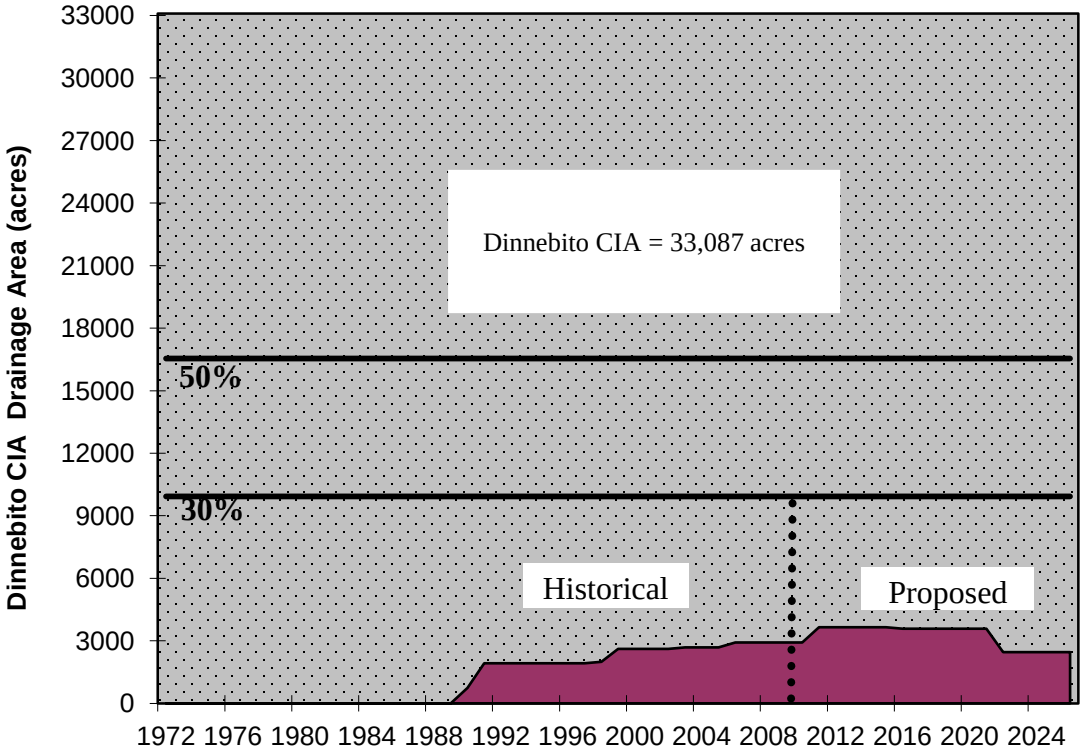


Figure 29: Dinnebito CIA Acres Managed with Impoundments, Kayenta Complex.

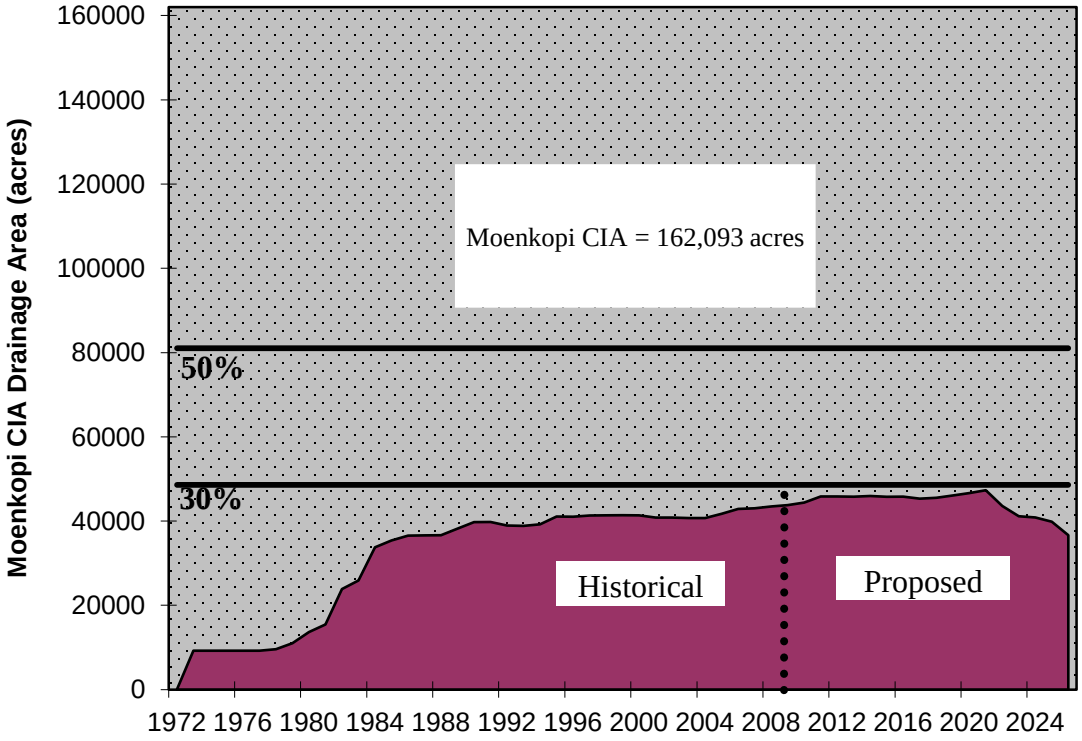


Figure 30: Moenkopi CIA Acres Managed with Impoundments, Kayenta Complex.

(162,093 acres). OSMRE must assess if the surface water quantities potentially generated from these maximum contributing acreages, and retained by impoundments, will impact the downstream irrigation, livestock, or aquatic and wildlife habitat water uses. The PHC concludes "comparisons of average annual runoff estimates indicate the impounded areas through December 2013 have the potential to, on average, reduce average annual runoff in the Dinnebito basin by no more than 1.4 percent, and in the Moenkopi basin by no more than 5.8 percent" (PWCC, v.11, ch.18, 2011).

Surface water for irrigation use was attempted in the Dinnebito (HUC 15020017) near the community of Rocky Ridge; however, conditions limited the retention and use of surface water along Dinnebito Wash for agricultural water use. Variability in annual surface flow rates ranging three orders of magnitude, coupled with high sediment transport rates during flash flood events, likely limit the effectiveness of impoundments for agricultural use on Dinnebito Wash. However, the community of Moenkopi, approximately 70 miles downstream from the Kayenta Complex along Moenkopi Wash, may use water in the alluvial channel for agricultural irrigation. Farmers in the Moenkopi Village area may dig pits in Moenkopi Wash to reach the saturated alluvium, pumping the saturated alluvium for irrigation water when necessary and available (OSMRE, 2011b). Watering of livestock may occur along Moenkopi Wash and Dinnebito Wash at channel pools. However, the location, duration, extent, and quality of the resultant surface water pools the left behind downstream of the Kayenta Complex are unknown.

Moenkopi and Dinnebito washes commonly experience flash flood events. The flash flood events scour the channel bottom, alter and extend the channel banks, and are capable of uprooting tamarisk populations with deep tap roots (OSMRE, 2009). The hydrologic environment of the ephemeral, sand-bed channels along Moenkopi and Dinnebito washes provides limited conditions for the sustainability of aquatic habitat. However, aquatic habitat has the potential for sustainability in a less aggressive environment such as near seeps, springs, and surface water bodies. Therefore, it is likely that the retention of surface water runoff in impoundments within the Kayenta Complex will enhance the potential for successful establishment of aquatic and wildlife species within the permit area, and not create material damage outside the permit area.

The alluvium near the community of Moenkopi supports agricultural irrigation use and is recharged by three mechanisms: direct precipitation, infiltration of surface water runoff to the alluvium, and groundwater discharge to the alluvium. Infiltration from direct precipitation provides the smallest recharge of the three mechanisms since the annual average precipitation is 5.96-inches at Tuba City, adjacent to the community of Moenkopi (PWCC, 1999). Alluvial recharge from surface water runoff infiltration has greater effect based on a flow model simulated release of 644 ac-ft to Moenkopi Wash from the permit area (PWCC, v.11, ch.18, 2011). The results indicate the entire 644 ac-ft volume infiltrated to the alluvium between the permit area and 45 miles downstream (approximately 25 miles upstream of the Village of Moenkopi), or an infiltration rate of 14.5 ac-ft per mile (PWCC, v.11, ch.18, 2011). Essentially,

> Short-term, rapid advance of the streamflow front over the initially dry alluvium occurs until the wetted channel is large enough to allow total infiltration to equal the release rate. Flow over the dry bed is influenced by [the ability of the material to adsorb] which initially pulls water into the dry soil at a higher infiltration rate than occurs under higher saturation conditions. As the materials become more saturated, the infiltration rate decreases, allowing the front to move further downstream. (GeoTrans, 1992).

A third recharge mechanism occurs on Moenkopi Wash approximately 40 miles downstream of the Kayenta Complex, and approximately 30 miles upstream from the community of Moenkopi. In this segment, Moenkopi Wash alluvium is recharged by discharge from the N aquifer system in an area referred to as Blue Canyon in this document (Figure 31). Downcutting and erosion of Moenkopi Wash created a slot canyon exposing the Navajo Sandstone and creating features known locally as "the water

caves" (OSMRE, 2011b). The N aquifer hydraulic gradient near Blue Canyon induces groundwater discharge to Moenkopi Wash alluvium, providing a consistent source of recharge to the Moenkopi Wash alluvium. Regional numerical groundwater flow simulation quantifies the annual baseflow discharge to Moenkopi wash at 4,305 ac-ft prior to mining in 1955 (PWCC, 1999).

Figure 31: Blue Canyon on Moenkopi Wash (photo by Paul Clark, 11-8-2002).

The primary recharge mechanisms to the Moenkopi Wash alluvium are from both infiltration of surface water after storm flow events, and from N aquifer discharge at Blue Canyon. PWCC operations influence these two recharge mechanisms to Moenkopi Wash alluvium. One recharge mechanism is associated with surface water runoff, and the second mechanism is associated with groundwater discharge from the N aquifer. N aquifer groundwater discharge impacts to Moenkopi Wash alluvium are further discussed in Section 5.2.4.1. The Moenkopi CIA for surface water runoff is 162,093 acres of the 1,689,600 acre Moenkopi watershed (HUC 15020017). Therefore, PWCC may manage a maximum of 9.6-percent of the Moenkopi watershed (HUC 15020017). OSMRE recognizes that decreases in surface flows are of concern to Moenkopi area farmers relying on sub-flow in Moenkopi Wash alluvium for agricultural irrigation supply water. Therefore, OSMRE will establish a surface water quantity material damage threshold and limit for the amount of surface area managed by surface water impoundments within the Kayenta Complex to minimize potential surface water quantity impact on agricultural irrigation water supply.

5.1.2.2 Surface Water Quantity Material Damage Threshold and Limit

The surface water quantity monitoring program and PAP have provided sufficient information for OSMRE to assess surface water quantity impacts. After assessing the potential surface water quantity impact of the mining operation on existing and foreseeable agricultural irrigation, livestock, and aquatic and wildlife habitat water uses, OSMRE has determined that the operation has been designed to minimize surface water quantity impacts within the permit area and prevent material damage outside the permit and adjacent area by limiting the surface area managed by surface water impoundments. The Kayenta Mine Environmental Assessment (EA) (OSMRE, 2011c), identifies a level of moderate impact if the watershed area controlled by impoundments is between 30 to 50 percent of the total drainage area, and major impacts greater than 50-percent. Therefore, OSMRE defines the surface water quantity material damage threshold at 30-percent of Moenkopi or Dinnebito CIA managed by impoundments. If conditions are above the threshold, then mine plan operations will be regulated to ensure impacts are minimized and a level of material damage not reached. Material damage is defined as greater than 50-percent of the Moenkopi CIA or Dinnebito CIA managed by surface water impoundments.

5.1.3 Surface Water Quality

Several recharge mechanisms influence surface water quality within the permit and adjacent area. Precipitation generates rainfall runoff in the ephemeral washes, entraining sands, silts, and clays, inducing elevated concentrations of total suspended solids (TSS). The elevated TSS concentrations influence the cation exchange capacity, and ultimately the chemical composition of the surface water. Recharge also occurs from baseflow in areas where the Wepo Formation is in hydrologic communication with the alluvium. Wet reaches are typically evident where the Wepo Formation water discharges to the alluvium, and most apparent when precipitation events have not recently occurred. The effect of precipitation on spoil surface area also influences the surface water quality. During mining and through bond release, surface water impoundments capture surface water runoff that was in contact with the spoil material. The impounded surface water may discharge over the spillway during precipitation events exceeding the 10-year 24-hour event design capacity, or infiltrate through the bottom of the impoundments, entering the Wepo Formation and alluvial and surface water systems.

5.1.3.1 Surface Water Quality Monitoring Program

Above-mining and below-mining locations were selected on the primary washes transecting the Kayenta Complex: Yellow Water Canyon Wash, Coal Mine Wash, Moenkopi Wash, Dinnebito Wash (Figure 11). The four primary washes are monitored in order to evaluate compliance with the NNSWQS (NNEPA, 2007) and the HTWQS (Hopi Tribe, 2008). The document entitled: “Guidance for Assessing the Quality of Navajo Nation Surface Waters to Determine Impairment (Integrated 305(b) Reporting and 303(d) listing)” (NNEPA 2008) identifies the minimum number of sample values required to determine support of designated uses. Most WQS require a minimum 5 values in 3 years for use assessment. Dissolved oxygen, pH, suspended sediments, temperature, and turbidity require a minimum 10 values in 10 years for use assessment. Based on previously collected surface water information, coupled with continued monitoring at locations 15, 25, 26, 34, and 155, OSMRE finds the surface water quantity program sufficient for OSMRE to make the required evaluation for material damage potential in this CHIA. Continued surface water quantity monitoring at locations 15, 25, 26, 34, and 155 is necessary to reinforce hydrologic impact conclusions.

5.1.3.2 Impact Potential to Existing and Foreseeable Uses

The surface water quality regime was characterized and monitored by PWCC using 14 monitoring locations in the permit and adjacent area (Figure 11). The monitoring program was established to

evaluate surface water quality impacts from overland flow on mine disturbed area to the washes, resulting in the addition of dissolved solids to the surface water system and potential for material damage to the hydrologic balance.

The NNEPA Water Quality Program (WQP) and Hopi Tribe Water Resources Program (WRP) have identified designated uses for Moenkopi and Dinnebito Washes, and identified WQS of chemical parameters which are considered to have the potential to adversely impact the designated water resource use. Moenkopi Wash has the following designated uses: Secondary Human Contact, Agricultural Livestock Watering, Agricultural Irrigation Water Supply, Aquatic and Wildlife Habitat (acute and chronic), and Fish Consumption. Dinnebito Wash has the same water use designations as Moenkopi Wash with the exception of Agricultural Water Supply. The NNEPA WQP developed WQS in 2004, and revised them in 2007, which are the current standards under the CWA (NNEPA, 2007). The Hopi Tribe WRP developed similar WQS in 2008, revised them in 2010, and was approved by the USEPA for implementation in 2011 (Hopi Tribe, 2008). Table 5 provides the HTWQS (Hopi Tribe, 2008) applicable to the Dinnebito and Moenkopi CIAs. Table 6 provides the NNSWQS (NNEPA, 2007) applicable to the Dinnebito and Moenkopi CIAs.

Surface Water Quality Assessment Protocol

The Hopi Tribe WRP and NNEPA WQP are integral components in the protection of the hydrologic balance and surface water quality. As such, OSMRE will work in partnership with the tribes if concentrations of chemical parameters have potential to change the present or potential use outside the permit area.

(1) WQS defined and implemented by the NNEPA WQP and Hopi Tribe WRP are protected by the material damage definition.
(2) Discharges to the surface water are reported to USEPA under point source permit No. NN0022179, and permit No. AZR0F121 issued under the 2008 Multi-Sector General Permit for Stormwater.
(3) Stream channels are monitored for evaluation with water quality criteria (e.g. numeric in-stream) promulgated by the NNEPA WQP and Hopi Tribe WRP.
(4) If monitoring shows that WQS have been exceeded for 4 out of 4 consecutive sampling events, OSMRE will notify the appropriate CWA authority, and request assistance in determining if a persistent water quality violation exists. A frequency of four was selected to account for seasonal variability and consistency with quarterly monitoring required at 30 CFR 816.41.
(5) If the appropriate CWA authority determines a water quality violation exists, OSMRE will evaluate the chemical parameter of concern to determine whether the mining operation caused the violation.
(6) If the mining operation is the cause of the violation, OSMRE will use the appropriate permitting and enforcement procedures to correct the water quality violation.

Table 7 provides summary statistics of downstream monitoring locations for chemical parameters with a WQS applicable to the Dinnebito Wash and Moenkopi Wash CIAs. The summary information considers non-detected concentrations to equal the method detection limit (MDL). For example, if a MDL is 100 mg/L, then the value is included in summary statistics as a detected concentration of 100 mg/L. Although the approach may skew the summary statistics, this approach was applied to both upstream and downstream assessment locations, and provides a method for cursory assessment. The highest reported concentrations at downstream monitoring locations were compared to the most protective WQS. Nine chemical parameters were above the most protective WQS: cadmium, chloride, lead, manganese, mercury, molybdenum, selenium, sulfate, and TDS. The remaining parameters evaluated will not be carried forward for assessment.

Chemical Parameter	Units	Groundwater (DWS, PCC, GWR)	Partial Body Contact (PBC)	Agricultural Livestock (AgL)	Agricultural Irrigation (AgI)	Aquatic and Wildlife (ephemeral) A&W_e - Acute	Aquatic and Wildlife (ephemeral) A&W_e - Chronic
Aluminum	mg/L	NNS	NNS	5.0 (D)	5.0 (D)	NNS	NNS
Antimony	µg/L	5.6	370	NNS	NNS	NNS	NNS
Arsenic	µg/L	10	280	200	2000	440 (D)	230 (D)
Barium	µg/L	2000	186,670	NNS	NNS	NNS	NNS
Beryllium	µg/L	4	1870	NNS	NNS	NNS	NNS
Boron	µg/L	1400	186,670	NNS	1000	NNS	NNS
Cadmium	µg/L	5	470	50	50	calculation	calculation
Chloride	mg/L	250	NNS	NNS	NNS	230	230
Chromium	µg/L	100	NNS	1000	1000	NNS	NNS
Chromium III	µg/L	NNS	1,400,000	NNS	NNS	calculation	calculation
Chromium VI	µg/L	20	2800	NNS	NNS	34 (D)	23 (D)
Cobalt	mg/L	NNS	NNS	1.0 (D)	0.05 (D)	NNS	NNS
Copper	µg/L	1300	9330	500	5000	calculation	calculation
Cyanide	µg/L	140	18,670	200	NNS	84	19
Fluoride	µg/L	4000	56,000	NNS	NNS	NNS	NNS
Iron	µg/L	300	NNS	NNS	NNS	NNS	NNS
Lead	µg/L	15	15	100	10,000	calculation	calculation
Manganese	µg/L	50	130,670	NNS	10,000	NNS	NNS
Mercury	µg/L	2	280	10	NNS	2.4 (D)	0.01 (D)
Methylmercury	µg/L	NNS	NNS	NNS	NNS	NNS	NNS
Molybdenum	mg/L	NNS	NNS	NNS	0.01 (D)	NNS	NNS
Nickel	µg/L	610	18,670	NNS	NNS	calculation	calculation
Nitrate as N	µg/L	10,000	1,493,330	NNS	NNS	NNS	NNS
Nitrite as N	µg/L	1000	93,330	NNS	NNS	NNS	NNS
NO3+NO2	µg/L	10,000	NNS	NNS	NNS	NNS	NNS
pH	–	5.0-9.0	6.5-9.0	6.5-9.0	4.5-9.0	6.0-9.0	6.0-9.0
Selenium	µg/L	170	4670	50	20	33	2.0
Silver	µg/L	35	4670	NNS	NNS	calculation	calculation
Sulfate	mg/L	250	NNS	NNS	NNS	250	250
TDS	mg/L	500	NNS	NNS	NNS	500	500
Thallium	µg/L	0.24	75	NNS	NNS	NNS	NNS
Uranium	µg/L	30 (D)	2800	NNS	NNS	NNS	NNS
Vanadium	µg/L	NNS	NNS	100	100	NNS	NNS
Zinc	µg/L	7400	280,000	25,000	10,000	calculation	calculation

All concentrations are total unless otherwise noted
calculation - value dependent on sample hardness

NNS - no numeric standard
D - Dissolved

µg/L - micrograms per liter
mg/L - milligrams per liter

Table 5. Hopi Tribe Water Resources Program 2008 Water Quality Standards (Hopi Tribe, 2008).

Chemical Parameter	Units	Secondary Human Contact (ScHC)	Livestock Watering (LW)	Agricultural Water Supply (AgWS)	Aquatic and Wildlife (ephemeral) A&W$_e$ - Acute	Aquatic and Wildlife (ephemeral) A&W$_e$ - Chronic
Aluminum	µg/L	NNS	NNS	5000	750	87
Antimony	µg/L	370	NNS	NNS	88 (D)	30 (D)
Arsenic	µg/L	280	200	2000	340 (D)	150 (D)
Barium	µg/L	98,000	NNS	NNS	NNS	NNS
Beryllium	µg/L	1870	NNS	NNS	NNS	NNS
Boron	µg/L	126,000	5000 (D)	NNS	15000	10000
Cadmium	µg/L	470	NNS	50	calculation	calculation
Chloride	µg/L	4000	11	NNS	19	11
Chromium	µg/L	NNS	1000	1000	NNS	NNS
Chromium III	µg/L	1,400,000	NNS	NNS	calculation	calculation
Chromium VI	µg/L	2800	NNS	NNS	16 (D)	11 (D)
Cobalt	µg/L	NNS	1000 (D)	50 (D)	NNS	NNS
Copper	µg/L	9330	500 (D)	200 (D)	calculation	calculation
Cyanide	µg/L	18,670	5.2	NNS	22	5.2
Fluoride	mg/L	56,000	NNS	NNS	NNS	NNS
Iron	µg/L	NNS	NNS	NNS	NNS	NNS
Lead	µg/L	15	100	10,000	calculation	calculation
Manganese	µg/L	NNS	NNS	NNS	NNS	NNS
Mercury	µg/L	280	10	NNS	2.4	calculation
Methylmercury	µg/L	NNS	NNS	NNS	NNS	NNS
Molybdenum	µg/L	NNS	NNS	1000 (D)	NNS	NNS
Nickel	µg/L	18,670	NNS	NNS	calculation	calculation
Nitrate as N	µg/L	1,493,330	NNS	NNS	NNS	NNS
Nitrite as N	µg/L	93,330	NNS	NNS	NNS	NNS
NO3+NO2	µg/L	NNS	132	NNS	NNS	NNS
pH	–	6.5-9.0	6.5-9.0	4.5-9.0	6.0-9.0	6.0-9.0
Selenium	µg/L	4670	50	20	33	2.0
Silver	µg/L	4670	NNS	NNS	calculation	NNS
Sulfate	mg/L	NNS	NNS	NNS	NNS	NNS
TDS	mg/L	NNS	NNS	NNS	NNS	NNS
Thallium	µg/L	75	NNS	NNS	700 (D)	150 (D)
Uranium	µg/L	2800	NNS	NNS	NNS	NNS
Vanadium	µg/L	NNS	100 (D)	100 (D)	NNS	NNS
Zinc	µg/L	280,000	25,000	10,000	calculation	calculation

All concentrations are total unless otherwise noted
calculation - value dependent on sample hardness
NNS - no numeric standard

µg/L - micrograms per liter
mg/L - milligrams per liter
D - Dissolved

Table 6. NNEPA Water Quality Program 2007 Surface Water Quality Standards (NNEPA, 2007).

					Dinnebito Wash CIA				Moenkopi Wash CIA			
					Location 34 Storm Water Samples				Locations 25, 26, and 155 Storm Water Samples			
Chemical Parameter	Most Protective WQS	WQS	Units	Type	# Samples	Low	Median	High	# Samples	Low	Median	High
Aluminum	Aquatic (NN)	0.75 (T)	mg/L	Dissolved	n=20	0.03	0.05	0.45	n=54	0.03	0.05	0.72
Antimony	Aquatic (NN)	88	µg/L	Dissolved	n=10	1	1	10	n=24	1	1	12
Arsenic	Aquatic (HT)	230	µg/L	Dissolved	n=17	0.8	1	5	n=46	0.5	1	51
Barium	Secondary Contact (NN)	98000 (T)	µg/L	Dissolved	n=12	50	70	200	n=32	20	100	270
Bicarbonate	NNS	NNS	mg/L	Dissolved	n=49	43.9	91	614	n=112	57	116	399
Boron	Agricultural (NN)	1000 (T)	µg/L	Dissolved	n=34	20	70	140	n=111	10	70	360
Calcium	NNS	NNS	mg/L	Dissolved	n=49	16	158	520	n=112	16.8	89.2	505
Cadmium	Fish Consumption (NN)	8 (T)	µg/L	Dissolved	n=17	3	5	10	n=50	3	5	10
Chloride	Aquatic (HT)	230 (T)	mg/L	Total	n=34	1	12	55	n=112	2	12	261
Chromium	Agricultural (HT)(NN)	1000 (T)	µg/L	Dissolved	n=18	10	10	10	n=52	10	10	50
Copper	Agricultural (NN)	200	µg/L	Dissolved	n=20	10	10	10	n=55	10	10	50
Fluoride	Secondary Contact (NN)	56 (T)	mg/L	Total	n=34	0.1	0.7	1	n=112	0.1	0.6	1.1
Iron	NNS	NNS	mg/L	Total	n=31	7.22	551.5	2960	n=103	0.05	274	2610
Lead	Secondary Contact (NN)	15 (T)	µg/L	Dissolved	n=16	20	20	60	n=49	20	20	60
Magnesium	NNS	NNS	mg/L	Dissolved	n=49	4	56.5	500	n=112	3	28	511
Manganese	Agricultural (HT)	10 (T)	mg/L	Total	n=31	0.13	12.9	26.4	n=103	0.014	7.96	64
Mercury	Aquatic (HT)	0.01	µg/L	Dissolved	n=15	0.1	0.2	0.2	n=46	0.1	0.2	2.3
Molybdenum	Agricultural (HT)	0.01	µg/L	Dissolved	n=10	1	3	50	n=28	1	1	50
Nickel	Fish Consumption (NN)	4600 (T)	µg/L	Dissolved	n=10	10	20	30	n=29	10	10	20
Nitrate as N	Secondary Contact (NN)	1493 (T)	mg/L	Total	n=34	0.99	2.4	6.1	n=111	0.02	1.5	14.9
Nitrite as N	Secondary Contact (NN)	93.3 (T)	mg/L	Total	n=34	0.01	0.01	0.03	n=111	0.01	0.06	0.37
NO3+NO2	Livestock Watering (NN)	132	mg/L	Total	n=34	0.99	2.5	6.1	n=94	0.02	1.7	15.1
pH	All Uses	< 9.0	s.u.	Total	n=34	6.5	7.7	8.3	n=112	6.5	7.7	8.5
Selenium	Aquatic (HT)(NN)	2	µg/L	Dissolved	n=17	1	2.9	20	n=48	0.7	1	5
Silver	Secondary Contact (NN)	4670 (T)	µg/L	Dissolved	n=10	5	10	10	n=29	5	10	20
Sodium	NNS	NNS	mg/L	Dissolved	n=49	3.9	48	680	n=112	5.4	47	780
Sulfate	Aquatic (HT)	250 (T)	mg/L	Total	n=34	30	660	2118	n=112	20	310	4880
TDS	Aquatic (HT)	500	mg/L	Total	n=34	122	1090	3094	n=112	94	580	7750
Vanadium	Agricultural (HT)(NN)	100 (T)	µg/L	Dissolved	n=20	5	10	16	n=54	5	10	30
Zinc	Agricultural (HT)(NN)	10 (T)	mg/L	Dissolved	n=20	0.01	0.01	0.03	n=55	0.01	0.01	0.18

NNS - No Numeric Standard
WQS - Water Quality Standard
mg/L - milligrams per liter
µg/L - micrograms per liter
NN - Navajo Nation
HT - Hopi Tribe
CIA - Cumulative Impact Area
T- Total

Table 7. Storm water sample ranges for downstream locations, Kayenta Complex (1986-2010).

One dissolved cadmium sample was reported at a value of 10 mg/L at a downstream location in the Moenkopi CIA. A review of the surface water quality data submitted in annual hydrologic monitoring reports (PWCC, 2011b) indicate the elevated value is attributed to an elevated MDL. The median cadmium value for Moenkopi CIA downstream monitoring locations is 5 mg/L (Table 7), and less than the medium upstream monitoring locations for cadmium (Table 2). Therefore, the NNEPA fish consumption designated use does appear to be compromised due to the activities at the Kayenta Complex.

One total chloride sample was reported at a value of 261 mg/L at a downstream location in the Moenkopi CIA. The median chloride value for Moenkopi CIA downstream monitoring locations is 12 mg/L (Table 7), and consistent with the medium upstream monitoring locations for chloride (Table 2). The isolated elevated detection slightly above Hopi Tribe designated use for aquatic and wildlife habitat, and has not been repeated. Therefore, the Hopi Tribe designated use for aquatic and wildlife habitat use does not appear to be compromised due to the activities at the Kayenta Complex.

All reported concentrations of lead are at the MDL. Median downstream values (Table 7) are consistent with median upstream values (Table 2). Reported lead values are less than agricultural livestock water supply WQS, but greater than PBC (Hopi Tribe, 2008) and ScHC (NNEPA, 2007) WQS of 15 mg/L. The designated use for PBC and ScHC, which are the same by definition, do not appear to be compromised due to the activities at the Kayenta Complex; however, additional verification with a lower MDL may be necessary after consultation with the Hopi Tribe WRP and Navajo Nation WQP.

Hopi Tribe WRP established a total manganese standard of 10 mg/L for agricultural irrigation. The NNEPA has no manganese standards for the designated uses in the Moenkopi and Dinnebito CIAs. Reported manganese concentrations are variable in both upstream and downstream monitoring location for Moenkopi and Dinnebito CIAs. Dinnebito upstream median total manganese concentrations is 16 mg/L, and 12.9 mg/L for the downstream monitoring location. Moenkopi upstream median total manganese is 10 mg/L, and 7.96 for the downstream monitoring locations. The highest manganese detection (64 mg/L) occurred at monitoring location 26 in 1991, and reported concentrations have been below 20 mg/L from 1997 – present. Based on comparison of upstream and downstream monitoring locations, the Hopi Tribe designated use for agricultural livestock watering does not appear to be compromised due to the activities at the Kayenta Complex.

Upstream and downstream monitoring for dissolved mercury in both the Dinnebito and Moenkopi CIAs identified one detection at downstream monitoring location 25 (2.3 µg/L). All remaining mercury values are a result of a MDL between 0.1 – 0.2 µg/L. The Hopi Tribe WQS for $A\&W_e$ (chronic) is 0.01 µg/L. The designated uses do not appear to be compromised due to the activities at the Kayenta Complex; however, additional verification with a lower MDL may be necessary after consultation with the Hopi Tribe WRP and Navajo Nation WQP.

Molybdenum has a designated use WQS for agricultural water supply established by the Hopi Tribe WRP (10 µg/L) and NNEPA (1000 µg/L). All reported concentrations are a reflection of the MDL. When the MDL is less than 10 µg/L, no concentrations have been detected. Therefore, the agricultural water supply designated use does appear to be compromised from molybdenum concentrations due to the activities at the Kayenta Complex.

Selenium WQS are available for all designated uses in the Dinnebito and Moenkopi CIAs. Both the Hopi Tribe WRP and NNEPA established a WQS of 20 µg/L for agricultural irrigation water, and a WQS of 2 µg/L for $A\&W_e$ (chronic). All storm water quality samples collected at downstream monitoring locations were less than 20 µg/L. Lower detections are a result of the level of MDL being reported. The designated use for $A\&W_e$ (chronic) does not appear to be compromised due to the activities at the Kayenta Complex; however, additional verification with a lower MDL may be necessary after consultation with the Hopi Tribe WRP and Navajo Nation WQP.

Hopi Tribe WRP established a sulfate designated use standard for A&W$_e$ of 250 mg/L. This is the only designated use with a sulfate water quality standard applicable to the Moenkopi and Dinnebito CIAs. Results from upstream monitoring on Dinnebito Wash has a median sulfate concentration of 900 mg/L (Table 2), compared to a median downstream concentration of 660 mg/L (Table 7). Results from upstream monitoring on Moenkopi Wash has a median sulfate concentration of 150 mg/L (Table 2), compared to a median downstream concentration of 310 mg/L (Table 7). Although the downstream median sulfate concentration for the Moenkopi CIA is double the upstream median, downstream concentrations are within established sulfate variability, and no increasing trends were identified during review of the monitoring data. Therefore, the designated use for A&W$_e$ does not appear to be compromised due to the activities at the Kayenta Complex; however, OSMRE will notify Hopi Tribe WRP since detection is greater than 250 mg/L for 4 more consecutive samples.

TDS is very similar to sulfate for both designated uses and concentrations. A TDS WQS has been established by Hopi Tribe WRP for the designated use of A&W$_e$. This is the only designated use with a TDS water quality standard applicable to the Moenkopi and Dinnebito CIAs. Results from upstream monitoring on Dinnebito Wash have a median TDS concentration of 1444 mg/L, compared to a median downstream concentration of 1090 mg/L. Results from upstream monitoring on Moenkopi Wash have a median TDS concentration of 440 mg/L, compared to a median downstream concentration of 580 mg/L. Although the downstream median TDS are slightly higher than the upstream median, downstream concentrations are within established TDS variability, and no increasing trends are apparent in the downstream monitoring data (Figure 32). Therefore, the designated use for A&W$_e$ does not appear to be compromised due to the activities at the Kayenta Complex; however, OSMRE will notify Hopi Tribe WRP since detection is greater than 500 mg/L for 4 more consecutive samples at location 25.

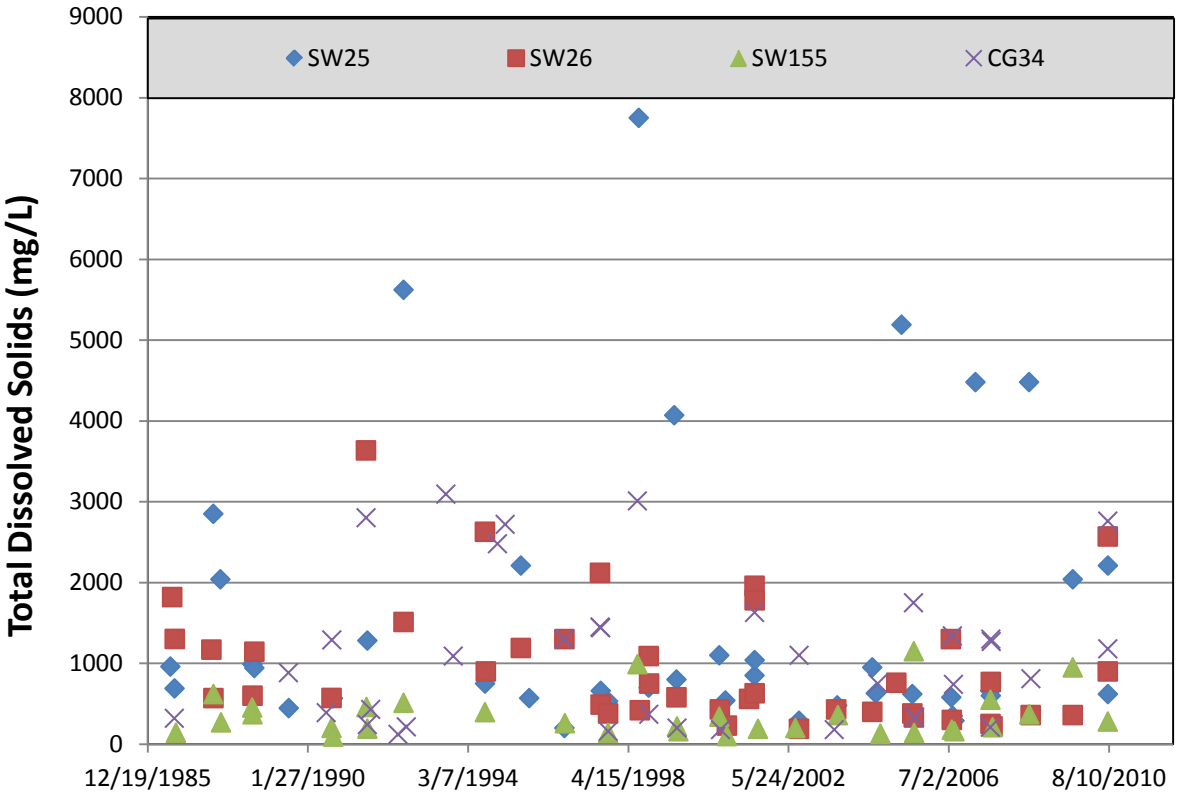


Figure 32. Downstream Surface Water TDS Concentrations, Kayenta Complex (1986 – 2010).

5.1.3.3 Surface Water Quality Material Damage Threshold and Limit

In summary, PWCC's hydrologic balance protection plan includes an approach to handle earth materials and surface water runoff in a manner that minimizes the formation of acidic or toxic drainage, and prevents additional contributions of suspended solids and other water pollutants from entering streamflow outside the permit area to the extent possible. As such, all areas disturbed by the mining operation drain to a series of sediment settling and containment ponds or dams which are designed to contain at least the 10-year, 24-hour runoff event plus an additional amount of sediment storage. Pond discharges from flow events exceeding the pond capacity are monitored for effluent compliance concentrations and reported in accordance with the requirements of NPDES permit number NN0022179.

The surface water monitoring program has provided sufficient information for OSMRE to make the impact assessment. After assessing the potential surface water quality impact of the mining operation on existing and foreseeable uses of Secondary Human Contact, Partial Body Contact, Agricultural Livestock Watering, Agricultural Water Supply, Aquatic and Wildlife Habitat (acute and chronic), and Fish Consumption water uses, OSMRE has determined that the operation has been designed to minimize surface water quality impacts within the permit area and prevent material damage outside the permit and adjacent area. OSMRE has developed a protocol to integrate Hopi Tribe WRP and NNEPA after review of monitoring data. OSMRE will work with the Hopi Tribe WRP and the NNEPA to evaluate potential mining impacts on established WQS.

5.2 Groundwater

The coal resources mined at the Kayenta Complex reside in the Wepo Formation of the Mesa Verde Group. The Mesa Verde Group consists of the overlying Yale Point Sandstone, the Wepo Formation, and the underlying Toreva Formation. Alluvial channels truncate the Yale Point Sandstone and Wepo Formations within the assessment area delineated in Section 2.2.1, limiting regional horizontal flow. OSMRE will evaluate the potential of the Kayenta Complex operation to result in contamination, diminution, or interruption of alluvial and Wepo Formation groundwater outside the permit area that may result in the inability to utilize water resources for existing and foreseeable livestock use.

Additionally, as discussed in Section 3.2, PWCC utilizes groundwater from water supply wells within the permit area. The wells predominantly withdraw groundwater from the N aquifer system, and a small portion is withdrawn from limited screened intervals of the overlying D aquifer system. The N aquifer is utilized regionally by Hopi and Navajo communities for domestic supply water, and the D aquifer is utilized in isolated areas where the water quantity and quality permits domestic and livestock water supply use. PWCC's past and present N aquifer use creates both water quantity and quality concerns that will be evaluated in this assessment.

5.2.1 Alluvium

OSMRE will evaluate whether the monitoring program has been appropriately designed to provide alluvial water quantity and quality information necessary to assess potential impacts in accordance with 30 CFR 780.21(g). OSMRE will also evaluate the potential impact of the Kayenta Complex on downstream uses outside the permit area related to alluvial water quantity and quality, and potential impact to the existing and foreseeable use of agricultural livestock watering.

5.2.1.1 Alluvial Quantity

The alluvial washes within the permit area are characterized as having large variations in both vertical saturated thickness and cross-sectional width based on seismic refraction studies and drill log information.

Variability of hydrologic characteristics was also confirmed through aquifer testing, where transmissivity results span three orders of magnitude (Figure 15). Additionally, the alluvial systems in the various washes are not continuous within the permit area. Some areas of the alluvium have up to 34-feet of saturated thickness, while other areas of the same wash may only have a thin veneer of unsaturated alluvium accumulated. However, OSMRE will evaluate the use potential based on water quantity and potential water quantity impact to the existing and foreseeable uses due to the Kayenta Complex.

5.2.1.1.1 Alluvial Quantity Monitoring Program

The monitoring program of the valley alluvium for water quantity was implemented to characterize background conditions, natural seasonal fluctuations, and identify the existing and foreseeable use potential of alluvial water. Specifically, mining related water quantity impact on the potential use of alluvial water for livestock watering has been identified as a concern for this evaluation.

The monitoring program identified that the groundwater quantity in the alluvial system is variable, and fluctuations in the background alluvial monitoring well data are predominantly related to precipitation and associated infiltration of surface water flow. Also, since precipitation is spatially variable, water level trends will generally mimic each other, but the amplitudes may vary depending on the spatial distribution of precipitation events and the amount of runoff generated as surface flow in the washes. The general trend measured in alluvial background monitoring locations 69, 77, 87, and 108R has been decreasing. The four background monitoring locations, coupled with multiple wells along the alluvial washes, provide good information for evaluating water quantity variations. Therefore, OSMRE finds that the existing alluvial monitoring program, which includes wells upgradient of mining activities, wells at the downgradient permit boundary of the primary washes, and wells along the primary washes, provide sufficient information for OSMRE's impact evaluation (Figure 13).

5.2.1.1.2 Alluvial Quantity Impact Potential to Designated and Foreseeable Uses

In order to quantify alluvium inflow reduction for comparison to outflow reduction, Darcy's Law was used. Darcy's Law relates outflow to hydraulic gradient, hydraulic conductivity of the porous medium, and a cross-sectional area. The calculations are detailed in Table 8. In 2002, the water levels declined from baseline in all background alluvial monitoring wells as follows: 77 (-0.27 feet), 108R (-3.63 feet), 69 (-3.66 feet), and 87 (-8.24 feet). Multiplying the channel width at each of the locations with the water level decline in saturated alluvium yields the cross-sectional area for background baseline evaluation. Next, water level pairs were identified for alluvial wells close to the background monitoring wells for hydraulic gradient calculations. Finally, hydraulic conductivity values were derived from pump test data performed on the specific background monitoring well. Since pump test data was not available for location 77, the average hydraulic conductivity value from 87, 108R, and 69, was used for quantity calculation at location 77. Additionally, no alluvial monitoring wells are in close proximity to locations 87 and 77; therefore, the average gradient from 108R and 69 was used for the gradient variable.

The inflow quantity reduction in the alluvium was most significant for the two background tributaries comprising Coal Mine Wash. By 2002, the alluvial inflow to the permit area via Coal Mine wash has decreased by approximately 7.73 ac-ft when compared with water level information from the early 1980's. Similarly, Dinnebito alluvium has a 0.67 ac-ft inflow decline in 2002 and Moenkopi a 1.53 ac-ft decline in 2002, when compared to water level information in the early 1980's. These background inflow volume declines were compared to the volumetric flow declines at the downgradient permit boundaries (Table 8).

Alluvial Monitoring Well	Setting	Wash	Channel Width	Head Decline	Saturated X-Section Decrease (Area)	Well Pair for Gradient Calculation	Change in Head (dh)	Change in Length (dl)	Gradient (dh/dl) (i)	Hydraulic Conductivity (K)	Discharge (Q=KiA)	Discharge (Q=KiA)	Discharge (Q=KiA)
			feet	feet	$feet^2$		feet	feet		ft/year	$feet^3$/year	gal/year	ac-ft/year
ALUV87	Background	Moenkopi	1000	8.24	8240				**0.0126**	640	66447	497061	1.53
ALUV108R	Background	Dinnebito	1600	3.63	5808	ALUV168	41.48	3261	0.0127	396	29256	218847	0.67
ALUV69	Background	Coal Mine	800	3.66	2928	ALUV13R	44.53	3572	0.0125	8888	324427	2426879	7.45
ALUV77	Background	Coal Mine	1100	0.27	297				**0.0126**	**3308**	12379	92603	0.28
							Annual Alluvial Inflow Reduction				**432509**	**3235390**	**9.93**
ALUV95	Downstream	Moenkopi	640	2.78	1779	ALUV93	10.26	3416	0.0030	4047	21627	161778	0.50
ALUV170	Downstream	Dinnebito	1280	1.39	1779	ALUV169	15.11	2485	0.0061	**4047**	43782	327512	1.01
ALUV19	Downstream	Coal Mine	480	10.34	4963	ALUV197	1.59	1087	0.0015	**4047**	29381	219783	0.67
							Annual Alluvial Outflow Reduction				**94789**	**709074**	**2.18**

Table 8: Alluvial Quantity Outflow Calculations for Primary Washes (2002).

Water level decreases of 0.27 feet to 8.24 feet have been measured at the background monitoring locations; therefore, decreases can be expected at the outflow areas since inflow to the alluvial aquifer system has decreased. Downgradient alluvial monitoring locations 19, 95 and 170 were used for comparison to the background information and assessment of potential mining related impact to existing and foreseeable livestock use. The water level declines at the three downgradient alluvial monitoring wells were as follows: 19 (-10.34 feet), 95 (-2.78 feet), and 170 (-1.39 feet). Using information of water level change, hydraulic conductivity, and hydraulic gradient, the total discharge reduction was determined and compared to the background reduction. Comparatively, Moenkopi Wash had a 1.53 ac-ft/yr inflow reduction at background location 87, and a 0.50 ac-ft/yr outflow reduction at downgradient location 95. Coal Mine Wash had a combined inflow reduction at background locations 69 and 77 of 7.73 ac-ft/yr, and a 0.67 ac-ft/yr reduction at downgradient location 19. Dinnebito Wash had an inflow reduction of 0.28 ac-ft/yr at background location 108R, and a 1.01 ac-ft/yr reduction at downgradient location 170.

Overall, alluvial quantity reductions have been measured in the background alluvial monitoring wells and downgradient alluvial monitoring wells adjacent to the permit boundary. Inflow quantity reductions are greater than outflow reductions. The discrepancy appears to be the result of retaining storm flow surface water in impoundments and baseflow discharge from the Wepo Formation. The impoundments allow storm flow water to be temporarily retained, and the retained water subsequently infiltrates through the bottom of the retaining structure and into the channel alluvium.

Historically, five locations within the permit and adjacent area were developed for alluvial water use. The locations are identified as 8A-PHS-10, 4M-190, and Sagebrush Well within the permit area, while Reed Well and Grapevine Well are located adjacent to the permit boundary on Moenkopi Wash (Figure 8). Additionally, two alluvial springs that discharged at a flow rate of 1-2 gpm were identified in the northwestern portion of the permit area. The two alluvial springs are identified as 8A-140 and 8M-141.

The water quantity of the alluvial system is largely related to the surface water flow and subsequent infiltration to the alluvium. As such, fluctuations in alluvial water levels and spring flow rates are typical. The fluctuations limit sustainable development of the alluvium. For instance, Sagebrush well is a cistern (artificial underground tank for storing liquid), located in the middle of the channel, and not utilized or maintained for several decades. Storm flow events occasionally overtop the cistern; therefore, the sediment rich storm flow water has induced the cistern to become filled with sediment. Similarly, location 8A-PHS-10 has not been operated for several decades and occasionally overtopped by storm flow events. Location 4M-190 has been cataloged as a historical use location, but any identifiable structure has either washed away during storm events, or buried by accumulated sediment, as there have been no visible observations of the location for several decades. Reed Well and Grapevine Well are also cistern-like structures, abandoned for several decades, and no longer operable.

5.2.1.1.3 Alluvial Quantity Material Damage Threshold and Limit

The available quantity of alluvial water stored in the alluvial system varies depending on location within the alluvial channel and quantity of water infiltrated in response to storm flow events. Additionally, developing alluvial water for agricultural livestock use is maintenance intensive due to the sediment transported during storm flow events, evidenced by the condition of the historical use locations. Although the reliability of using the alluvial system for agricultural livestock water supply development is low and maintenance prohibitive, surface water impoundment structures from the mining operations locally enhance alluvial water quantity, and the operations will not compromise foreseeable use of alluvial water quantity. Therefore, OSMRE will not establish a material damage criterion related to alluvial water quantity, but continued water alluvial water quality monitoring is necessary.

5.2.1.2 Alluvial Quality

Alluvial water quality of the primary drainages within the Kayenta Complex has been monitored for several decades, and data from the monitoring period 1986 – 2010 is evaluated in this assessment. The water quality information will be utilized to assess potential development of the alluvial water for livestock watering, and evaluate the potential impact of the mining operations on the foreseeable livestock watering use within the permit and adjacent area.

5.2.1.2.1 Alluvial Quality Monitoring Program

Similar to the monitoring program objectives presented previously, monitoring of the valley alluvium for water quality was implemented to characterize background conditions, natural seasonal variations, and identify the existing and foreseeable use potential of the alluvial water for livestock watering. Seasonal variations will not be evaluated separately, since seasonal variation is apparent but not statistically significant between monitoring locations.

Figure 13 illustrates that alluvial water quality information has been obtained at 80 locations within the permit area. There are currently 32 locations sampled as part of the active alluvial quality monitoring program. The remaining locations have been properly abandoned. The active locations are sampled either annually or semi-annually. Semi-annual monitoring is typically done at locations where geochemical trending of some water quality parameters has been observed. Eight locations are currently monitored semi-annually. Water quality samples are analyzed for a full suite of parameters consisting of parameters that have Arizona, Federal, or Navajo Nation livestock drinking water limits, all significant parameters necessary to perform QA/QC checks on laboratory data, and those parameters necessary to evaluate mining impacts (PWCC, v.11, ch.16, 2011).

The information obtained at the abandoned alluvial monitoring locations, coupled with ongoing monitoring of the existing locations, provide the necessary information to characterize background

conditions, natural seasonal variations, and evaluate the water quality impact of the mining operations on the potential for watering livestock within the permit and adjacent area. Therefore, OSMRE finds that the alluvial monitoring is appropriately designed and implemented.

5.2.1.2.2 Alluvial Quality Impact Potential to Designated and Foreseeable Uses

Historical attempts have been made to develop alluvial water resources within in the permit and adjacent area. However, none of the locations have been utilized or maintained for several decades, and some of the locations have been either washed downstream during flood events or are filled with sediment. The lack of alluvial use locations within the permit and adjacent area is largely a function of the dynamic water quantity conditions in the channel alluvium, which is dependent on the duration and intensity of the surface water storm flow events. Another challenge pertinent to alluvial aquifer development is the fact that it is not continuously hydraulically connected through any significant geographic area. However, this evaluation will consider the potential to develop alluvial water within the permit and adjacent area to support livestock watering. HTWQS (Hopi Tribe, 2008) and NNSWQS (NNEPA, 2007) for agricultural livestock water supply will be used to support water quality evaluation of the alluvial aquifer.

Chemical parameters with an agricultural livestock water supply WQS, and major cations and anions are identified on Table 9. Downstream monitoring locations for the Moenkopi alluvial CIA identified one detection of cadmium above the agricultural livestock WQS (50 µg/L) at location 19. The elevated detection is a result of an elevated MDL in 1997, and subsequent concentrations have been less than the WQS the remainder of the monitoring period.

The Hopi Tribe WRP and NNEPA WQP established an agricultural livestock water supply WQS for lead at 100 µg/L. All reported concentrations are a result of the MDL. However, when the MDL is less than 100 µg/L, no positive concentrations above 100 µg/L have been identified.

Selenium concentrations measured at upstream and downstream alluvial monitoring locations are less than the agricultural livestock water supply WQS (50 µg/L), except for one detection (57 µg/L) at downstream monitoring location 172. The one selenium detection above 50 µg/L was followed by three samples that were less than 50 µg/L.

An agricultural livestock water supply WQS is not established for TDS. TDS is an aggregate indicator of the presence of a broad array of chemical constituents and provides a reasonable indication of the overall water quality. Elevated TDS concentrations typically correspond to elevated concentrations in one or more major cations or anions. Review of the upstream TDS data at location 87 indicates a significant increase from 2005 – 2010 (Figure 33). Monitoring location 87 is considered an upstream background location, and the cause for the significant increase is unknown. After the initial TDS increase at location 87 from 2005 – 2007, measured concentrations are returning to concentrations within the previously recorded range. The return to previously measured concentrations indicate the cause is likely not persistent, but the elevated concentrations will likely migrate through the Moenkopi alluvium within the permit area. Measured TDS concentrations in downstream Moenkopi alluvial monitoring well 95, indicate the poorer quality water has not reached downstream alluvial well 95 (Figure 34). Elevated TDS concentrations are expected to occur at location 95 in future sampling events. Overall, upstream and downstream monitoring of TDS indicates the range varies between 500 – 7000 mg/L. Continued monitoring at upstream and downstream monitoring locations continues to be necessary to assessment if elevated concentrations are the result of mining related impacts from the Kayenta Complex.

					Dinnebito Wash CIA				Moenkopi Wash CIA			
					Location 170				Locations 19, 95, and 172			
Chemical Parameter	Agricultural Livestock Watering WQS	WQS	Units	Type	# Samples	Low	Median	High	# Samples	Low	Median	High
Aluminum	HT	5	mg/L	Dissolved	n=55	0.03	0.2	0.2	n=133	0.03	0.05	0.5
Arsenic	HT and NN	200	µg/L	Dissolved	n=55	1	1	6	n=133	0.5	1	7
Bicarbonate	NNS	NNS	mg/L	Dissolved	n=55	605	803.5	903	n=138	61	372	891
Boron	NN	5000	µg/L	Dissolved	n=55	210	290	380	n=134	30	120	310
Calcium	NNS	NNS	mg/L	Dissolved	n=55	440	504	596	n=135	60.3	463	600
Cadmium	HT and NN	50	µg/L	Dissolved	n=55	3	20	30	n=135	3	5	80
Chloride	NNS	NNS	mg/L	Total	n=55	32	46	70	n=137	10	43.5	96
Chromium	HT and NN	1000	µg/L	Dissolved	n=55	10	50	50	n=133	5	10	80
Copper	HT and NN	500	µg/L	Dissolved	n=55	10	50	80	n=133	5	10	50
Lead	HT and NN	100	µg/L	Dissolved	n=55	20	200	200	n=133	1	20	200
Magnesium	NNS	NNS	mg/L	Dissolved	n=55	421	483	629	n=137	17	260	610
Mercury	HT	10	µg/L	Dissolved	n=55	0.1	0.2	0.3	n=135	0.1	0.2	1.3
Selenium	HT and NN	50	µg/L	Dissolved	n=55	1	2.5	12	n=135	1	5	57
Sodium	NNS	NNS	mg/L	Dissolved	n=55	505	635.5	1150	n=137	63.1	310.5	737
Sulfate	NNS	NNS	mg/L	Total	n=55	3300	3960	5800	n=137	90	2523.5	4200
TDS	NNS	NNS	mg/L	Total	n=55	5718	6424	9540	n=138	420	4054	7120
Vanadium	HT and NN	100	µg/L	Dissolved	n=55	5	30	50	n=133	5	10	50
Zinc	HT and NN	25	mg/L	Dissolved	n=55	0.01	0.05	0.1	n=133	0.01	0.02	5.81

NNS - No Numeric Standard
WQS - Water Quality Standard
mg/L - milligrams per liter
µg/L - micrograms per liter
NN - Navajo Nation
HT - Hopi Tribe
CIA - Cumulative Impact Area
T- Total

Table 9. Downstream Alluvial Water Quality Summary (1986 – 2010), Kayenta Complx.

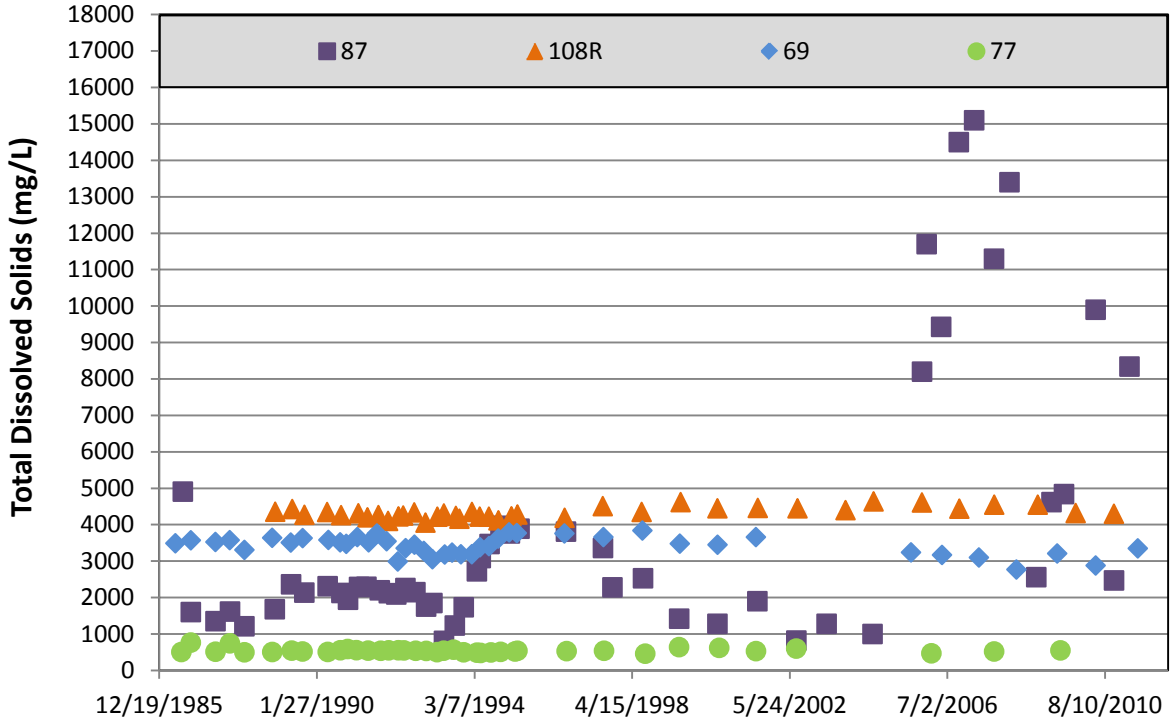


Figure 33. TDS Concentrations (1986 – 2010), Upstream Alluvial Monitoring Locations.

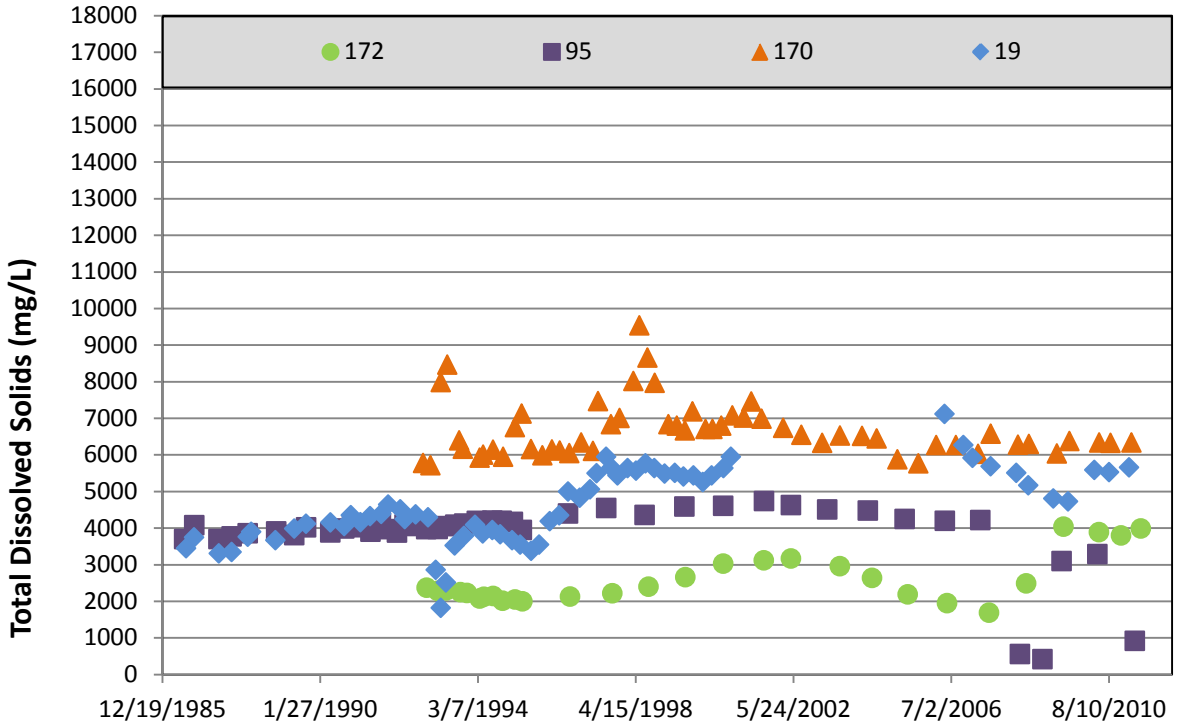


Figure 34. TDS Concentrations (1986 – 2010), Downstream Alluvial Monitoring Locations.

5.2.1.2.3 Alluvial Quality Material Damage Threshold and Limit

Overall, evaluation of alluvial water quality indicates that water quality is subject to some seasonal variability and a large amount of variability from location to location. Agricultural livestock watering use was considered for evaluation; however, historical alluvial use locations within the alluvial cumulative impact area have all been abandoned and no attempts to develop alluvial water have been initiated over the past 40 years within the CIA. Accessibility to potable public water standpipes and retention of surface water impoundments for livestock watering make development of the saturated alluvium for livestock watering a challenging and maintenance-intensive alternative. After comparison of upstream water quality with downstream water quality related to WQS and major cations and anions, there are no indications that the mining operation is compromising the agricultural livestock supply water outside the permit area. Alluvial water quality will continue to be monitored and evaluated against available livestock water quality standards. Similar to the surface water quality assessment protocol described in Section 5.1.3.2, if monitoring demonstrates that WQS have been exceeded for 4 out of 4 sampling events, OSMRE will the appropriate CWA authority, and evaluate if the exceedances are the result of a mining related impact.

5.2.2 Wepo Formation

The Wepo Formation lies within the late Cretaceous Mesa Verde Group. Due to the late Cretaceous depositional environment, the water bearing zones of the Mesa Verde Group are largely perched and intertongue with less permeable material. The Wepo Formation contains low yielding perched aquifers in some locations, and the permeable aquifer zones pinch out or are vertically displaced owing to some minor structure within the Kayenta Complex (PWCC, v.11, ch.18, 2011). The springs and seeps of the Mesa Verde Group identified by PWCC within the permit area emanate from contact zones between the bottom of permeable sandstones and the top of relatively impermeable shale layers exposed along the sides of washes, discharging into the alluvium (PWCC, v.9, ch.15, 2011).

The depositional environment during the late Cretaceous left a thick complex sequence of intertonguing siltstone, mudstone, sandstone, and coal beds (Figure 6). The Wepo Formation contains some discontinuous saturated zones, but attempts to utilize this water source have received limited success. The coal resources in the Wepo Formation of the Mesa Verde Group are being mined at the Kayenta Complex, and may intercept groundwater from the upper part of the Wepo Formation. Limited interception of the saturated Wepo has already occurred during the mining of coal resource areas N-11, J-1/N-6, N-14, J-16, J-19/J-20, and J-21. Since surface mining will potentially incept groundwater from the Wepo Formation, the hydrologic impacts in the Wepo Formation associated with mining were evaluated as part of the PHC determination (PWCC, v.11, ch.18, 2011). Similarly, OSMRE will evaluate the hydrologic consequences related to Wepo water quantity and quality, and assess the impact of the mining operations on the livestock water supply use of Wepo Formation water within the Wepo CIA.

5.2.2.1 Wepo Formation Quantity

PWCC experience of surface coal mining on Black Mesa has identified that “the permeable units within the Wepo Formation are perched aquifers in some locations, pinch out, or are vertically displaced owing to some minor structure within the Kayenta Complex” (PWCC, v.11, ch.18, 2011). Therefore, some conservative simplifying assumptions were necessary for impact evaluation of Wepo water quantity. The assumptions are conservative in that they overestimate the amount and areal extent of the Wepo water impacted. The overestimation of the annual water quantity withdraw allows for a protective delineation of a potential impact area for the Wepo Formation, and users of Wepo groundwater.

Assumptions of a continuous, confined, saturated Wepo Formation having a uniform thickness are significant simplifying assumptions for the purpose of hydrogeologic evaluation. Mining experience of the Wepo Formation, borehole data from geologic characterization of the coal resources throughout the Kayenta Complex, and aquifer testing of monitoring wells in the Wepo aquifer zones demonstrate the conservative nature of the above assumptions (PWCC, v.10, ch.15, 2011). Transmissivity values for the Wepo Formation, which reflect the ability of the aquifer to transmit water, can be found in Figure 18.

With respect to spoil material, which is predominantly composed of the Wepo Formation, these assumptions may not be as conservative. Where pit mining has occurred, replacing the original material of the Wepo Formation with spoil material, results in much higher porosity and permeability (PWCC, v.11, ch.18, 2011). This is due in part to the fact that the increase in surface area that occurs when the coal is mined from the Wepo Formation also results in increasing the total volume of the spoil material, changing the Wepo aquifer properties within the reclaimed areas of the Kayenta Complex.

5.2.2.1.1 Wepo Formation Quantity Monitoring Program

Forty-six Wepo monitoring locations have been installed within the Kayenta Complex to assess water quantity impacts to the Wepo Formation water bearing units. Twenty-five Wepo monitoring wells are currently retained for evaluating impacts to the Wepo Formation. Recognizing the discontinuity of the Wepo aquifer, PWCC typically installed a Wepo monitoring well upgradient and downgradient of active and future coal pit areas to assess immediate water quantity impacts related to mining (Figure 16).

The historical and existing Wepo Formation monitoring well network provides the appropriate information to assess water quantity impacts attributed to the mining operations on the Wepo Formation. Therefore, OSMRE finds that the monitoring program of the Wepo Formation has been appropriately designed and implemented to provide the necessary information for hydrologic impact assessment.

5.2.2.1.2 Wepo Formation Quantity Impact Potential

Historical and existing users of the Wepo Formation water were identified within the Wepo CIA delineated in Section 2.2.1. Utilizing USGS, BIA, and Tribal databases, and PWCC field investigations, six Wepo well locations have been identified within the CIA, and are denoted by the following well IDs on Figure 8: 8T-506, 8A-PHS-15, 4K-309, 4T-512, 4K-380, 4T-405. Well 8T-506 is completed in both the Wepo and underlying Toreva Formation. The available information for additional wells only includes the location coordinates and suspected aquifer zone being developed.

Nineteen Wepo aquifer springs and seeps have been identified within the Wepo water quantity impact area using USGS, BIA, Tribal databases, and PWCC field investigations. The 19 springs are denoted by the following IDs: DM-6, Hogan Gulch Spring, Goat Spring #2, 4M-190A, 4M-191, 2A-44, 8A-147, NSPG91, NSPG92, NSPG111, NSPG140, NSPG147, 8A-153, 8A-139, 8A-143, 8A-145, Pine Spring, Great Spring, and Sand Spring (Figure 8). Field investigation of the water resources within and immediately surrounding the Kayenta Complex indicates that many of these springs do not presently discharge, occur only as damp spots, or are indistinguishable in baseflow reaches (PWCC, v.11, ch.17, 2011). Therefore, only spring locations NSPG140, NSPG91, NSPG92, NSPG111, NSPG147, Sand Spring, Goat Spring #2, and Hogan Gulch Spring are monitored for evaluation of Wepo spring water quantity impacts. Discharge at these eight springs ranges from 0 - 4.2 gallons per minute, with NSPG92 having the highest recorded flow rate of the eight springs at 4.2 gallons per minute (PWCC, v.11, ch.18, 2011). Although use of Wepo Formation water is quite limited due to both the hydraulic and water quality characteristics of the aquifer, PWCC has minimized impacts to designated and foreseeable uses through water supply replacement within the Kayenta Complex. Given that the quantity of water available for use through this system is much greater than the original quantity that was used from the Wepo Foramtion, impacts to the designated uses have been minimized.

5.2.2.1.3 Wepo Formation Quantity Material Damage Criterion

OSMRE finds that the mining operations at the Kayenta Complex will not adversely impact existing or potential users of the Wepo Formation water outside the permit area due to the areal discontinuity of the saturated Wepo Formation. Additionally, eight Wepo springs are monitored within the Kayenta Complex and adjacent area. OSMRE has determined that the existing Wepo monitoring program is in compliance with 30 CFR 816.41, and PWCC shall continue the existing monitoring program for Wepo wells and Wepo springs. If the mining operation results in sustained spring flow depletion at these eight springs or well yield depletion at the eight wells, PWCC shall mitigate as required in 30 CFR 780.21. Therefore, OSMRE will not establish a material damage criterion specific to protection of Wepo water quantity.

5.2.2.2 Wepo Formation Quality

The removal of overburden and coal occurs in the Wepo Formation of the Mesa Verde Group at the Kayenta Complex. The Wepo Formation is incised by surface water drainages within the permit and adjacent area, making the saturated lithology within the Wepo Formation noncontiguous. However, these noncontiguous saturated sections of the Wepo Formation may be developed for water use. As presented previously, elevated TDS in the Wepo water limits development for domestic water supply within the permit area, but Wepo water may be utilized for livestock watering at some locations.

5.2.2.2.1 Wepo Formation Quality Monitoring Program

Mining areas that intercept a portion of saturated Wepo Formation act as ground water sinks, and the adjacent formation water will flow back toward the mined area in some locations and potentially saturate a portion of the backfill spoil material replaced in the coal resource areas. Due to the potential for backfill spoil material to re-saturate and cause water quality degradation, PWCC conducted several focused spoil water studies in coal resource areas N-7, N-2, N-14, and J-16, which intercepted Wepo Formation water. Eleven spoil wells were installed in the N-2 spoil; two in the N-7 spoil, six in N-14 spoil, and one well was completed in the J-16 spoil (Figure 16).

The historical and existing Wepo monitoring well network and focused spoil saturation studies provide the necessary information to assess water quality impacts attributed to the mining operations on the Wepo aquifer. Therefore, OSMRE finds that the hydrologic characterization and monitoring program of the Wepo aquifer system have been appropriately designed and implemented to provide the necessary information for hydrologic impact assessment.

5.2.2.2.2 Wepo Formation Quality Impact Potential

The concentrations of major cations and anions identified at background Wepo monitoring wells were compared to the median concentrations from spoil monitoring wells. Spoil water quality provides an indication of local water quality impacts of mining on Wepo Formation water. The major cation concentrations of sodium, calcium, and magnesium are illustrated on Figure 35. The major anion concentrations of chloride, bicarbonate, and sulfate are illustrated on Figure 36. Since TDS provides an indication of the overall water quality, Figure 37 illustrates background Wepo TDS concentrations compared to the median spoil TDS concentration.

Limited precipitation and associated infiltration to groundwater, and the discontinuous nature of water bearing zones in the Wepo Formation cause resaturation of the spoil material in the reclaimed mine pits to be slow. Many of the spoil wells that have been installed to monitor the potential effects of reclamation are still dry. Any impacts adjacent to the mine pits are minimized due to the shift of the hydraulic gradient towards the mine pits caused by this extremely slow rate of resaturation. This limits any effective transport of spoil water to adjacent areas of the Wepo aquifer.

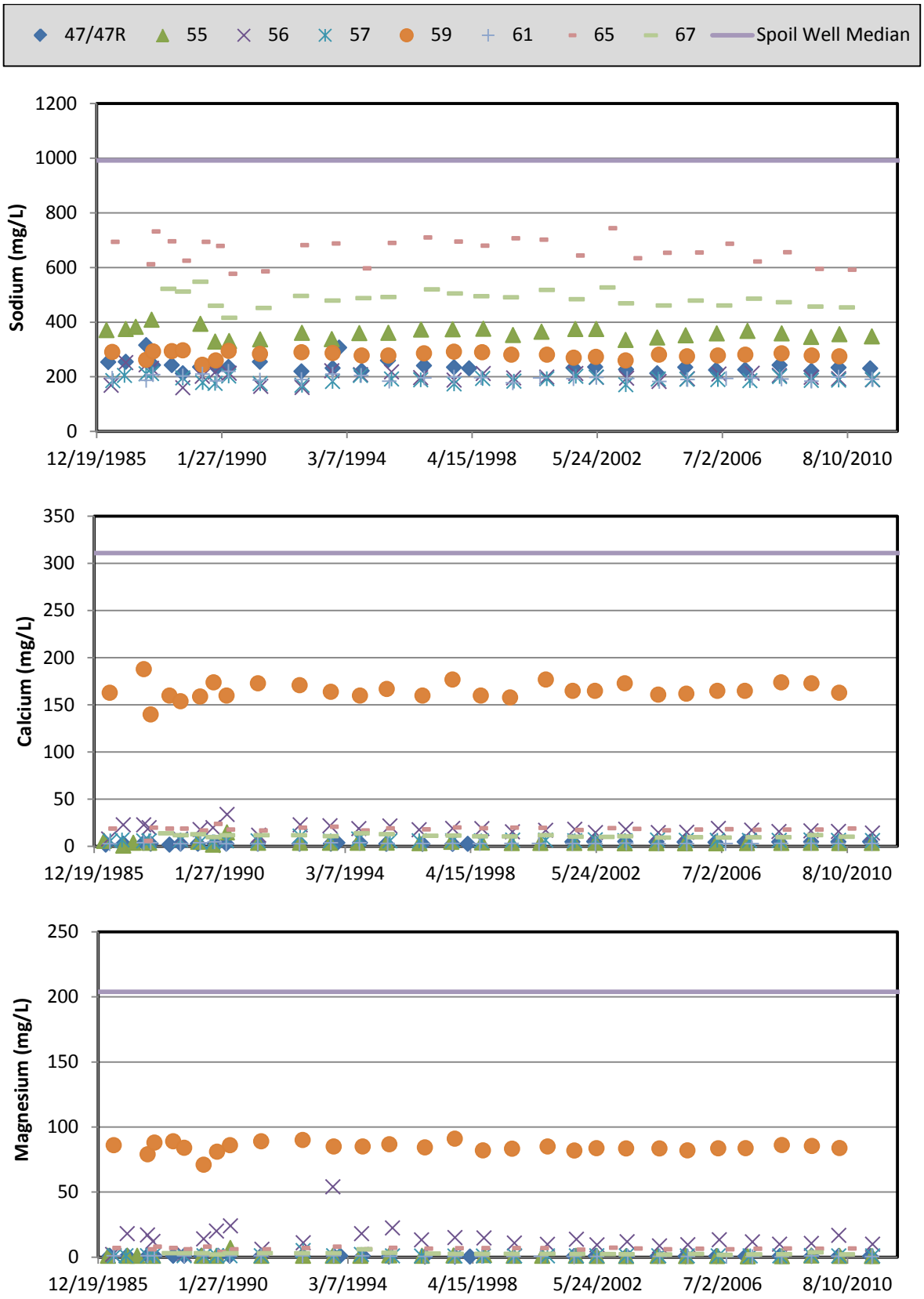


Figure 35. Wepo Background Wells and Spoil Median Concentration for Major Cations.

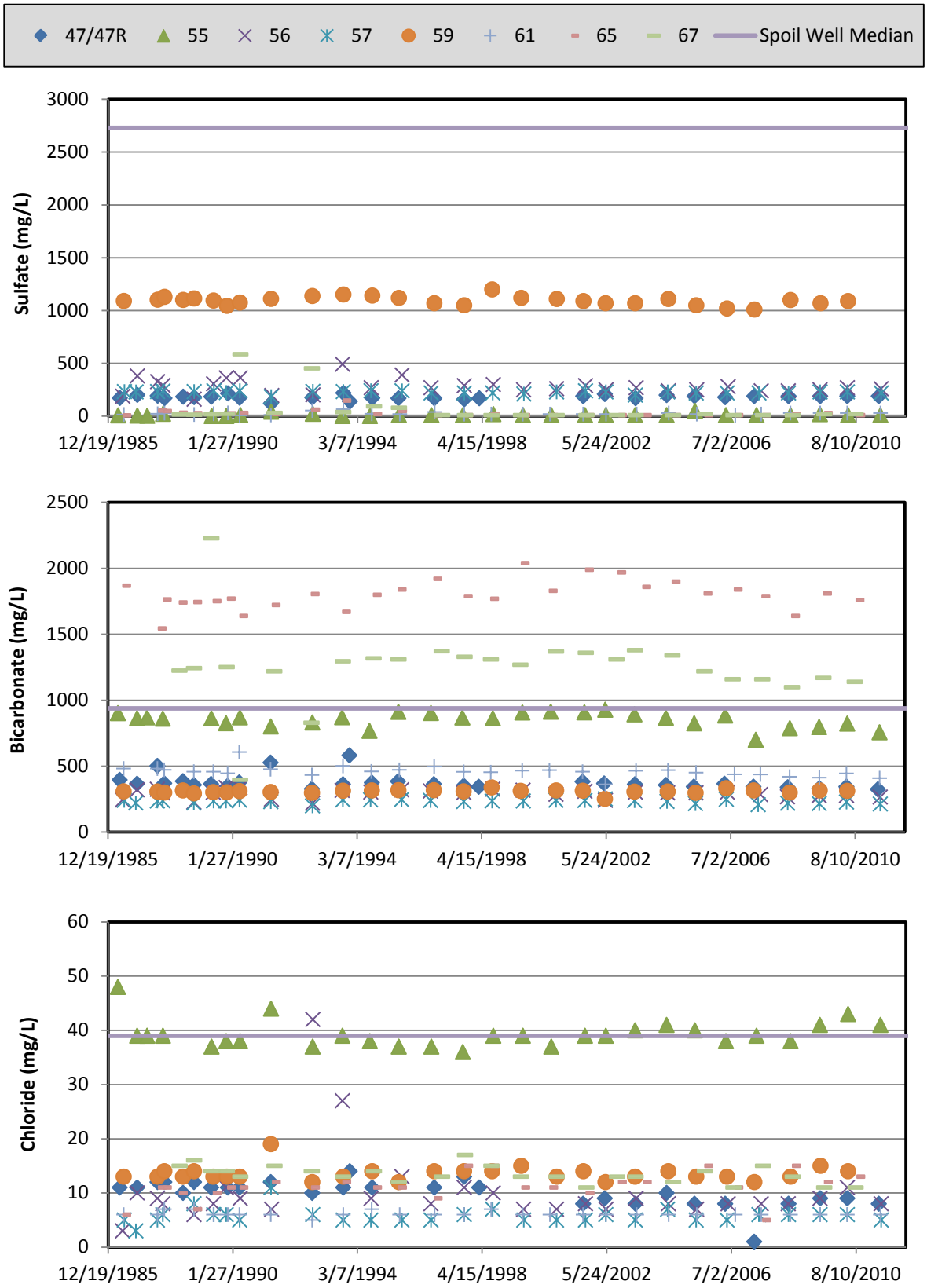


Figure 36. Wepo Background Wells and Spoil Median Concentration for Major Anions.

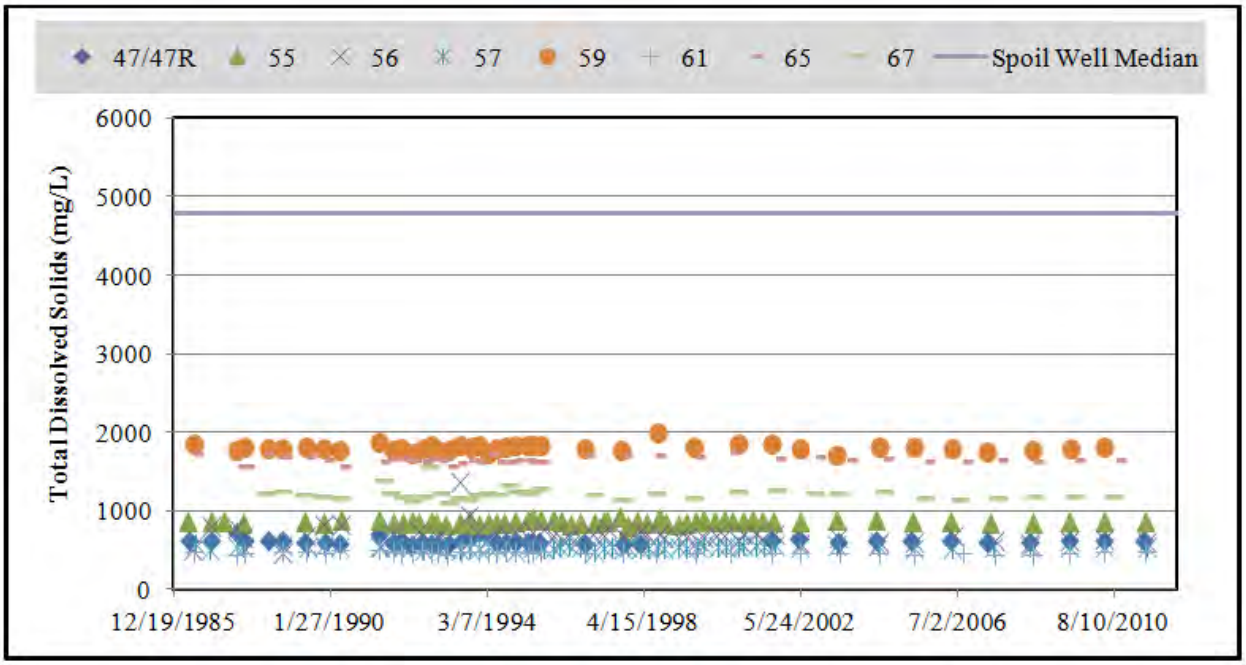


Figure 37. Wepo Background Wells and Spoil Median Concentration for TDS.

5.2.2.2.3 Wepo Formation Quality Material Damage Criterion

The impact of mining at the Kayenta Complex on Wepo Formation water quality outside of the permit area has been negligible with respect to livestock uses. Historically, there has been only isolated use of water from the Wepo Formation for livestock, and generally the water quality prevents it from being a widespread water source within the permit and adjacent area. Although spoil water could conceivably migrate into Wepo Formation along the periphery of backfilled mine pits, the hydraulic gradient is toward the spoil from the Wepo Formation. Combined with the low hydraulic conductivity and the discontinuous nature of Wepo Formation, there is no indication that water from the spoil is migrating or would migrate to any great extent into the Wepo Formation. Spoil water quality for major cations, anions, and TDS are elevated compared to background concentrations; however, the potential for degraded water quality migration outside the mine pit area is limited. If water quality migration outside the mine pit area occurred, the alluvial water quality monitoring program in the receiving alluvial channels will identify the migration of associated impacts. Therefore, OSMRE will not establish a material damage criterion specific to mining impacts on Wepo Formation water quality. OSMRE regularly evaluates quarterly monitoring data to ensure impacts to the Wepo Aquifer are minimized to the mine pit areas.

5.2.3 D aquifer

The D aquifer is confined above by the vertically thick and areally extensive Mancos Shale Formation. The D aquifer is confined below by the Carmel Formation in the northeastern area of Black Mesa, and the Carmel Formation becomes semi-confining toward the southwest edge of Black Mesa. Baseline conditions for the D aquifer system were established using water quality analysis (including isotope evaluation) and using groundwater modeling. The 3D Model (PWCC, 1999) was developed to evaluate the potential mining related impact on the D and N aquifers separated by the Carmel Siltstone Formation. However, it should be noted that substantially less historical and transient information exists for the D

aquifer system compared to the N aquifer system. As such, the 3D Model (PWCC, 1999) did not undergo a transient calibration (i.e. simulating water levels changing over time) for the D aquifer system, as was performed for the N aquifer system, although a reasonable steady state (pre-significant pumping) water level map was achieved using the available D aquifer historical information (Figure 21).

PWCC operates water supply wells within the Kayenta Complex to support mining operations. The water supply wells are partially screened in some of the hydrologic units of the D aquifer (Table 10). Water supply wells NAV2, NAV3, NAV4, NAV5, NAV6, NAV7, and NAV8 are screened in portions of the Entrada sandstone (overlying the Carmel Formation), and NAV2 and NAV5 are also screened in portions of the Morrison Formation (overlying the Entrada Formation). Although these water supply wells are predominantly screened in the N aquifer, some water is derived from the overlying D aquifer. Since the D aquifer system water is partially or solely relied on at some communities for municipal water supply, agricultural use, and cultural use, the water quantity impacts associated with mine related drawdown are of concern and the subject of evaluation in this section.

Well Number	D-Aquifer			N-Aquifer			
	Morrison	Entrada	Carmel	Navajo	Kayenta	Wingate	Chinle
2	0[1]	0[1]	27	735	150	194	0
3/3P	0	0	10	690	170	268	0
4	26	160	150	700	60	308	0
5	203	155	150	725	155	229	0
6/6P	0	0	0	684	160	294	18
7	0	122	150	690	165	206	0
8	0	0	163	787	0	0	0
9	0	0	4	710	150	245	0

[1]Well Number 2 is not completed in the D-aquifer; however, the annular space around its blank casing, adjacent t the D-aquifer, is not grout sealed. D-aquifer water has the potential to migrate into the well bore.

Table 10: PWCC Pumping Wells Screened Aquifer Zone (feet) (PWCC, v.11, ch.15, 2011).

5.2.3.1 D aquifer Quantity

The D aquifer system is not extensively developed for water supply use. Wells that pump water from the D aquifer system are typically windmills, providing water for agricultural livestock water supply. PWCC withdraws D aquifer from wells partially screened in the D aquifer for industrial supply water. The communities of Chilchinbito, Kitsillie, and Kykotsmovi withdraw water from the D aquifer system for domestic water supply.

Two windmill wells are within 15-miles of the PWCC pumping center: identified as 4T-402 and 4K-387 (Figure 20). Windmill well 4T-402 withdraws water from the Dakota Sandstone Formation and is approximately 1-mile from the PWCC pumping center. Windmill well 4K-387 is screened in both the Cow Springs and Dakota Formations, and is approximately 15-miles from the PWCC pumping center. Maximum predicted drawdown attributed to PWCC pumping is greatest at well 4T-402, and is estimated at 50 feet of drawdown (PWCC, v.11, ch.18, 2011). The more distant windmill, 4K-387, is estimated to realize approximately 10-feet of drawdown related to PWCC pumping; however, the location is no longer available for use (PWCC, v.11, ch.18, 2011).

Figure 38 illustrates the D aquifer model simulated drawdown attributed to PWCC and community pumping from baseline condition to 2006 (PWCC, 1999). PWCC reduced wellfield pumping on December 31, 2005 by 70-percent compared to historical annual pumped quantities. Therefore, the illustrated drawdown centered on the Kayenta Complex represents a simulated maximum drawdown. The local D aquifer drawdown attributed to PWCC pumping is predicted to recover as the D aquifer system responds to the decreased PWCC pumping rate.

Water quantity concerns have been identified for domestic and agricultural water supply. The windmill in closest proximity to PWCC pumping has an available water column of approximately 550 feet, of which PWCC pumping may reduce by 50 feet. Windmill well 4K-387 is no longer operational. Therefore, OSMRE finds that PWCC impact on locations 4T-402 and 4K-387 will not adversely affect the existing or foreseeable use at these locations due to the limited amount of drawdown attributed to PWCC pumping.

5.2.3.1.1 D aquifer Quantity Material Damage Criterion

Simulated water level at windmill well 4T-402 will decrease by approximately 10-percent. Although an obstruction in the well prohibits water level confirmation, the operation of the windmill has not been compromised during the 40-plus year operation of the PWCC wellfield. Although a 10-percent reduction in water level elevation was simulated at location 4T-402, no additional operation cost has occurred since the location is wind powered. If the water availability is compromised, PWCC is responsible for water replacement in accordance with 30 CFR 816.41(h). Therefore, OSMRE will not establish a material damage criterion for the D aquifer quantity due to the absence of potential impact on domestic supply water, livestock supply water, or agricultural supply water.

5.2.3.2 D aquifer Quality Material Damage Criterion

Figure 22 illustrates difference in confined aquifer potentiometric surface between the D aquifer and N aquifer systems. Section 4.2.4.2 characterizes the overall D aquifer system quality as poor, compared to the N aquifer system. The natural hydrologic impact potential is for poorer quality D aquifer water to migrate downward to the N aquifer system (Truini and Longsworth, 2003). Therefore, since no hydrologic mechanism is present for PWCC operations to impact D aquifer quality OSMRE will not establish a material damage limit or monitoring criteria.

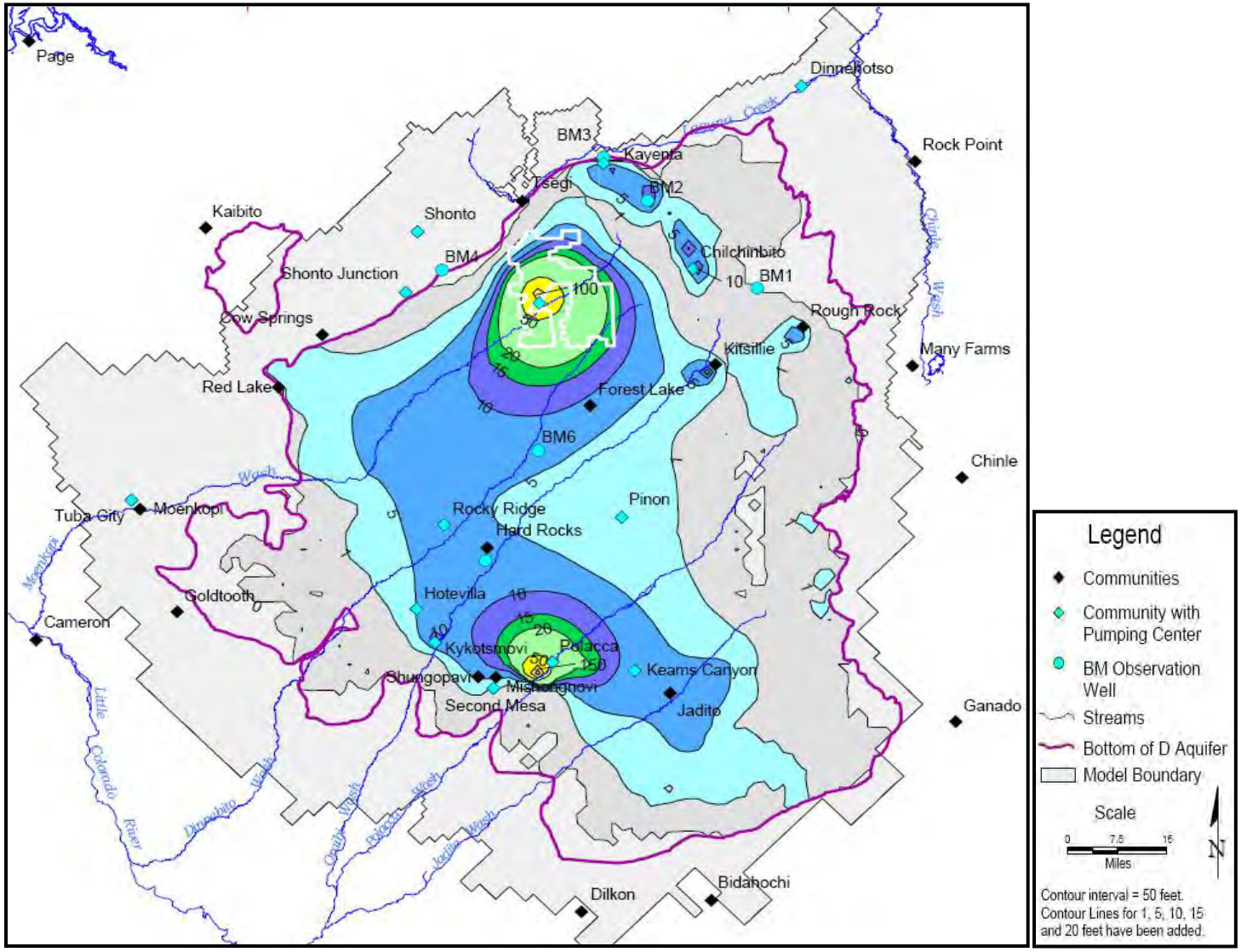


Figure 38: Groundwater Model Simulated D aquifer Drawdown in 2006 (PWCC, 1999).

5.2.4 N aquifer

PWCC pumping of the confined N aquifer prompted several concerns related to a reduction in the water pressure. The following groundwater concerns related to N aquifer pumping for coal mining operations will be evaluated for this CHIA:

- The potential impact of PWCC drawdown on community water supply wells.
- The potential impact on N aquifer baseflow to area washes.
- The potential impact on N aquifer spring discharge.
- The potential for land subsidence related to N aquifer drawdown.
- The potential for water quality degradation from the overlying D aquifer.

In order to assist in the evaluation of the concerns identified above, PWCC commissioned the development of a regional groundwater flow model for the D aquifer and N aquifer systems (3D Model), to be used for predicting and assessing potential mining related hydrologic impacts. The specific objectives of the 3D Model, were as follows (PWCC, 1999):

- Construct an accurate depiction of the geologic framework (lithology, structure, stratigraphy) that controls the flow of water in the D- and N aquifer formations within Black Mesa Basin;
- Study the components of recharge, leakage, ET, and discharge in order to refine values and understand their influence on the hydrologic system;
- Utilize both current and historical data on pumping rates and water levels to guide model design and calibration;
- Calibrate to both non-pumping and pumping conditions;
- Use a parameter-estimation approach to minimize bias;
- Simulate effects of future pumping on flow system; and
- Compare future pumping effects between USGS 2D and 3D models.

The 3D Model advances the previous USGS model (Brown and Eychaner, 1988) used in the 1989 Black Mesa CHIA for the following reasons:

- It has a finer grid spacing, which allows for a more accurate simulation of pumping effects near both the mine and adjacent communities.
- It incorporates more recent data on water levels and withdraws.
- It examined a longer historical data period (beginning in 1956 rather than 1965).
- It evaluated various pumping scenarios to predict water levels to the year 2054, rather than to 2014.
- It provides a more detailed characterization and analysis of system recharge.
- It evaluates geologic structure that influences groundwater flow.
- It provides better model boundaries and increases the model extent.
- It provides a more complex definition of the hydrologic system, using additional model layers to simulate the D aquifer system.

OSMRE has independently reviewed the 3D Model and determined that the model satisfies the intended objectives outlined above, and it is the most comprehensive groundwater assessment tool for predictive impact evaluations necessary to address concerns related to PWCC water supply pumping.

The 3D Model accounts for the 70-percent reduction in PWCC pumping, which after December 31, 2005, and makes predictions for the future potentiometric surface of the N aquifer based on variables such as different pumping scenarios, recharge rates, and evapotranspiration rates. The 3D model was validated against measured data in 2005 and 2010 to verify that model simulated water levels are consistent with measured trends.

5.2.4.1 N aquifer Quantity

Groundwater flows from areas of high groundwater hydraulic head to areas of lower groundwater hydraulic head. The areas of high groundwater head occur near the predominant recharge areas to the northwest and southeast of the Black Mesa basin (Figure 27). The aquifer naturally discharges as springs and baseflow to the northeast and southwest of the Black Mesa basin at areas of lower groundwater elevation. Prior to N aquifer pumping, the steady-state flow system pattern had a hydrologic groundwater divide oriented northwest to southeast, and passing near the southwest corner of the Kayenta Complex (Figure 27). A groundwater divide is a non-structural boundary from which groundwater moves away from the divide in both directions, and flow does not occur across the boundary. The steady-state flow system was developed from the evaluation of all available water levels in the Black Mesa basin.

After evaluating the quality of available water level information, 344 wells and springs were retained for the development of a steady-state potentiometric surface, and used as pre-pumping calibration targets (Figure 26). In a calibrated steady-state model, simulated water levels should not significantly differ from measured water levels. The difference between the simulated and measured water levels is considered the residual error, and represents the difference between model derived hydraulic head and field measured target values. The procedure for calibrated steady-state model development is explained in greater detail in the 3D Model report (PWCC, 1999). The procedure provided in the calibration report documentation and the residual water level error after calibration have been reviewed by OSMRE and determined acceptable.

Groundwater pumped from the confined area of the N aquifer is released from aquifer storage, making it vital to understand the concept of aquifer storage. The N aquifer is approximately 2500 feet below ground surface at the Kayenta Complex. Due to significant depth, the N aquifer matrix is under a tremendous amount of stress from the weight of the overlying rock and water. The pressure of the water and the structural skeleton of the aquifer material together support the downward stresses induced by the weight of the overlying material. The difference between the downward stress and the water pressure is called the effective stress, that part of the downward stress that is supported by the aquifer matrix (structural skeleton). The water and the aquifer matrix itself respond to the applied effective stress by expanding and contracting.

For instance, water fills the void spaces of the Wingate Sandstone, Moenave Formation, Kayenta Formation, and the Navajo Sandstone forming the N aquifer. When the N aquifer is pumped, water pressure decreases due to a reduction in interstitial pore water pressure caused by the pumping well. Therefore, the water pressure that was initially countering the downward stresses is reduced, and the stress load borne by the aquifer matrix increases. Since the net pressure is less (original water pressure minus pumping induced pressure decline) when pumping occurs, water levels decline when compared to the original steady state condition. This pumping induced water level change between pre- and post-pumping is known as drawdown; and its areal extent known as the cone of depression. However, it is important to note that the apparent expansion and contraction of the water in the aquifer and the aquifer matrix itself are characterized by the change in total hydraulic head in a well. The total hydraulic head is reflected in the static water level found in the well bore and respond to changes in the hydrostatic (water) pressure. The water levels in the confined N aquifer reflect the hydrostatic pressure regime in the aquifer and are an indication of the net stresses exerted on the N aquifer.

Specific storage is defined as the volume of water that a unit volume of aquifer takes into or releases from storage under a unit change in hydraulic head under saturated aquifer conditions (Freeze and Cherry, 1979). As the cone of depression grows, a larger area of aquifer material is available to contribute water to the pumping well. Therefore, drawdown near the pumping center will occur quickly at first, with drawdown exponentially slowing as a greater volume of aquifer material is influenced. In the confined area of the N aquifer system for the Black Mesa basin, PWCC and community pumping has occurred from 1968 to present. The most recent USGS N aquifer monitoring reports that the hydrographs for all but one of the dedicated Black Mesa (BM) observation wells have shown consistent water level declines in the confined area since 1972 (Macy and Brown, 2011). Due to the generally constant pumping volume from 1969-2005, the rate of static water level decline has slowed in recent years as the cone of depression has encompassed a larger contributing area. The increase in the volume of aquifer influenced by pumping has allowed more water to be released from storage, thus slowing the rate of growth of the cone of depression.

5.2.4.1.1 N aquifer Quantity Monitoring Program

As PWCC and community pumping has continued in the Black Mesa region since 1968, the flow system has changed, and the system is no longer in steady-state equilibrium as water continues to come from aquifer storage in the confined N aquifer attributed to the decrease in N aquifer water pressure from pumping. The changes are monitored by the USGS using an areally extensive monitoring network consisting of approximately 37 wells in the confined and unconfined portions of the N aquifer (Figure 39). Of the 37 wells, 6 are dedicated for the sole purpose of monitoring water level changes, and are not pumped for any beneficial use. Wells that are periodically pumped may give a false representation of the drawdown in the regional aquifer system since small cones of depression develop at the pumping wells. Therefore, in an effort to get the best annual representation the regional aquifer system using available wells, the USGS will only collect and report a water level measurement after the well remains idle for an appropriate period of time. The idle, non-pumping, period will vary from location to location depending on the magnitude of pumping stress at the various community wells or remote windmills. If the recent pumping occurred at the location at the time of data collection, a drawdown value will not be reported since it will give a false representation of the regional aquifer drawdown.

Six monitored wells in the USGS monitoring program are not pumped, and identified as BM-1 through BM-6 (Figure 39). The BM-well series were installed in the early 1970's, and have a nearly complete non-equilibrium water level record. Monitoring wells BM-2, BM-3, BM-4, BM-5, and BM-6 are equipped with automated continuous recording devices that record a water level measurement every 15-minutes, and the data is posted to a USGS website every 4-hours (USGS, 2011).

The BM-well series are primarily completed in the Navajo Sandstone, and were specifically located and installed for the purpose of evaluating drawdown related to pumping of the N aquifer. Since the BM-well series are not pumped for water supply purposes, the water levels represent true N aquifer system drawdown. Therefore, the quality of water level data in the BM-well series is extremely high for OSMRE's regulatory purposes. OSMRE finds that the N aquifer ground water quantity monitoring program is currently sufficient for OSMRE to make the required evaluation for material damage potential in this CHIA.

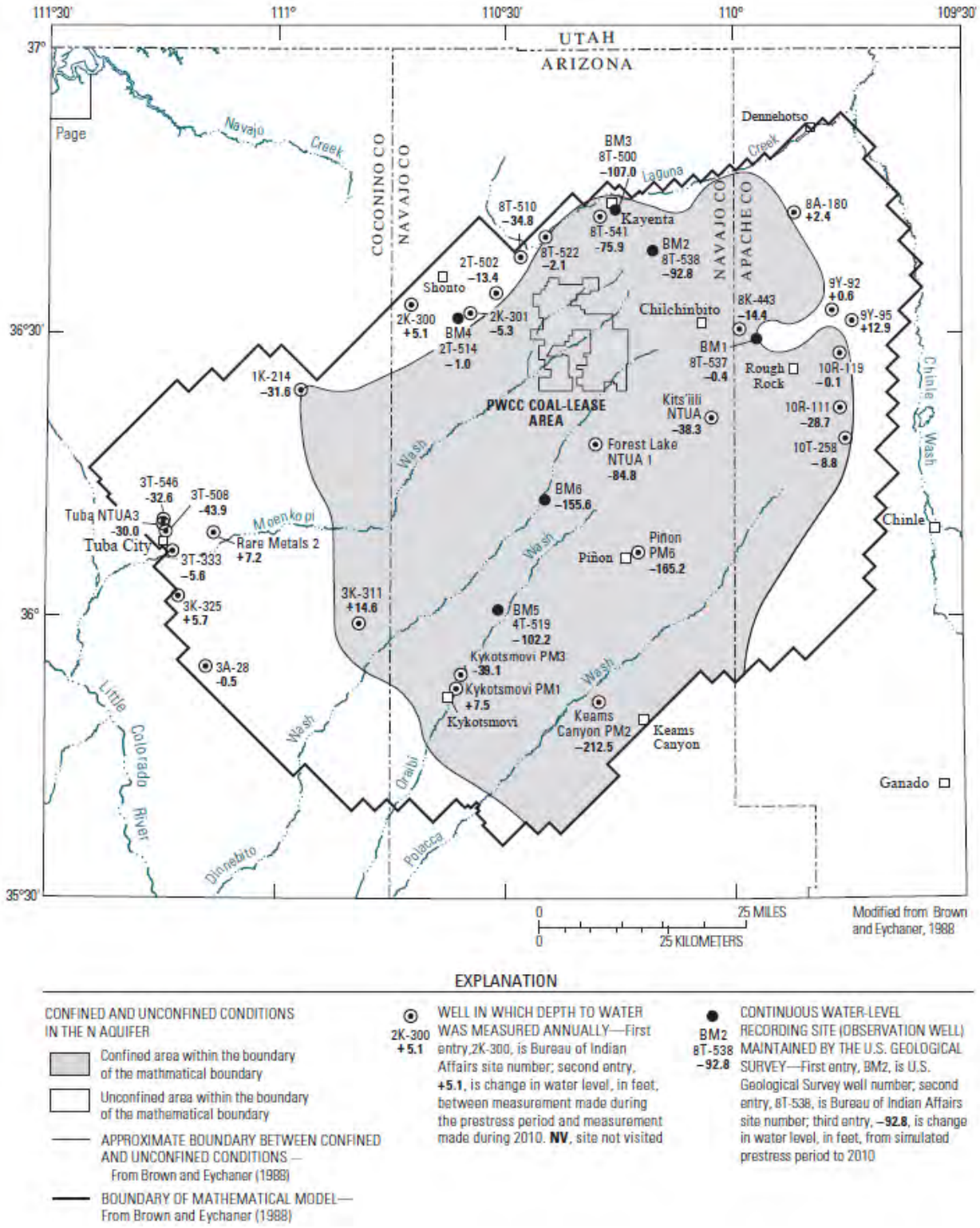


Figure 39: N aquifer water level changes from the pre-stress period to 2010 (Macy and Brown, 2011).

5.2.4.1.2 Transient Modeling

Changes in the regional groundwater system over time can be identified by using a numerical groundwater flow model to simulate known pumping rate stresses in the hydrologic system after calibration of steady-state conditions (i.e. baseline) and pumping conditions. Most notably, the extent and magnitude of N aquifer system drawdown can be reasonably simulated for the regional system. The simulation of changing drawdown over time is considered transient modeling. Similar to the steady-state simulation, the transient model simulates all the inflows and outflows to the hydrologic system through time, and uses various snapshots in time of the measured drawn down water levels as calibration targets.

A total of 47 wells were used for the transient non-equilibrium calibration targets. The high quality data and the spatial distribution of the BM-well series locations provided justification to weight the BM-well series data with a higher confidence compared to the other 41 transient calibration target locations. Specific information on the weighting factors for the drawdown residuals can be found in the 3D Model report (PWCC, 1999). Since the BM-well series have the most complete water level records, and were installed specifically for evaluating N aquifer drawdown, considerable effort was taken to numerically simulate the measured drawdown in the BM-wells while honoring the geologic model. After reviewing the calibrated transient model, OSMRE has determined that the calibrated model provides acceptable agreement with the measured water level changes. Figure 40 illustrates a comparison of measured water levels in the BM-6 with four calibrated 3D Model simulations for the dataset (through 1996) and more recently collected data (including the period after PWCC reduced their pumping at the end of 2005). It should be noted that OSMRE relies on the "High Evapotranspiration (ET), 100% Recharge" for predictive analysis, since that calibrated model most accurately matches measured water level conditions. The "High ET, 100% Recharge" is considered the base-case model. However, the results of all four calibrated model simulations are presented to illustrate the negligible to minor sensitivity to evapotranspiration and recharge.

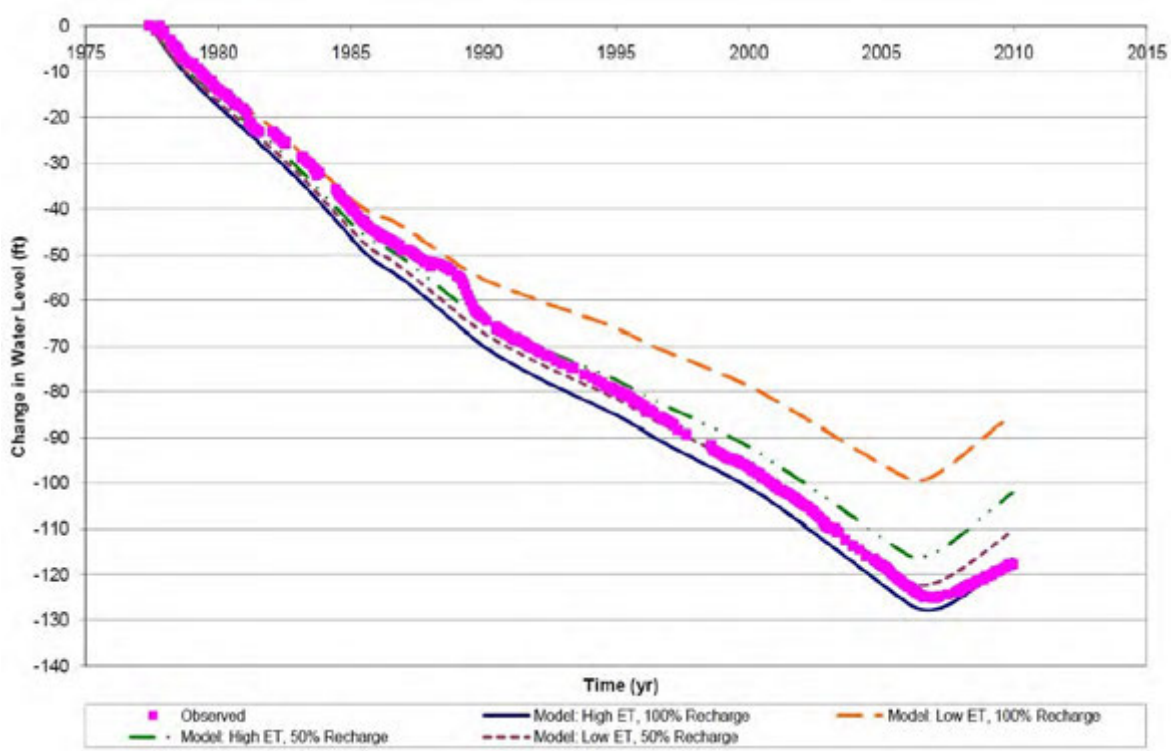


Figure 40: Simulated and Measured Drawdown at BM-6 (PWCC, v.11, ch.18, 2011).

In 2005, a supplemental report to the 3D Model further evaluated the sensitivity of model assumptions that may influence drawdown predictions, specifically N aquifer system thickness and aquifer structure. It also validated model predictions by comparing simulated and measured water levels for the BM wells through 2004 (PWCC, 2005). The model validation was completed again in 2010 using measured water level data through 2009, and results incorporated into the PWCC PHC (PWCC, v.11, ch.18, 2011). Aquifer thickness may influence transmissivity values, the amount of water held in storage, and ultimately water level measurements. The aquifer thickness in the confined area of the Navajo sandstone was divided by a factor of 2 to evaluate the sensitivity to aquifer thickness; however, hydraulic conductivity values had to be adjusted from the base case scenario (High ET, 100% Recharge) to adequately calibrate the new model to field measured water levels. The resultant calibrated model with reduced N aquifer system thickness provided similar agreement to the base-case 3D Model at the BM-series wells; however, simulated drawdown was lower at 5 of the 6 BM-wells compared to the base-case 3D Model. Therefore, although a calibrated model with thinner N aquifer system thickness is a reasonably good model of the N aquifer system, it is not as good at the base-case 3D Model.

The conceptual model for the base-case 3D Model also considered zones of lower hydraulic conductivity created by the deformation of rocks comprising the N aquifer along the Organ Rock and Comb Ridge monoclines north of the permit area. To test the sensitivity of the base-case model related to the effect of the lower hydraulic conductivity monocline zones, several additional calibrated models were developed. One additional calibrated model completely removed the monocline, and the other evaluated changes in hydraulic conductivity of the monocline zones related to measured water levels and drawdown. Removal of the low hydraulic conductivity monocline zones resulted in a calibrated model in good overall agreement between measured and simulated pre-pumping water levels, but the base-case 3D Model provides better overall agreement and is a better representation of the flow system and more accurately simulates the effects of PWCC pumping. Hydraulic conductivity of the monocline zones was also increased by two orders of magnitude using a separate calibrated model to evaluate if the increased hydraulic conductivity affects the predictions of PWCC pumping. The results indicate that the hydraulic conductivity can be increased in the monocline zones and yield similar simulated drawdown in the BM-wells compared to the base-case 3D Model (PWCC, 2005). However, increasing the hydraulic conductivity of the monocline may mask PWCC impacts from pumping near Kayenta and at the PWCC wellfield.

In summary, PWCC provided a numerical groundwater flow model of the Black Mesa basin for the D aquifer system and the N aquifer system; representing the D aquifer system as three hydrogeologic units, the N aquifer system as three hydrogeologic units, and separated by a low permeability confining unit. The model was successfully calibrated to simulate non-pumping equilibrium conditions (pre-1956), and then was successfully calibrated to simulate measured drawdown from 1956 through 1996. Once the transient groundwater model can adequately simulate drawdown when compared to measured drawdown while honoring the conceptual geologic model, the flow model is considered calibrated, and can be used for predictive simulations. Several sensitivity analyses verified that the base-case 3D Model most accurately simulates predictive drawdown effects from PWCC pumping while honoring the most reasonable conceptual geologic model.

The 3D Model, base-case scenario, will be used to evaluate concerns related to the PWCC pumping of the N aquifer. The N aquifer water quantity concerns to be evaluated for this CHIA are (1) impact to community N aquifer water supply wells, (2) impact to irrigation users in the Moenkopi area, (3) impact to N aquifer spring discharge, and (4) the potential for land subsidence.

5.2.4.1.3 N aquifer Impact Potential to Designated and Foreseeable Uses

Community Water Supply Wells

PWCC began pumping the N aquifer system to support mining operations at the Kayenta Complex in 1968 at 100 ac-ft/yr (Macy and Brown, 2011). By 1972, the annual pumping rate increased to 3,682 ac-ft. From 1972 through 2005, the average annual pumping rate was 3,983 ac-ft/yr, with the highest annual withdraw of 4,643 ac-ft occurring in 2002 (Macy and Brown, 2011). On January 1, 2006, the annual use of N aquifer decreased to an approximate rate of 1,400 ac-ft/yr.

Community pumping for municipal water supply also occurs in the confined N aquifer. In 1968, municipal community pumping in the confined N aquifer was 150 ac-ft (Macy and Brown, 2011). Municipal pumping rates steadily increased to 1,610 ac-ft of annual withdraw in the confined N aquifer in 2000, and averaged 1,409 ac-ft from 1998 - 2007 (Macy and Brown, 2011).

As described previously, groundwater pumping reduces pore water pressure. Since the net pressure is less (original water pressure minus pumping induced pressure decline) when pumping occurs, water levels have declined when compared to the original steady state condition. This pumping induced water level change between pre- and post-pumping is known as drawdown; and the areal extent of which is known as the cone of depression. It is the cone of depression in the confined N aquifer, represented by changes in pore water pressure, which has been raised as a concern by area residents. However, the saturated thickness of the confined N aquifer has remained unchanged, and the water resource remains available for the existing and foreseeable demands for municipal supply water.

As water is released from confined storage and the cone of depression grows, a larger area of aquifer material is available to contribute water to the pumping well. Therefore, drawdown near the pumping center will occur quickly at first, with drawdown exponentially slowing as a greater volume of aquifer material is influenced. Figure 41 illustrates the extent and magnitude of drawdown created by PWCC pumping from 1969 to 2005. Although the saturated thickness in the confined N aquifer has not changed, the drawdown contours represent a reduction in water pressure. Since are 70-percent reduction in PWCC pumping began on January 1, 2006, Figure 41 illustrates the approximate magnitude and extent of PWCC pumping influence on the N aquifer. USGS monitoring of the BM-well series, provides field measured confirmation for the simulated drawdown. The BM-well series had the following drawdown on December 31, 2005: BM-2 (85-feet), BM-3 (100-feet), BM-4 (0-feet), BM-5 (90-feet), and BM-6 (155-feet). Similar to measuring drawdown in the confined N aquifer, water level increases are expected in response to the reduced pumping rate at the PWCC wellfield. Since the drawdown measured at the BM-wells is a combination of both PWCC pumping and community pumping, complete recovery is not expected due to continued community and PWCC pumping.

PWCC wellfield pumping does not preclude the ability to develop the water resource for municipal water supply. However, the lowering of the potentiometric surface causes an increase in electrical power costs to lift the water to surface. The PWCC 3D Model provides the ability to separate the drawdown associated the municipal pumping and PWCC. Table 11 provides a snapshot of drawdown attributable to PWCC pumping at calendar year 1970, 1980, 1990, 2000, 2005, and 2010 for community water supply wells in the confined N aquifer. Table 12 provides a snapshot of annual pumping volume for community wells in the same calendar years.

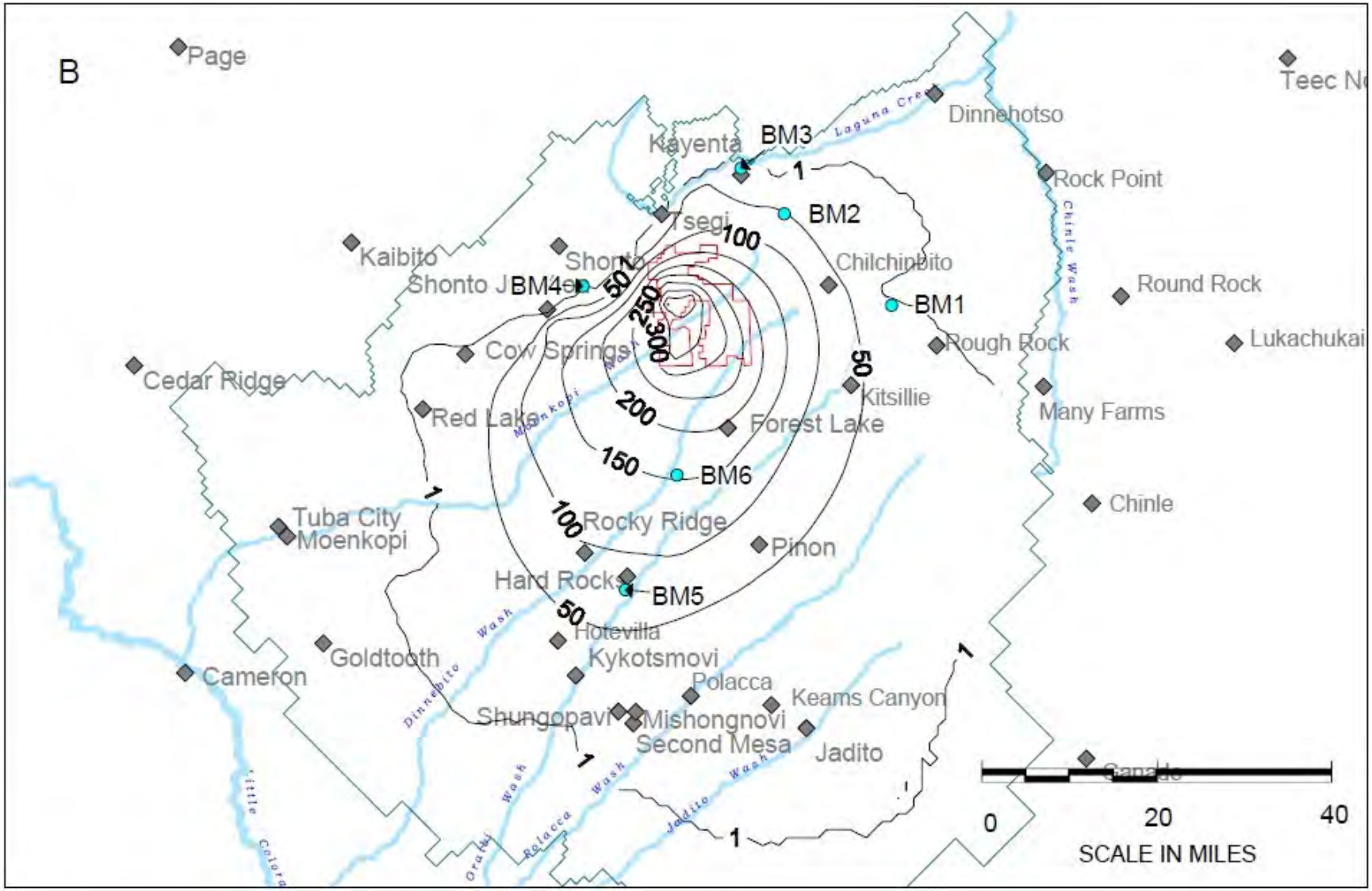


Figure 41: Simulated Drawdown in the N aquifer in 2005; Only PWCC Pumping (PWCC, v.11, ch.18, 2011).

Community Name	Well ID	1970	1980	1990	2000	2005	2010
Bacavi	only well	0.0	1.8	11.3	22.6	27.5	32.2
Chilchinbito	1	0.2	26.1	49.8	61.7	68.2	67.1
Chilchinbito	2	0.1	19.5	37.7	46.8	51.7	51.3
Chilchinbito	PM2	0.0	2.2	4.5	5.8	6.4	6.5
Chilchinbito	PM3	0.2	26.1	49.8	61.7	68.2	67.1
Forest Lake	4T-523	2.7	94.8	147.8	174.7	198.5	157.4
Hard Rock	2	0.2	28.2	65.9	90.7	103.3	106.9
Hopi Civic Center	only well	0.0	1.3	9.4	19.8	24.5	29.0
Hopi Cultural Center	only well	0.0	0.9	7.4	16.6	20.9	24.9
Hopi High School	No. 1	0.0	0.3	2.7	6.4	8.0	9.5
Hopi High School	No. 2	0.0	0.3	2.7	6.2	7.8	9.3
Hopi High School	No. 3	0.0	0.3	2.9	6.9	8.7	10.6
Hotevilla	PM1	0.0	2.0	11.9	23.6	28.6	33.5
Hotevilla	PM2	0.0	1.6	10.3	21.0	25.8	30.3
Kayenta	1	0.2	11.9	17.7	23.8	25.9	24.7
Kayenta	2	0.0	3.6	7.5	9.5	11.4	14.1
Kayenta	3	0.1	8.5	14.4	19.5	21.7	21.8
Kayenta	4	0.2	12.7	17.8	23.9	25.9	24.3
Kayenta	5	0.2	13.5	20.8	27.6	30.0	28.6
Kayenta	6	0.2	15.8	12.3	23.9	25.9	24.9
Kayenta	7	0.1	2.1	6.3	7.9	9.4	10.7
Kayenta	PM2	0.0	2.3	8.0	12.4	14.1	16.2
Kayenta	PM3	0.0	2.3	8.0	12.4	14.1	16.2
Keams Canyon	No. 2	0.0	0.3	3.0	6.8	8.5	10.1
Keams Canyon	No. 3	0.0	0.3	3.0	6.8	8.5	10.1
Kitsillie	1	0.0	0.0	0.2	0.6	0.8	0.9
Kitsillie	2	0.1	18.6	45.1	60.5	67.9	71.4
Kykotsmovi	PM1	0.0	1.2	9.2	19.5	24.2	28.7
Kykotsmovi	PM2	0.0	1.0	7.7	16.6	20.6	24.5
Kykotsmovi	PM3	0.0	1.2	8.9	18.7	23.1	27.3
Low Mountain	PM2	0.0	0.5	3.6	0.0	0.0	0.0
Mishongnovi	only well	0.0	0.4	4.4	11.1	14.3	17.3
Pinon	1	0.0	10.7	35.3	54.4	62.4	69.0
Pinon	2	0.0	8.1	29.3	46.4	53.4	59.6
Pinon	3	0.0	4.4	18.7	31.0	36.0	40.6
Pinon	PM6	0.0	14.1	42.2	63.0	72.1	78.7
Polacca	PM4	0.0	0.5	5.3	12.4	15.7	18.8
Polacca	PM5	0.0	0.0	0.1	0.3	0.4	0.5
Polacca	PM6	0.0	0.0	0.1	0.3	0.4	0.5
Rocky Ridge	PM2	0.1	23.3	57.9	81.7	93.2	98.3
Rocky Ridge	PM3	0.1	23.3	57.9	81.7	93.2	98.3
Rough Rock	1	0.0	2.0	6.8	0.1	11.1	12.2
Rough Rock	PM3	0.0	1.8	6.3	9.2	10.4	11.5
Rough Rock	PM5	0.0	1.6	5.8	8.5	9.6	10.6
Rough Rock	PM6	0.0	1.3	4.6	6.8	7.7	8.5
Rough Rock	PM7	0.0	1.8	6.3	9.2	10.4	11.5
Second Mesa	No. 1	0.0	0.2	3.4	8.9	11.7	14.3
Second Mesa	PM2	0.0	0.3	4.1	10.4	13.5	0.2

Table 11. PWCC Portion of Total Simulated Drawdown (feet) (PWCC, v.11, ch.18, 2011).

Community Name	Well ID	1970	1980	1990	2000	2005	2010
Bacavi	only well	0.0	0.0	0.0	21.5	4.9	5.6
Chilchinbito	1	0.0	12.0	18.2	25.5	17.1	19.5
Chilchinbito	2	0.0	12.0	17.6	12.2	29.0	33.0
Chilchinbito	PM2	0.0	0.0	7.0	3.5	4.0	4.6
Chilchinbito	PM3	0.0	0.0	7.2	7.8	6.2	7.0
Forest Lake	4T-523	0.0	0.6	12.8	12.8	14.0	15.9
Hard Rock	2	0.0	0.0	0.0	22.2	1.9	2.1
Hopi Civic Center	only well	0.0	2.5	2.5	2.5	3.5	4.0
Hopi Cultural Center	only well	0.6	4.7	11.2	10.7	11.1	12.6
Hopi High School	No. 1	0.0	0.0	7.2	2.6	4.0	4.5
Hopi High School	No. 2	0.0	0.0	4.3	17.9	6.0	6.9
Hopi High School	No. 3	0.0	0.0	2.2	17.7	12.6	14.4
Hotevilla	PM1	8.0	11.6	21.0	4.8	10.3	11.8
Hotevilla	PM2	0.0	6.5	3.6	20.5	23.3	26.6
Kayenta	1	0.0	63.6	59.7	81.8	81.1	92.4
Kayenta	2	42.5	63.6	58.2	55.8	67.6	76.9
Kayenta	3	42.5	63.6	68.0	66.3	83.1	94.6
Kayenta	4	0.0	63.6	86.1	107.0	100.8	114.8
Kayenta	5	0.0	63.6	229.7	152.2	147.0	167.4
Kayenta	6	0.0	63.6	95.6	95.8	78.9	89.8
Kayenta	7	0.0	63.6	82.6	53.1	80.8	92.0
Kayenta	PM2	42.5	63.6	55.1	34.6	56.4	64.2
Kayenta	PM3	42.5	63.6	21.7	41.7	46.5	53.0
Keams Canyon	No. 2	3.9	12.3	32.6	39.6	23.9	27.2
Keams Canyon	No. 3	0.0	9.8	31.2	54.1	13.4	15.3
Kitsillie	1	0.0	0.0	10.4	0.8	8.2	9.3
Kitsillie	2	0.0	0.0	0.0	8.2	13.1	14.2
Kykotsmovi	PM1	3.8	8.1	23.2	31.0	35.2	40.1
Kykotsmovi	PM2	0.0	17.8	42.7	19.4	40.1	45.6
Kykotsmovi	PM3	3.4	8.0	2.9	48.0	28.8	32.8
Low Mountain	PM2	0.0	8.7	8.0	0.0	0.0	0.0
Mishongnovi	only well	0.0	0.0	3.1	6.0	8.0	9.1
Pinon	1	0.0	0.0	54.6	76.2	64.7	73.6
Pinon	2	0.0	0.0	15.1	90.2	54.2	61.7
Pinon	3	0.0	0.0	8.6	122.6	20.3	23.1
Pinon	PM6	4.3	13.4	35.5	17.5	19.9	58.2
Polacca	PM4	0.0	0.0	29.7	45.0	51.1	58.2
Polacca	PM5	0.0	0.0	26.1	92.2	100.7	114.6
Polacca	PM6	0.0	0.0	3.6	2.3	9.1	10.4
Rocky Ridge	PM2	5.0	8.6	5.8	0.0	10.3	11.8
Rocky Ridge	PM3	0.0	6.3	8.7	13.7	15.3	17.4
Rough Rock	1	0.0	0.0	12.0	12.9	14.4	16.3
Rough Rock	PM3	5.9	7.8	0.7	6.4	4.8	5.5
Rough Rock	PM5	5.91	7.81	13.04	11.69	13.12	14.82
Rough Rock	PM6	5.91	7.81	22.46	11.61	21.54	24.33
Rough Rock	PM7	0	0	4.34	5.8	3.9	4.4
Second Mesa	No. 1	0	0	0.72	0.8	0.27	0.3
Second Mesa	PM2	1.5	3.54	8.69	5.6	5.1	5.81

Table 12. Annual Pumping at Community Supply Wells (ac-ft) (PWCC, v.11, ch.18, 2011).

Using an assumed power cost value of $0.074 Kw/hr, annual pumped volume, and drawdown attributable to PWCC pumping, the increase in cost to operate a well in the confined N aquifer can be calculated using the following equation (Campbell and Lehr, 1974):

$$Cost\ /\ Hour = \frac{(pumping\,rate\ (gpm))\,x\,(Lift + friction\ (ft))\ x\ (0.746)\,x\,(power\ (K/kW-hr))}{(3960)\ x\ (pump\,efficiency)\ x\ (motor\,efficiency)}$$

Where:

Friction = 0
Pump Efficiency = 0.75 (75%)
Motor Efficiency = 0.90 (90%)
Power Costs = $0.074 per kW-hr

There is a cost for lifting the water, and a separate cost associated with the pressure loss caused by friction in the pump column. The following discussion only addresses the cost for lifting the water, as that cost is a function of the depth to water, and thus the drawdown caused by pumping at the Kayenta Complex. The term "friction" in the above equation is set to zero, so that the calculated cost only reflects the cost to lift the water. Using the above equation and assumptions, coupled with the annual pumping rate and drawdown information, an assessment of PWCC impacts on municipal well locations can be completed. Consistent with the Kayenta Mine EA (OSMRE, 2011c), percent increase in pumping costs attributable to PWCC pumping will be used for impact assessment criteria. Percent increase in pumping cost at community supply wells attributable to N aquifer pumping at the Kayenta Complex are provided in Table 13. The impacts are considered moderate if there is a 26 – 50 percent increase in pumping costs. Therefore, OSMRE will establish the material damage threshold as a 26-percent increase in pumping cost. The impacts are considered major if increases in pumping costs are greater than 50-percent, and considered the material damage limit.

Forest Lake is the closest community in the confined N aquifer relative the PWCC pumping center. In 2005, drawdown attributable to PWCC pumping was 198.5 feet (Table 11). In 2010, the drawdown at Forest Lake attributable to PWCC pumping is 157.4 feet. The water level rise reflects the influence of PWCC's 70-percent reduction in N aquifer pumping at the end of 2005. Percent increase in pumping costs at Forest Lake attributable to PWCC is 18.1% in 2005, and 14.4% in 2010.

Pinon is the community in the confined N aquifer with the high annual volume of pumping. Review of Pinon well PM6 indicates drawdown attributable to PWCC pumping in 2005 of 72.1 feet, and 78.7 feet in 2010 (Table 11). Water level recovery at Pinon well PM6 due to reduced PWCC pumping is simulated to begin in 2011, and is delayed compared to Forest Lake due to proximity to the PWCC pumping center (PWCC, v.11, ch.18, 2011). Percent increase in pumping costs at Pinon PM6 attributable to PWCC pumping is 9.7% in 2005, and 10.6% in 2010.

Similar to the community of Pinon, the community of Rocky Ridge is about the same distance from the PWCC pumping center, and the maximum drawdown attributed to PWCC pumping occurs in 2010. Simulated drawdown attributable to PWCC pumping at Rocky Ridge well PM2 is 93.2 feet in 2005, and 98.3 feet in 2010 (Table 11). Percent increase in pumping costs at Rocky Ridge well PM6 is 20.0% in 2005, and 21.1% in 2010 (Table 13). Rocky Ridge represents the location with highest percent increase attributable to PWCC pumping, and is below the material damage threshold of 26%.

Community Name	Well ID	1970	1980	1990	2000	2005	2010
Bacavi	only well	0.0	0.2	1.2	2.5	3.0	3.6
Chilchinbito	1	0.0	5.7	10.9	13.5	14.9	14.6
Chilchinbito	2	0.0	7.1	13.7	17.1	18.8	18.7
Chilchinbito	PM2	0.0	0.6	1.1	1.4	1.6	1.6
Chilchinbito	PM3	0.0	6.5	12.3	15.2	16.8	16.6
Forest Lake	4T-523	0.2	8.6	13.5	15.9	18.1	14.4
Hard Rock	2	0.0	4.6	10.7	14.7	16.7	17.3
Hopi Civic Center	only well	0.0	0.3	2.5	5.2	6.4	7.5
Hopi Cultural Center	only well	0.0	0.1	0.9	1.9	2.4	2.9
Hopi High School	No. 1	0.0	0.1	0.6	1.4	1.7	2.0
Hopi High School	No. 2	0.0	0.1	0.6	1.5	1.8	2.2
Hopi High School	No. 3	0.0	0.1	0.7	1.7	2.1	2.6
Hotevilla	PM1	0.0	0.2	1.3	2.5	3.0	3.5
Hotevilla	PM2	0.0	0.2	1.1	2.2	2.8	3.2
Kayenta	1	0.1	5.9	8.7	11.7	12.7	12.1
Kayenta	2	0.0	0.7	1.6	2.0	2.4	2.9
Kayenta	3	0.1	4.9	8.4	11.4	12.6	12.7
Kayenta	4	0.1	6.2	8.6	11.6	12.5	11.8
Kayenta	5	0.1	6.0	9.2	12.3	13.3	12.7
Kayenta	6	0.1	10.0	7.8	15.1	16.4	15.7
Kayenta	7	0.0	1.2	3.5	4.4	5.3	5.9
Kayenta	PM2	0.0	1.0	3.5	5.4	6.1	7.1
Kayenta	PM3	0.0	1.0	3.5	5.4	6.1	7.1
Keams Canyon	No. 2	0.0	0.1	1.0	2.3	2.9	3.4
Keams Canyon	No. 3	0.0	0.1	1.0	2.3	2.9	3.4
Kitsillie	1	0.0	0.0	0.0	0.0	0.1	0.1
Kitsillie	2	0.0	1.4	3.5	4.7	5.2	5.5
Kykotsmovi	PM1	0.0	0.6	4.2	8.8	11.0	13.1
Kykotsmovi	PM2	0.0	0.5	3.5	7.5	9.4	11.1
Kykotsmovi	PM3	0.0	0.6	4.2	8.9	11.0	13.0
Low Mountain	PM2	0.0	0.1	0.7	0.0	0.0	0.0
Mishongnovi	only well	0.0	0.0	0.6	1.4	1.8	2.2
Pinon	1	0.0	1.4	4.7	7.3	8.4	9.3
Pinon	2	0.0	1.1	3.9	6.2	7.2	8.0
Pinon	3	0.0	0.6	2.5	4.2	4.8	5.5
Pinon	PM6	0.0	1.9	5.7	8.5	9.7	10.6
Polacca	PM4	0.0	0.3	3.1	7.3	9.2	11.0
Polacca	PM5	0.0	0.0	0.1	0.2	0.2	0.3
Polacca	PM6	0.0	0.0	0.1	0.2	0.2	0.3
Rocky Ridge	PM2	0.0	5.0	12.4	17.5	20.0	21.1
Rocky Ridge	PM3	0.0	5.0	12.4	17.5	20.0	21.1
Rough Rock	1	0.0	0.3	1.0	0.0	1.6	1.7
Rough Rock	PM3	0.0	0.3	0.9	1.3	1.5	1.6
Rough Rock	PM5	0.0	0.5	1.9	2.8	3.2	3.5
Rough Rock	PM6	0.0	0.2	0.6	1.0	1.1	1.2
Rough Rock	PM7	0.0	0.3	0.9	1.3	1.4	1.6
Second Mesa	No. 1	0.0	0.1	1.2	3.2	4.2	5.1
Second Mesa	PM2	0.0	0.1	1.1	2.8	3.6	0.0

Table 13. Percent Lift Cost Increase Attributable to PWCC Pumping at Community Wells.

N aquifer Baseflow

Baseflow represents groundwater discharge to surface water that has seeped into a stream bed. Baseflow occurs in unconfined conditions, and the discharge rate is dependent on the water table elevation height in relation to surface water elevation in the receiving streambed. The N aquifer water level elevations adjacent to the various washes where the exposed N aquifer is unconfined are typically higher than the surface water elevations in the various washes, allowing for baseflow discharge to occur. In the N aquifer CIA, baseflow from the N aquifer occurs at Chinle Wash, Laguna Creek, Pasture Canyon, Moenkopi Wash, Dinnebito Wash, Oraibi Wash, Polacca Wash, Jadito Wash, and Cow Springs; there are areas where surface stream activity has eroded through the overlying geologic units, exposing the N aquifer in the various washes.

Using the 3D Model, impacts to baseflow discharge at the above listed washes can be assessed. Table 14 presents the discharge reductions from pre-pumping conditions in 1955. The discharge reductions to the washes attributed to PWCC pumping, community pumping, and all pumping are presented for the year 2005. Washes projected to have the highest reduction in baseflow in 2005 due to N aquifer pumping include Laguna Creek, Pasture Canyon, and Polacca Wash. However, the flow reduction for the three washes with highest simulated reduction in baseflow is largely attributed to community N aquifer pumping, not PWCC pumping. Currently, PWCC pumping has not caused more than 0.5% reduction in baseflow to any of the washes receiving discharge from the N aquifer.

	1955		2005		Change due to Pumping			% Reduction	
Pumping	All	Non-PWCC	All	Non-PWCC	All	Non-PWCC	PWCC	All	PWCC
Chinle Wash	498.9	498.9	498.8	498.8	0.0	0.0	0.0	0.01	0.00
Laguna Creek	2535.4	2535.4	2434.5	2443.2	100.9	92.2	8.7	3.98	0.34
Pasture Canyon	426.8	426.8	389.4	389.4	37.3	37.3	0.0	8.74	0.000
Moenkopi Wash	4305.1	4305.1	4283.3	4302.7	21.8	2.4	19.4	0.51	0.45
Dinebito Wash	515.6	515.6	515.0	515.3	0.6	0.3	0.3	0.12	0.06
Oraibi Wash	458.1	458.1	455.5	455.9	2.7	2.2	0.4	0.58	0.10
Polacca Wash	440.5	440.5	431.1	432.1	9.4	8.4	1.0	2.12	0.22
Jaidito Wash	2027.4	2027.4	2015.1	2018.2	12.3	9.2	3.1	0.61	0.15
Cow Spring	2178.0	2178.0	2169.1	2177.3	8.9	0.7	8.2	0.41	0.37

Note: All Discharge Rates in acre-feet per yer.

Table 14: Effects of Pumping on Simulated Discharge to Streams: 1955–2005 (PWCC, v.11, ch.18, 2011)

Moenkopi Wash is the only wash potentially impacted by PWCC pumping in the Black Mesa area that relies on N aquifer baseflow water for a designated use. Hopi and Navajo farmers in the Moenkopi area may pump water from Moenkopi Wash alluvium to irrigate crops. Since baseflow provides a constant source of water to saturate the alluvium, reduction in Moenkopi baseflow attributed to PWCC pumping is a concern. However, as presented in Table 14, Moenkopi baseflow reductions attributed to PWCC pumping do not exceed 1% of the total baseflow.

Consistent with the Kayenta Mine EA (OSMRE, 2011c), simulated percent reduction in baseflow discharge attributable to PWCC pumping will be used for impact assessment criteria. The impacts are considered moderate if there is a 21 to 30-percent simulated reduction in groundwater discharge. Therefore, OSMRE will establish the material damage threshold as a 21-percent simulated reduction in groundwater discharge. The impacts are considered major if simulated reduction in groundwater discharge is greater than 30-percent. The 30-percent reduction will be considered the material damage limit.

N aquifer Spring Discharge

The N aquifer system is regionally continuous throughout the groundwater CIA in the Black Mesa Basin. The N aquifer system is hydraulically confined in the interior of the Black Mesa Basin and becomes unconfined around the basin where the hydrologic formations are exposed at the surface. Similar to baseflow, the discharge rate is dependent on the water table elevation height in relation to surface water elevation in the receiving channel. The N aquifer water level elevations where the exposed N aquifer is unconfined are typically higher than the elevations of the adjacent downcut channels and formation outcrop areas, allowing for spring discharge to occur and formation water to seep at the formation outcrop areas.

Springs and seeps may emanate from the N aquifer formations along the confined—unconfined boundary. The Hopi communites at the southern extent of Black Mesa were largely settled due to their proximity to springs and seeps. However, due to its stratigraphic position above the N aquifer system, springs and seeps from the D aquifer system discharge near the Hopi communites, and the N aquifer system discharges as baseflow approximately 5-10 miles south of the Hopi communites where the washes downcut through the N aquifer formations. Springs and seeps also emanate on the western edge of Black Mesa at and near the communities of Moenkopi and Tuba City. Area residents are concerned about four specific springs and seeps in the Moenkopi and Tuba City area related to PWCC pumping, although it is acknowledged that more than four springs exist in this area. The four springs are known as Pasture Canyon Spring, Kerley Valley Spring, Red Point Outcrop Spring, and the Moenkopi School Spring. The subject of this impact assessment is whether PWCC pumping at Kayenta Complex will significantly and measurably impact spring discharge and the associated cultural and irrigation water uses.

Figure 41 illustrates the cone of depression for PWCC pumping at Kayenta Complex from 1956 through 2005. Figure 41 illustrates that the effects of PWCC pumping do not propagate out to the unconfined N aquifer in the Tuba City and Moenkopi area. Although beyond the scope of this assessment, it appears that local pumping in this area will impact spring flow and baseflow based on the proximity of springs to the local pumping areas. In 2009, Tuba City pumped 962.3 ac-ft, and Moenkopi pumped 79.6 ac-ft from the unconfined N aquifer (Figure 10). The lack of potential impact in the Tuba City area from PWCC pumping is due to differences in the type of aquifer system at the PWCC pumping center compared to the Tuba City pumping center. Both the Tuba City and PWCC pumping centers withdraw water from the N aquifer; however, the N aquifer is unconfined at Tuba City and confined at the PWCC wellfield.

Pumped water comes from aquifer storage. In a confined setting, aquifer storage is small (0.005 – 0.00005) compared to larger values (0.01 – 0.30) in an unconfined setting (Freeze and Cherry, 1979). Since the values are small in a confined setting, a larger area is influenced (represented as drawdown or changes in pressure head) to accommodate the water withdraw demand. Although the pressure head component of water level elevation changes, the saturated thickness remains unchanged in a confined aquifer. In an unconfined setting, the saturated thickness of the aquifer changes in response to pumping; therefore, the values of water coming from storage are much higher. As modeled and measured, PWCC effects of pumping the confined area of the N aquifer propagate out to the confined-unconfined boundary, where the hydrologic characteristics change. The fact that the hydrologic characteristic change from confined to unconfined is why measurable effects of PWCC pumping stop outward propagation near this boundary. Conversely, the hydrologic characteristics of pumping an unconfined system at Tuba City is why the effects of drawdown do not propagate very far from Tuba City even though a significant volume of water is withdrawn annually.

Even though the effects of Tuba City pumping do not extend very far from the Tuba City pumping, the N aquifer springs of concern are in close proximity to the Tuba City pumping, causing the spring flows in the area to potentially be impacted. For instance, the 3D Model predicts zero reduction in flow to Pasture

Canyon attributed to PWCC pumping, yet approximately a 9% reduction in Pasture Canyon discharge in 2005 attributed to local pumping (Table 14).

Due to the current N aquifer water withdraws at Tuba City, and the Village of Moenkopi to a lesser extent, which are near the N aquifer springs of concern, reductions in flow discharge are likely to occur if current community pumping trends continue. However, PWCC pumping of the N aquifer will not have impact on N aquifer springs of concern for religious and irrigation use in the area. Burro Spring is the only location on the confined—unconfined boundary with a historical monitoring record. Burro Spring discharge is statistically variable from year to year, but consistently flowing at less than a gallon a minute. Community pumping of the N aquifer near Burro Spring puts the sustainability of Burro Spring flow at risk. No additional N aquifer springs have been identified for monitoring as part of the USGS cooperative effort concerning the monitoring of N aquifer hydrologic resources. Additionally, a new delineation of the confined N aquifer extent has not been proposed during the USGS Cooperators annual meetings. The Black Mesa water resource monitoring program was established in 1971 by the USGS in cooperation with the Arizona Department of Water Resources. In 1983, the BIA entered into the cooperative effort. Overall, the persistence of this low flow spring at the confined—unconfined N aquifer boundary provides support that water quantity impacts have been minimized in this sensitive area.

Land Subsidence

There are three mechanisms that contribute to the compressibility of a porous medium. Compressibility can be achieved by: (1) compression of water, (2) compression of individual sand grains, and (3) by rearrangement of sand grains into a more closely packed configuration (Freeze and Cherry, 1979). The compressibility of individual well-sorted quartz sand grains is considered negligible, but the rearrangement of sand grains can often be the cause of land subsidence from pumping. Pore water pressure typically supports the packing arrangement of the aquifer material in unconsolidated basin fills. Therefore, when pore water pressure decreases in unconsolidated basin fills, the packing arrangement may change to a more closely packed arrangement. The closer arrangement may result in a decrease in aquifer thickness, which translates to the surface as a depression, or subsidence.

When the N aquifer is pumped, the pore water pressure decreases, and water comes from aquifer storage. Theoretically, the opportunity exists for the N aquifer sand grains to rearrange and cause subsidence. However, rearrangement of the aquifer material from pumping typically occurs in younger poorly sorted unconsolidated basin deposits; but the N aquifer is an old consolidated well sorted sandstone deposit. The N aquifer sediments are more than 135 million years old, and are buried deep enough that the majority of compaction and rearrangement has already occurred. Because the rocks in the Black Mesa area are presently being eroded, the rocks in the N aquifer have been subjected to greater stresses in the geologic past than they are currently. GeoTrans (1993) used eleven thin sections of rock sampled from the Navajo Sandstone to evaluate grain size, mineral content and cementation. The results of the evaluation identified that the high overburden pressure over the extensive period of time caused the quartz grains to weld together, confirming that subsequent rearrangement of the aquifer material would be minimal, if any. Additionally, the quartz sand grains comprising the Navajo Sandstone were concave/convex, which supports the concept that rearrangement of the aquifer material has already been realized from the high overburden pressure over the significant period of time due to the concave/convex deformation observed in the quartz grains.

PWCC also evaluated the results of triaxial compression tests on Navajo Sandstone samples taken at outcrops in the unconfined portion of the N aquifer. Pressures ranging between 400 psi and 2,000 psi were applied during testing, with the highest pressures being equivalent to the effective stress on the Navajo Sandstone in the center of the Black Mesa Basin. Compressibility determined from the results of the applied pressures during laboratory testing ranged from 2.78×10^{-7} ft^2/lb to 3.04×10^{-8} ft^2/lb, which results in the potential aquifer thickness reduction ranging from 1.93 feet to 17.44 feet in the center of the

basin where impacts would be most realized (GeoTrans, 1993). The results of the testing are conservatively biased toward greater compressibility for the following reasons:

(1) The samples were taken from unconfined outcrops where Navajo Sandstone compaction and stress release has partially occurred.
(2) The outcrop samples encountered some degree of weathering and loss of cementation.
(3) The compression test samples were oriented to apply the maximum loading parallel to the bedding planes, where the actual stress on the aquifer material is nearly perpendicular to the bedding plane. A sample loaded perpendicular to the bedding is expected to be stiffer, resulting in less compression than those loaded parallel to the bedding planes.

The compaction results derived from laboratory testing identified that the potential for measurable surface subsidence to occur as a result of PWCC wellfield pumping, is unrealistic. The conservative bias of the laboratory tests suggest that using samples from the confined area, and stressing the samples perpendicular to the bedding plane would result in less than 17-feet of reduction in N aquifer thickness. Additionally, a 17-foot reduction in N aquifer thickness would not likely translate through 2000-feet of overlying sediments to result in a 17-foot reduction in land surface. Rather, the overlying sediments would likely experience minute deformation to compensate for the change in thickness, resulting in immeasurable surface elevation change. PWCC also conducted video surveys of several Black Mesa mine water supply wells, the most recent occurring in September 2004 on well NAV5. No evidence of casing distress was noted in any of the surveyed well as might be expected if significant compression of the Navajo Sandstone or overlying units has occurred.

However, on February 13, 2003 and May 1, 2003 representatives from OSMRE, Navajo Nation Minerals Dept, Navajo Nation Water Resources Dept, USGS, PWCC, and Black Mesa residents investigated a report of land subsidence south of the lease boundary (OSMRE, 2004). Land subsidence features in the form of sinkholes, cracks, and slumps were reported near Forest Lake, about seven miles south of the Kayenta Complex. After investigation, the representatives identified that all of the subsidence features of concern were either in or adjacent to unconsolidated alluvial valley deposits. Several years of severe drought prior to the year 2003 produced desiccation cracks in the near surface, fine-grained, unconsolidated alluvial sediments. During periods of short and intense rainfall, surface runoff piped through the cracks. The piped water enlarged the cracks in the unconsolidated alluvium until the surface was undermined, forming near surface cavities that collapsed and became small sinkholes, and eventually larger slump areas within the alluvium.

PWCC has provided documentation to suggest that structural collapse of the N aquifer is unlikely. Additionally, field investigations have not revealed documented evidence to indicate the structural collapse of the N aquifer. Therefore, OSMRE finds that material damage to the structural stability of the N aquifer has not occurred, and the potential to cause material damage to existing and foreseeable uses is not supported by the available data and observations, and a material damage criterion is not warranted.

5.2.4.1.4 N aquifer Quantity Material Damage Threshold and Limit

In summary, PWCC pumping of the confined N aquifer system has reduced the water pressure within the N aquifer system. The reduction in water pressure does not limit the ability of the communities to utilize the N aquifer water resource for existing and foreseeable domestic water supply. However, a regional N aquifer monitoring network with reliance on the BM-wells, and a local water level monitoring at the PWCC wellfield will continue to be monitored to verify impact predictions in the base-case 3D Model, and validate simulated predictions against measured data. OSMRE will protect the N aquifer water resource by establishing material damage criteria with a threshold of a 26-percent increase in pumping

costs attributable to PWCC pumping, and a material damage limit of greater than a 50-percent increase in pumping costs.

Additionally, N aquifer baseflow will be assessed with the calibrated and validated 3D Model. Confirmation of simulated baseflow discharge to Moenkopi Wash using area specific monitoring near the primary discharge location was contemplated; however, cultural sensitivities and concerns of environmental surface impacts restricted the feasibility to implement confirmation monitoring. Therefore, based on the small simulated reduction in baseflow and cultural sensitivity to the specific baseflow discharge area, it is appropriate to rely on numerical simulation for impact assessment related to baseflow discharge. OSMRE will protect the N aquifer baseflow by establishing a material damage threshold of 21-percent reduction in simulated baseflow, and a material damage limit of greater than 30 percent reduction in simulated baseflow.

OSMRE finds that PWCC has adequately demonstrated the lack of measurable impact to N aquifer spring flow for the N aquifer springs of concern attributed to PWCC pumping. One low-flow spring, Burro Spring, exists at the confined—unconfined boundary, and will continue to be monitored for persistence. Therefore, OSMRE will not establish a material damage criterion for potential impacts to the reduction of N aquifer spring discharge. Regional N aquifer monitoring with reliance on the BM-wells, and a local water level monitoring at the PWCC wellfield will continue to be evaluated to verify impact predictions in the base-case 3D Model.

5.2.4.2 Navajo Aquifer Quality

Groundwater flows from areas of high hydraulic head potential to areas of low hydraulic head potential, and generally follows the flow path of least resistance. The total hydraulic head potential is reflected in the static water level measured in the wellbore. The water levels in the confined N aquifer reflect the hydrostatic pressure regime in the aquifer and are an indication of the net stresses exerted on the N aquifer.

The D aquifer system water predominantly flows horizontally due to the Carmel Formation aquitard separating the D aquifer and N aquifer systems. However, D aquifer water levels typically have a higher groundwater levels compared to N aquifer water levels, which means that there is a downward component of groundwater flow (Figure 22). Water level drawdown from pumping of the N aquifer system creates a greater difference between D aquifer and N aquifer water levels; therefore, the downward movement of water increases as drawdown increases. The rate at which water moves is determined by the vertical permeability of the Carmel Formation, its thickness, and the difference in water levels between the D and N aquifers.

The N aquifer is characterized as having a good water quality compared to the overlying D aquifer (Truini and Macy, 2006). In general, N aquifer water meets water quality standards for domestic supply established by NNEPA and HTWRP, while D aquifer water is not as good and typically does not meet domestic supply water quality standards. Therefore, a hydrologic impact concern related to N aquifer pumping is an increase in the leakage rate of poorer quality D aquifer water to the N aquifer, significantly degrading N aquifer water quality.

The USGS evaluated the hydrogeology of Black Mesa using geochemical and isotopic analysis, concluding that “the similarity of ground-water ages in the D aquifer to ages in the N aquifer suggests that leakage has been occurring for thousands of years” (Truini and Longsworth, 2003). The USGS evaluation also concluded that leakage is most likely to occur in the southern part of Black Mesa based on the geologic and hydrologic environment in that area (Truini and Longsworth, 2003). In the northern part of Black Mesa, isotopic analysis revealed significant statistical differences between the D aquifer and N aquifer water (Truini and Longsworth, 2003). The statistical difference in the northern area suggests that

the leakage potential under natural pre-pumping conditions was not as great compared to the southern area. However, the pumping and associated drawdown created by PWCC has increased the potential leakage in the northern area compared to equilibrium steady-state conditions.

The evaluation by the USGS indicates that the rate of leakage of water from the D aquifer to the N aquifer in the northern area under pre-pumping conditions was small. Otherwise, the water in the N aquifer would have been impacted by the D aquifer water because the leakage has been occurring for thousands of years. If the natural leakage rate was low, a significant increase in leakage rate (for example, a 100-percent increase or doubling the leakage rate) would have immeasurable effect on the quality of water in the N aquifer. Conversely, if the rate of pre-pumping leakage was higher, the impact on the water quality could be appreciable with a smaller percentage increase in leakage rate. Thus, monitoring water quality is a better approach to measuring impact than estimating percentage increases in the leakage rate.

5.2.4.2.1 N aquifer Quality Monitoring Program

Since PWCC pumping increases the pre-mining leakage potential between the D aquifer and N aquifer, the degradation of N aquifer quality due to mine related pumping remains a hydrologic concern. The USGS predicted that any increase in leakage from the D aquifer would first appear as increased total TDS (Eychaner, 1983). The USGS (Eychaner, 1983) also identified increased chloride and sulfate concentrations as important indicators of increased D aquifer leakage. Therefore, the USGS and PWCC have compiled and evaluated TDS, chloride, and sulfate concentrations in N aquifer wells since the early 1980's. To date, "the USGS Black Mesa monitoring program has not detected any significant changes in the major-ion water chemistry of the N aquifer that are related to induced leakage" (Thomas, 2002) (Truini and Longsworth, 2003).

OSMRE has been evaluating N aquifer production well water quality for more than three decades for trends in TDS, sulfate, and chloride in addition to many other water quality parameters. No significant increasing or decreasing trends in concentrations of TDS, sulfate, or chloride have been observed at any PWCC production well. Figures 42, 43, and 44 illustrate concentrations at PWCC N aquifer wells for the last 15 years for TDS, sulfate, and chloride, respectively.

All samples from PWCC pumping wells at the Kayenta Complex have maintained a TDS concentration of less than 350 mg/L over the last 15 years. Additionally, all samples from PWCC pumping wells typically have maintained a chloride concentration less than 10 mg/L over the last 15 years. NAV8 has maintained sulfate concentrations of approximately 120 mg/L, compared to all other NAV wells with sulfate concentrations typically less than 30 mg/L over the last 15 years.

Slight variations in water quality between the various production wells are a result of the screened interval. For instance, as presented in Table 10, NAV8 is the only well not drilled past the Navajo Sandstone into the underlying Kayenta Formation and Wingate Sandstone. Therefore, NAV8 has consistently elevated TDS and sulfate concentrations when compared to the other NAV water supply wells. However, the use potential for the Navajo aquifer remains unchanged at all production wells and is suitable for domestic and livestock uses.

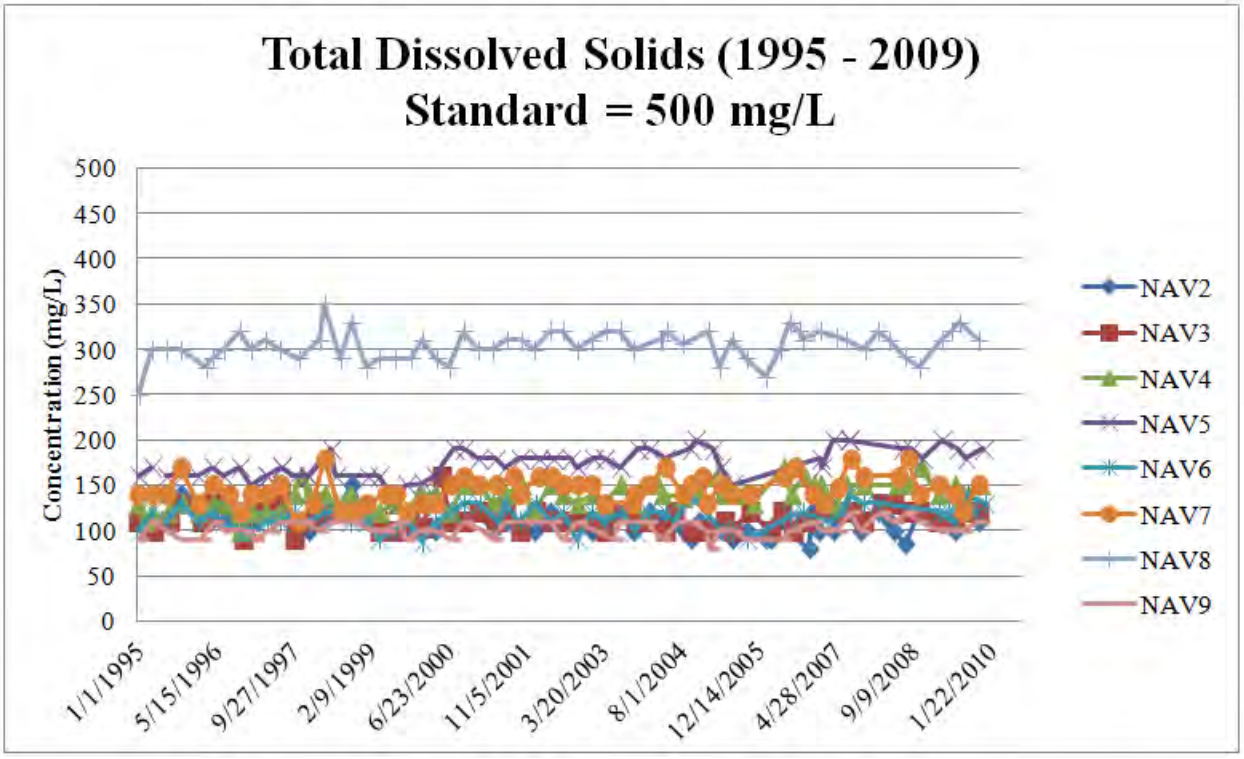


Figure 42: TDS Concentrations in PWCC Pumping Wells (1995 – 2009).

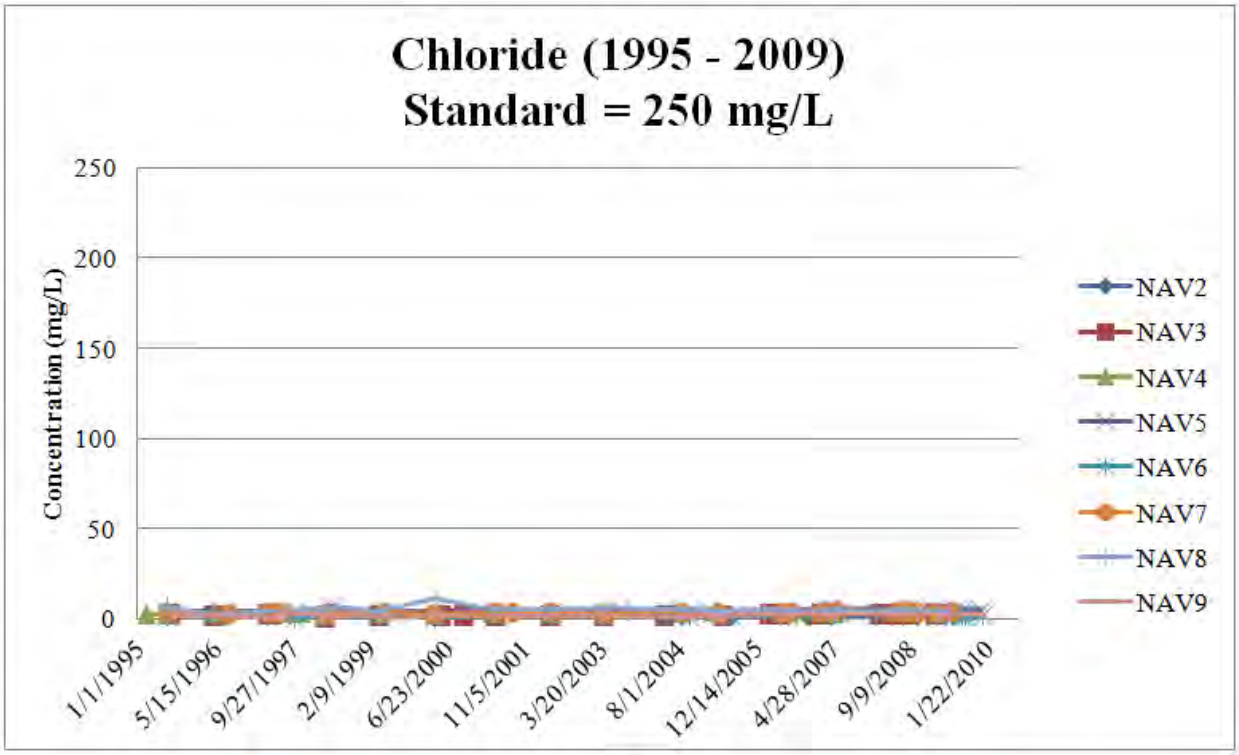


Figure 43: Chloride Concentrations in PWCC Pumping Wells (1995 – 2009).

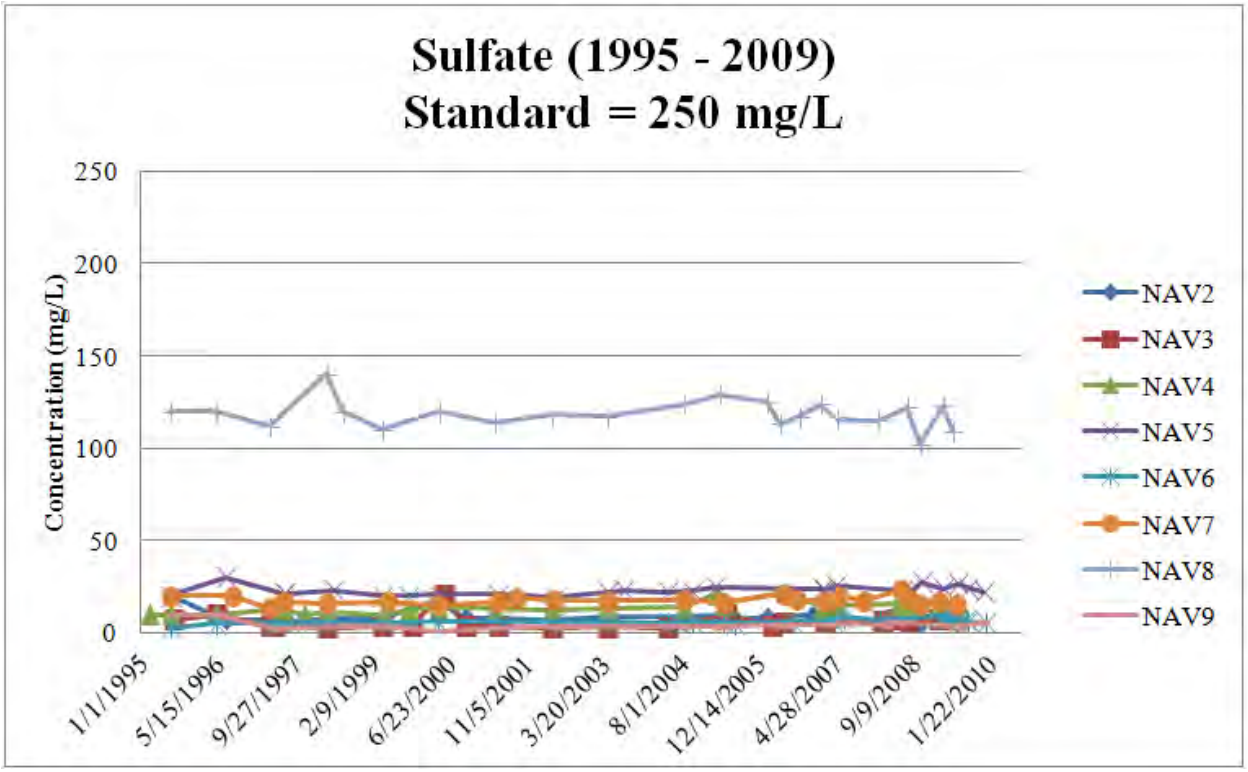


Figure 44: Sulfate Concentrations in PWCC Pumping Wells (1995 – 2009).

5.2.4.2.2 N aquifer Quality Impact Potential to Designated and Foreseeable Uses

Mine related pumping has not degraded the N aquifer water quality, and significant degradation causing material damage to the existing and foreseeable uses is unlikely to propagate outside the areal extent of the permit boundary. Water quality of the PWCC wellfield will continue to be assessed on a quarterly basis to ensure that the N aquifer continues to meet drinking water quality standards for TDS, sulfate, and chloride as established indictor water quality parameters.

5.2.4.2.3 N aquifer Quality Material Damage Threshold and Limit

OSMRE will assess N aquifer water quality impacts based on water quality at the PWCC wellfield, since highest N aquifer water quality impact potential is in the vicinity of the wellfield based on drawdown. OSMRE will continue to evaluate TDS, chloride, and sulfate water quality concentrations against the standards for domestic water supply. A material damage threshold of four consecutive exceedances will be established. A level of material damage will be considered a PWCC NAV well no longer meeting the TDS, chloride, and sulfate domestic water supply use standards. To date, PWCC pumping of the N aquifer has not caused material damage to the quality of N aquifer. PWCC's operation of the Kayenta Complex has been designed to prevent material damage to the quality of the N aquifer. However, water quality of the PWCC wellfield will continue to be assessed on a quarterly basis to ensure that the N aquifer continues to meet applicable water quality standards.

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Appendix E

Special Status Species Lists

NNHP
Navajo Natural Heritage Program

PO Box 1480
Window Rock, AZ
86515

P 928.871.6472
F 928.871.7603

http://nnhp.nndfw.org

16stan101

24-August-2016

Neil Lynn - Project Environmental Scientist
Stantec

SUBJECT: Kayenta Mine Permit Renewal Biological Evaluation

Neil Lynn,

NNHP has performed an analysis of your project in comparison to known biological resources of the Navajo Nation and has included the findings in this letter. The letter is composed of seven parts. The sections as they appear in the letter are:

1. **Known Species** – a list of all species within relative proximity to the project
2. **Potential Species** – a list of potential species based on project proximity to respective suitable habitat
3. **Quadrangles** – an exhaustive list of quads containing the project
4. **Project Summary** – a categorized list of biological resources within relative proximity to the project grouped by individual project site(s) or quads
5. **Conditional Criteria Notes** – additional details concerning various species, habitat, etc.
6. **Personnel Contacts** – a list of employee contacts
7. **Resources** – identifies sources for further information

Known Species lists "species of concern" known to occur within proximity to the project area. Planning for avoidance of these species is expected. If no species are displayed then based upon the records of the Navajo Nation Department of Fish and Wildlife (NNDFW) there are no "species of concern" within proximity to the project. Refer to the Navajo Endangered Species List (NESL) Species Accounts for recommended avoidance measures, biology, and distribution of NESL species on the Navajo Nation (http://nnhp.nndfw.org/sp_account.htm).

Potential Species lists species that are potentially within proximity to the project area and need to be evaluated for presence/absence. If no species are found within the Known or Potential Species lists, the project is not expected to affect any federally listed species, nor significantly impact any tribally listed species or other species of concern. Potential for species has been determined primarily on habitat characteristics and species range information. A thorough habitat analysis, and if necessary, species specific surveys, are required to determine the potential for each species.

Species of concern include protected, candidate, and other rare or otherwise sensitive species, including certain native species and species of economic or cultural significance. For legally protected species, the following tribal and federal statuses are indicated: NESL, federal Endangered Species Act (ESA), Migratory Bird Treaty Act (MBTA), and Eagle Protection Act (EPA). No legal protection is afforded species with only ESA candidate, NESL group 4 status, and species listed on the Sensitive Species List. Please be aware of these species during surveys and inform the NNDFW of observations. Reported observations of these species and documenting them in project planning and management is important for conservation and may

contribute to ensuring they will not be up listed in the future.

In any and all correspondence with NNDFW or NNHP concerning this project please cite the Data Request Code associated with this document. It can be found in this report on the top right corner of the every page. Additionally please cite this code in any biological evaluation documents returned to our office.

1. Known Species *(NESL=Navajo Endangered Species List, FE=Federally Endangered, FT=Federally Threatened, FC=Federal Candidate)*

Species

ACGE = Accipiter gentilis / Northern Goshawk NESL G4
MIMO = Microtus mogollonensis / Navajo Mountain Vole NESL G4
STOCLU = Strix occidentalis lucida / Mexican Spotted Owl NESL G3 FT

2. Potential Species

Species

ACGE = Accipiter gentilis / Northern Goshawk NESL G4
AEAC = Aegolius acadicus / Northern Saw-whet Owl NESL G4
AQCH = Aquila chrysaetos / Golden Eagle NESL G3
CASP = Carex specuicola / Navajo Sedge NESL G3 FT
CIRY = Cirsium rydbergii / Rydberg's Thistle NESL G4
EMTREX = Empidonax traillii extimus / Southwestern Willow Flycatcher NESL G2 FE
FAPE = Falco peregrinus / Peregrine Falcon NESL G4
LIPI = Lithobates pipiens / Northern Leopard Frog NESL G2
MIMO = Microtus mogollonensis / Navajo Mountain Vole NESL G4
PLZO = Platanthera zothecina / Alcove Bog-orchid NESL G3
STOCLU = Strix occidentalis lucida / Mexican Spotted Owl NESL G3 FT
ZIVA = Zigadenus vaginatus / Alcove Death Camass NESL G3

3. Quadrangles (7.5 Minute)

Quadrangles

Cliff Rose Hill (36110-D2) / AZ
Long House Valley (36110-E4) / AZ
Yucca Hill (36110-D3) / AZ

4. Project Summary *(EO1 Mile/EO 3 Miles=elements occuring within 1 & 3 miles., MSO=mexican spotted owl PACs, POTS=potential species, RCP=Biological Areas)*

SITE	EO1MI	EO3MI	QUAD	MSO	POTS	AREAS
T35 19E Sec 001	None	ACGE, STOCLU	Cliff Rose Hill (36110-D2) / AZ	None	STOCLU, LIPI, FAPE, EMTREX, AQCH, AEAC	Area 3

SITE	EO1MI	EO3MI	QUAD	MSO	POTS	AREAS
T35 19E Sec 001	ACGE	ACGE, STOCLU	Yucca Hill (36110-D3) / AZ	None	STOCLU, FAPE, EMTREX, AQCH, AEAC, ACGE	Area 3
T35 19E Sec 002	ACGE	ACGE, STOCLU	Yucca Hill (36110-D3) / AZ	None	STOCLU, FAPE, EMTREX, AQCH, AEAC, ACGE	Area 3
T35 19E Sec 003	ACGE	ACGE	Yucca Hill (36110-D3) / AZ	None	STOCLU, FAPE, EMTREX, AQCH, AEAC, ACGE	Area 3
T35 19E Sec 004	ACGE	ACGE, MIMO	Yucca Hill (36110-D3) / AZ	None	STOCLU, FAPE, EMTREX, AQCH, AEAC, ACGE	Area 3
T35 19E Sec 005	ACGE	ACGE, MIMO	Yucca Hill (36110-D3) / AZ	None	STOCLU, FAPE, EMTREX, AQCH, AEAC, ACGE	Area 3
T35 19E Sec 007	MIMO	ACGE, MIMO	Yucca Hill (36110-D3) / AZ	None	STOCLU, FAPE, EMTREX, AQCH, AEAC, ACGE	Area 3
T35 19E Sec 008	ACGE	ACGE, MIMO	Yucca Hill (36110-D3) / AZ	None	STOCLU, FAPE, EMTREX, AQCH, AEAC, ACGE	Area 3
T35 19E Sec 009	ACGE	ACGE, MIMO	Yucca Hill (36110-D3) / AZ	None	STOCLU, FAPE, EMTREX, AQCH, AEAC, ACGE	Area 3
T35 19E Sec 010	ACGE	ACGE	Yucca Hill (36110-D3) / AZ	None	STOCLU, FAPE, EMTREX, AQCH, AEAC, ACGE	Area 3
T35 19E Sec 011	ACGE	ACGE	Yucca Hill (36110-D3) / AZ	None	STOCLU, FAPE, EMTREX, AQCH, AEAC, ACGE	Area 3
T35 19E Sec 012	ACGE	ACGE	Cliff Rose Hill (36110-D2) / AZ	None	STOCLU, LIPI, FAPE, EMTREX, AQCH, AEAC	Area 3
T35 19E Sec 012	ACGE	ACGE	Yucca Hill (36110-D3) / AZ	None	STOCLU, FAPE, EMTREX, AQCH, AEAC, ACGE	Area 3
T35 19E Sec 013	ACGE	ACGE	Cliff Rose Hill (36110-D2) / AZ	None	STOCLU, LIPI, FAPE, EMTREX, AQCH, AEAC	Area 3
T35 19E Sec 013	ACGE	ACGE	Yucca Hill (36110-D3) / AZ	None	STOCLU, FAPE, EMTREX, AQCH, AEAC, ACGE	Area 3
T35 19E Sec 014	ACGE	ACGE	Yucca Hill (36110-D3) / AZ	None	STOCLU, FAPE, EMTREX, AQCH, AEAC, ACGE	Area 3

SITE	EO1MI	EO3MI	QUAD	MSO	POTS	AREAS
T35 19E Sec 015	ACGE	ACGE	Yucca Hill (36110-D3) / AZ	None	STOCLU, FAPE, EMTREX, AQCH, AEAC, ACGE	Area 3
T35 19E Sec 016	ACGE	ACGE, MIMO	Yucca Hill (36110-D3) / AZ	None	STOCLU, FAPE, EMTREX, AQCH, AEAC, ACGE	Area 3
T35 19E Sec 017	ACGE	ACGE, MIMO	Yucca Hill (36110-D3) / AZ	None	STOCLU, FAPE, EMTREX, AQCH, AEAC, ACGE	Area 3
T35 19E Sec 018	MIMO	ACGE, MIMO	Yucca Hill (36110-D3) / AZ	None	STOCLU, FAPE, EMTREX, AQCH, AEAC, ACGE	Area 3
T35 19E Sec 021	ACGE	ACGE, MIMO	Yucca Hill (36110-D3) / AZ	None	STOCLU, FAPE, EMTREX, AQCH, AEAC, ACGE	Area 3
T35 19E Sec 022	ACGE	ACGE	Yucca Hill (36110-D3) / AZ	None	STOCLU, FAPE, EMTREX, AQCH, AEAC, ACGE	Area 3
T35 19E Sec 023	ACGE	ACGE	Yucca Hill (36110-D3) / AZ	None	STOCLU, FAPE, EMTREX, AQCH, AEAC, ACGE	Area 3
T35 19E Sec 027	ACGE	ACGE	Yucca Hill (36110-D3) / AZ	None	STOCLU, FAPE, EMTREX, AQCH, AEAC, ACGE	Area 3
T35 19E Sec 028	ACGE	ACGE, MIMO	Yucca Hill (36110-D3) / AZ	None	STOCLU, FAPE, EMTREX, AQCH, AEAC, ACGE	Area 3
T35 19E Sec 029	ACGE	ACGE, MIMO	Yucca Hill (36110-D3) / AZ	None	STOCLU, FAPE, EMTREX, AQCH, AEAC, ACGE	Area 3
T35 19E Sec 032	None	ACGE, MIMO	Yucca Hill (36110-D3) / AZ	None	STOCLU, FAPE, EMTREX, AQCH, AEAC, ACGE	Area 3
T35 19E Sec 033	None	ACGE, MIMO	Yucca Hill (36110-D3) / AZ	None	STOCLU, FAPE, EMTREX, AQCH, AEAC, ACGE	Area 3
T36 18E Sec 004	MIMO	ACGE, MIMO, STOCLU	Long House Valley (36110-E4) / AZ	None	STOCLU, MIMO, FAPE, EMTREX, AQCH, AEAC, ZIVA, PLZO, CIRY, CASP	Area 1
T36 18E Sec 005	ACGE, MIMO, STOCLU	ACGE, MIMO, STOCLU	Long House Valley (36110-E4) / AZ	None	STOCLU, MIMO, FAPE, EMTREX, AQCH, AEAC, ZIVA, PLZO, CIRY, CASP	Area 1

SITE	EO1MI	EO3MI	QUAD	MSO	POTS	AREAS
T37 18E Sec 028	MIMO, STOCLU	ACGE, MIMO, STOCLU	Long House Valley (36110-E4) / AZ	MSO PAC 555171 - Yellow Water Northwest	STOCLU, MIMO, FAPE, EMTREX, AQCH, AEAC, ZIVA, PLZO, CIRY, CASP	Area 1
T37 18E Sec 029	MIMO	ACGE, MIMO, STOCLU	Long House Valley (36110-E4) / AZ	None	STOCLU, MIMO, FAPE, EMTREX, AQCH, AEAC, ZIVA, PLZO, CIRY, CASP	Area 1
T37 18E Sec 032	ACGE, MIMO	ACGE, MIMO, STOCLU	Long House Valley (36110-E4) / AZ	None	STOCLU, MIMO, FAPE, EMTREX, AQCH, AEAC, ZIVA, PLZO, CIRY, CASP	Area 1
T37 18E Sec 033	MIMO	ACGE, MIMO, STOCLU	Long House Valley (36110-E4) / AZ	None	STOCLU, MIMO, FAPE, EMTREX, AQCH, AEAC, ZIVA, PLZO, CIRY, CASP	Area 1

5. Conditional Criteria Notes *(Recent revisions made please read thoroughly. For certain species, and/or circumstances, please read and comply)*

A. **Biological Resource Land Use Clearance Policies and Procedures (RCP)** - The purpose of the RCP is to assist the Navajo Nation government and chapters ensure compliance with federal and Navajo laws which protect, wildlife resources, including plants, and their habitat resulting in an expedited land use clearance process. After years of research and study, the NNDFW has identified and mapped wildlife habitat and sensitive areas that cover the entire Navajo Nation.
The following is a brief summary of six (6) wildlife areas:
1.***Highly Sensitive Area*** – recommended no development with few exceptions.
2.***Moderately Sensitive Area*** – moderate restrictions on development to avoid sensitive species/habitats.
3.***Less Sensitive Area*** – fewest restrictions on development.
4.***Community Development Area*** – areas in and around towns with few or no restrictions on development.
5.***Biological Preserve*** – no development unless compatible with the purpose of this area.
6.***Recreation Area*** – no development unless compatible with the purpose of this area.
None - outside the boundaries of the Navajo Nation
This is not intended to be a full description of the RCP please refer to the our website for additional information at http://www.nndfw.org/clup.htm.

B. **Raptors** – If raptors are known to occur within 1 mile of project location: Contact Chad Smith at 871-7070 regarding your evaluation of potential impacts and mitigation.

o **Golden and Bald Eagles**- If Golden or Bald Eagle are known to occur within 1 mile of the project, decision makers need to ensure that they are not in violation of the Golden and Bald Eagle Nest Protection Regulations found at http://nnhp.nndfw.org/docs_reps/gben.pdf.

o **Ferruginous Hawks** – Refer to "Navajo Nation Department of Fish and Wildlife's Ferruginous Hawk Management Guidelines for Nest Protection" http://nnhp.nndfw.org/docs_reps.htm for relevant information on avoiding impacts to Ferruginous Hawks within 1 mile of project location.

o **Mexican Spotted Owl** - Please refer to the Navajo Nation Mexican Spotted Owl Management Plan http://nnhp.nndfw.org/docs_reps.htm for relevant information on proper project planning near/within spotted owl protected activity centers and habitat.

C. **Surveys** – Biological surveys need to be conducted during the appropriate season to ensure they are complete and accurate please refer to NN Species Accounts http://nnhp.nndfw.org/sp_account.htm. Surveyors on the Navajo Nation must be permitted by the Director, NNDFW. Contact Jeff Cole at (928) 871-7068 for permitting procedures. Questions pertaining to surveys should be directed to the NNDFW Zoologist (Chad Smith) for animals at 871-7070, and Botanist (Andrea Hazelton) for plants at (928)523-3221. Questions regarding biological evaluation should be directed to Jeff Cole at 871-7068.

D. **Oil/Gas Lease Sales** – Any settling or evaporation pits that could hold contaminants should be lined and covered. Covering pits, with a net or other material, will deter waterfowl and other migratory bird use. Lining pits will protect ground water quality.

E. **Power line Projects** – These projects need to ensure that they do not violate the regulations set forth in the Navajo Nation Raptor Electrocution Prevention Regulations found at http://nnhp.nndfw.org/docs_reps/repr.pdf.

F. **Guy Wires** – Does the project design include guy wires for structural support? If so, and if bird species may occur in relatively high concentrations in the project area, then guy wires should be equipped with highly visual markers to reduce the potential mortality due to bird-guy wire collisions. Examples of visual markers include aviation balls and bird flight diverters. Birds can be expected to occur in relatively high concentrations along migration routes (e.g., rivers, ridges or other distinctive linear topographic features) or where important habitat for breeding, feeding, roosting, etc. occurs. The U.S. Fish and Wildlife Service recommends marking guy wires with at least one marker per 100 meters of wire.

G. **San Juan River** – On 21 March 1994 (Federal Register, Vol. 59, No. 54), the U.S. Fish and Wildlife Service designated portions of the San Juan River (SJR) as critical habitat for Ptychocheilus lucius (Colorado pikeminnow) and Xyrauchen texanus (Razorback sucker). Colorado pikeminnow critical habitat includes the SJR and its 100-year floodplain from the State Route 371 Bridge in T29N, R13W, sec. 17 (New Mexico Meridian) to Neskahai Canyon in the San Juan arm of Lake Powell in T41S, R11E, sec. 26 (Salt Lake Meridian) up to the full pool elevation. Razorback sucker critical habitat includes the SJR and its 100-year floodplain from the Hogback Diversion in T29N, R16W, sec. 9 (New Mexico Meridian) to the full pool elevation at the mouth of Neskahai Canyon on the San Juan arm of Lake Powell in T41S, R11E, sec. 26 (Salt Lake Meridian). All actions carried out, funded or authorized by a federal agency which may alter the constituent elements of critical habitat must undergo section 7 consultation under the Endangered Species Act of 1973, as amended. Constituent elements are those physical and biological attributes essential to a species conservation and include, but are not limited to, water, physical habitat, and biological environment as required for each particular life stage of a species.

H. **Little Colorado River** - On 21 March 1994 (Federal Register, Vol. 59, No. 54) the U.S. Fish and Wildlife Service designated Critical Habitat along portions of the Colorado and Little Colorado Rivers (LCR) for Gila cypha (humpback chub). Within or adjacent to the Navajo Nation this critical habitat includes the LCR and its 100-year floodplain from river mile 8 in T32N R6E, sec. 12 (Salt and Gila River Meridian) to its confluence with the Colorado River in T32N R5E sec. 1 (S&GRM) and the Colorado River and 100-year floodplain from Nautuloid Canyon (River Mile 34) T36N R5E sec. 35 (S&GRM) to its confluence with the LCR. All actions carried out, funded or authorized by a federal agency which may alter the constituent elements of Critical Habitat must undergo section 7 consultation under the Endangered Species Act of 1973, as amended. Constituent elements are those physical and biological attributes essential to a species conservation and include, but are not limited to, water, physical habitat, and biological environment as required for each particular life stage of a species.

I. **Wetlands** – In Arizona and New Mexico, potential impacts to wetlands should also be evaluated. The U.S. Fish & Wildlife Service's National Wetlands Inventory (NWI) maps should be examined to determine whether areas classified as wetlands are located close enough to the project site(s) to be impacted. In cases where the maps are inconclusive (e.g., due to their small scale), field surveys must be completed. For field surveys, wetlands identification and delineation methodology contained in the "Corps of Engineers Wetlands Delineation Manual" (Technical Report Y-87-1) should be used. When wetlands are present, potential impacts must be addressed in an environmental assessment and the Army Corps of Engineers, Phoenix office, must be contacted. NWI maps are available for examination at the Navajo Natural Heritage Program (NNHP) office, or may be purchased through the U.S. Geological Survey (order forms are available through the NNHP). The NNHP has complete coverage of the Navajo Nation, excluding Utah, at 1:100,000 scale; and coverage at 1:24,000 scale in the southwestern portion of the Navajo Nation. In Utah, the U.S. Fish & Wildlife Service's National Wetlands Inventory maps are not yet available for the Utah portion of the Navajo Nation, therefore, field surveys should be completed to determine whether wetlands are located close enough to the project site(s) to be impacted. For field surveys, wetlands identification and delineation methodology contained in the "Corps of Engineers Wetlands Delineation Manual" (Technical Report Y-87-1) should be used. When wetlands are present, potential impacts must be addressed in an environmental assessment and the Army Corps of Engineers, Phoenix office, must be contacted. For more information contact the Navajo Environmental Protection Agency’s Water Quality Program.

J. **Life Length of Data Request** – The information in this report was identified by the NNHP and NNDFW's biologists and computerized database, and is based on data available at the time of this response. If project planning takes more than two (02) years from the date of this response, verification of the information provided herein is necessary. It should not be regarded as the final statement on the occurrence of any species, nor should it substitute for on-site surveys. Also, because the NNDFW information is continually updated, any given information response is only wholly appropriate for its respective request.

K. **Ground Water Pumping** - Projects involving the ground water pumping for mining operations, agricultural projects or commercial wells (including municipal wells) will have to provide an analysis on the effects to surface water and address potential impacts on all aquatic and/or wetlands species listed below. NESL Species potentially impacted by ground water pumping: Carex specuicola (Navajo Sedge), Cirsium rydbergii (Rydberg's Thistle), Primula specuicola (Cave Primrose), Platanthera zothecina (Alcove Bog Orchid), Puccinellia parishii (Parish Alkali Grass), Zigadenus vaginatus (Alcove Death Camas), Perityle specuicola (Alcove Rock Daisy), Symphyotrichum welshii (Welsh's American-aster), Coccyzus americanus (Yellow-billed Cuckoo), Empidonax traillii extimus (Southwestern Willow Flycatcher), Rana pipiens (Northern Leopard Frog), Gila cypha (Humpback Chub), Gila robusta (Roundtail Chub), Ptychocheilus lucius (Colorado Pikeminnow), Xyrauchen texanus (Razorback Sucker), Cinclus mexicanus (American Dipper), Speyeria nokomis (Western Seep Fritillary), Aechmophorus clarkia (Clark's Grebe), Ceryle alcyon (Belted Kingfisher), Dendroica petechia (Yellow Warbler), Porzana carolina (Sora), Catostomus discobolus (Bluehead Sucker), Cottus bairdi (Mottled Sculpin), Oxyloma kanabense (Kanab Ambersnail)

6. Personnel Contacts

Wildlife Manager
Sam Diswood
928.871.7062
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Wildlife Tech
Sonja Detsoi
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sdetsoi@nndfw.org

7. Resources

National Environmental Policy Act

Navajo Endangered Species List:
http://nnhp.nndfw.org/endangered.htm

Species Accounts:
http://nnhp.nndfw.org/sp_account.htm

Biological Investigation Permit Application
http://nnhp.nndfw.org/study_permit.htm

Navajo Nation Sensitive Species List
http://nnhp.nndfw.org/study_permit.htm

Various Species Management and/or Document and Reports
http://nnhp.nndfw.org/docs_reps.htm

Consultant List
(Coming Soon)

Dexter D Prall, GIS Supervisor - Natural Heritage Program
Navajo Nation Department of Fish and Wildlife

NNHP
Navajo Natural Heritage Program

PO Box 1480
Window Rock, AZ
86515

P 928.871.6472
F 928.871.7603

http://nnhp.nndfw.org

Invoice for 16stan101

8/24/2016

Please make payable to NAVAJO NATION

Project Measurements

Total Number of Quads:	3
Number of Additional Quads:	0
Cost ($75 plus $5 each additional Quad):	$75.00

(Please cut along the dashed line and return with payment)

Navajo Natural Heritage Program
PO Box 1480
Window Rock, AZ 86515

8/24/2016

PLEASE PAY THIS AMOUNT

Payment for Data Response 16stan101 $75.00

Please make payable to NAVAJO NATION

DNR File/Cat

THE HOPI TRIBE

LeRoy N. Shingoitewa
CHAIRMAN

Herman G. Honanie
VICE-CHAIRMAN

June 14, 2012

Suzy J. Baldwin
Government Relations Liaison
Four Corners Power Plant
Arizona Public Service
P.O. Box 355
Fruitland, New Mexico 87416

Greetings Ms. Baldwin,

Per our discussion on Monday, June 11, 2012 regarding Arizona Public Service (APS) request for a specific Hopi Tribal Threatened and Endangered Species list and other Species of Concerns for the Environmental Impact Study (EIS) on the Four Corners and Navajo Mine Energy Project.

The Hopi Tribe's Wildlife & Ecosystem Management Program (WEMP) follows the U.S. Fish & Wildlife Service's (USFWS) Threatened and Endangered Species and Species of Concern list for all wildlife, fish and aquatic species within Navajo and Coconino County, Arizona, when addressing any impacts on species, potential habitat and overall disturbance. (See attached updated list.)

The Hopi Tribe's WEMP does have Hopi Cultural Sensitive Species which are highly revered as sacred and spiritual species to the Tribe. The Tribe requires any potential impacts and disturbance on the species, potential habitat disturbance, and prey base impacts are address and mitigating measures are placed to lessen the various impacts. The Hopi Cultural Sensitive Species are:

1. **Golden eagle** *Aquila chrysaetos*
2. **Bald eagles** *Haliaeetus leucocephalus*
3. **Red-tailed hawk** *Buteo jamaicensis*

Wildlife & Ecosystems Management Program • PO Box 123 • Kykotsmovi, AZ 86039
Telephone Number: (928) 734-3605/3606/3607 • Fax Number: (928) 734-3609

Further consultation with the Hopi Tribe's Wildlife & Ecosystems Management Program is required when it is determined a potential breeding area may be impacted by potential projects.

For additional information and any questions regarding the Tribe's Cultural Sensitive Species listing, please contact the Clayton Honyumptewa, Director - Department of Natural Resource at (928) 734-3601 or by email at CHonyumptewa@hopi.nsn.us.

Thank you for your inquiry.

Sincerely,

Clayton Honyumptewa, Director
Department of Natural Resources

06/14/12
Date

United States Department of the Interior

OFFICE OF SURFACE MINING
RECLAMATION AND ENFORCEMENT
Western Region Office
1999 Broadway, Suite 3320
Denver, CO 80202-3050

August 29, 2016

To: Field Supervisor, U.S. Fish and Wildlife Service, Arizona Ecological Service, 2321 West Royal Palm Road, Suite 103, Phoenix AZ 85021-4951. Attention Steve Spangle

From: Amy McGregor, Kayenta Mine Permit Coordinator

Subject: Kayenta Mine Five Year Permit Renewal Project (Project) – Informal Request: Confirmation of Revised Species List for Endangered Species Act (ESA) Section 7 Consultation

This letter respectfully requests written confirmation of the attached list of species (Table 1) and associated critical habitats (as applicable) that will need to be considered during the ESA Section 7 consultation for the Project. The U. S. Fish and Wildlife Service's (the Service) response to this request will inform the on-going planning effort for Project compliance with the ESA. Confirmation of the attached list will allow the Office of Surface Mining Reclamation and Enforcement (OSMRE) to refine continuing efforts to gather information on these species in support of a Biological Assessment (BA) for the Project. A request for formal consultation will be made at a later time. The attached list was developed using the Service's Information, Planning, and Conservation System (IPaC) in combination with Natural Heritage Program data from Arizona, Utah, and Nevada, input received from agency biologists during various conference calls conducted for the Project, and information from other ongoing or recently completed projects at the Kayenta Mine.

Project Overview

OSMRE is developing an Environmental Assessment under the National Environmental Policy Act (NEPA) for the analysis of potential effects associated with the renewal of Peabody Western Coal Company (PWCC) mining Permit AZ-0001E. Approval of the renewal would authorize the continuation of ongoing mining operations at the Kayenta Mine in coal resource areas N-9, J-19, and J-21 from July 6, 2015 through July 5, 2020 (Figure 1). Approximately 842 acres would be disturbed during this five-year renewal period. The proposed renewal does not include any revisions to the mining and operations plan or the addition of any new mining areas. For the proposed renewal period, coal-mining operations would be assumed to continue at the recent historical pace of approximately 8.1 million tons per year (mtpy) and existing facilities would be used for ongoing operations.

The only new mine facilities that are proposed to be constructed as part of the mining in N-9, J-19, and J-21 under the renewal would be sediment ponds, roads, utilities, and topsoil stockpiles as new but previously approved portions of these three areas are mined.

Compared to the last permit renewal consultation process in 2011 this BA and EA will also examine the indirect impacts associated with the combustion of coal. Coal mined at the Kayenta Mine is sent via electric railroad 83 miles northwest to the Navajo Generating Station near Page, Arizona, in northern Coconino County.

The preliminary action area for federally listed and candidate species includes the Kayenta Mine Permit Area and indirect Project-related impacts around the NGS (Figure 2). For example, based on previous atmospheric deposition modeling, the preliminary action area includes the area around the NGS in which deposition of heavy metals occurs due to current operations of the coal fired generating facility. This area is roughly estimated to be a 20-kilometer (12.4 mile) radius circle centered on NGS (Figure 2). The atmospheric deposition area is based on the atmospheric modeling that was conducted for the ongoing Kayenta Mine Complex-Navajo Generating Station EIS. The preliminary action area also includes portions of the Colorado River Upstream and downstream of the 20-kilometer radius area (i.e. Southwest Colorado River region), the San Juan Arm of Lake Powell, and the San Juan River upstream to the Highway 371 bridge in Farmington, New Mexico. The upstream extent of the San Juan River component of the preliminary action area is based on RPM 1a of the April 8, 2015 FCPP-NMEP BO; and the study area for the San Juan River Ecological Risk Assessment (ERA) related to the ongoing Kayenta Mine Complex-Navajo Generating Station EIS and Section 7 Consultation; and may be adjusted based on the results of that analysis.

Please review the attached list in light of the preliminary action area described above and let us know if you have any questions, comments, or revisions. If you do not have any revisions, please confirm that you concur with the list of species provided in Table 1 to be carried forward in the BA for the Project.

Table 1. List of Federal Species Considered for the Kayenta Permit Renewal Project

Species	Listing Status[1]	Species Listing		Critical Habitat	
		Date Listed or Proposed for Listing	Federal Register Number	Date Designated	Federal Register Number
Birds					
California condor (*Gymnogyps californianus*)	E	March 11, 1967	32 FR 4001	September 24, 1976	41 FR 41914
Mexican spotted owl (*Strix occidentalis*)	T	March 16, 1993	58 FR 14248	August 31, 2004	69 FR 53182
Southwestern willow flycatcher (*Empidonax traillii extimus*)	E	February 27, 1995	60 FR 10694	October 19, 2005	70 FR 60886
Western yellow-billed cuckoo (*Coccyzus americanus*)	T	October 3, 2014	79 FR 59991	December 2, 2014	79 FR 71373
Mammals					
Black-footed ferret (*Mustela nigripes*)	E	March 11, 1967	32 FR 4001	None designated	NA
Fish					
Bonytail (*Gila elegans*)	E	April 23, 1980	45 FR 27710	March 21, 1994	59 FR 13374
Colorado pikeminnow (*Ptychocheilus lucius*)	E	March 11, 1967	32 FR 4001	March 21, 1994	59 FR 13374

Humpback chub (*Gila cypha*)	E	March 11, 1967	32 FR 4001	March 21, 1994	59 FR 13374
Razorback sucker (*Xyrauchen texanus*)	E	October 23, 1991	56 FR 54957	March 21, 1994	59 FR 13374
Roundtail chub (*Gila robusta*)	P	July 12, 2005	70 FR 39981	July 12, 2005	70 FR 39981
Reptiles					
Northern Mexican gartersnake	T	July 8, 2014	79 FR 38677	July 10, 2013 (Proposed)	78 FR 41549
Plants					
Brady pincushion cactus (*Pediocactus bradyi*)	E	October 26, 1979	44 FR 61784	None designated	NA
Fickeisen plains cactus (*Pediocactus peeblesianus* var. *fickeiseniae*)	E	October 1, 2013	78 FR 60607	None designated	NA
Navajo sedge (*Carex specuicola*)	T	May 8, 1985	50FR 19370	May 8, 1985	50 FR 19370

1. T = Threatened, E = Endangered, and P = Proposed for listing

Thank you for your consideration of this informal request.

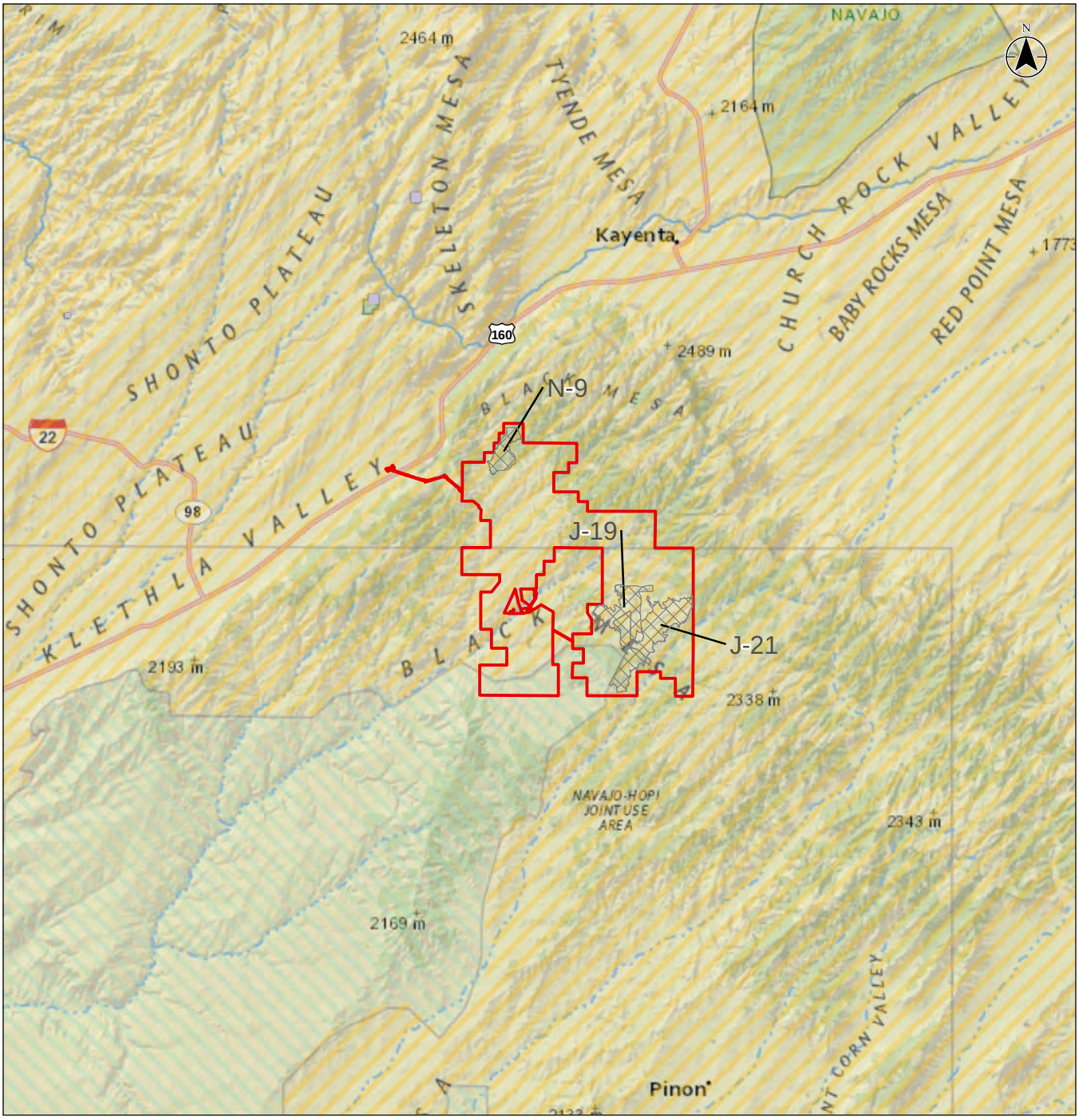
CC: Ms. Brenda Smith
Assistant Field Supervisor
U.S. Fish and Wildlife Service
Ecological Services
Southwest Forest Service Science Complex
2500 South Pine Knoll Drive
Flagstaff, AZ 86001

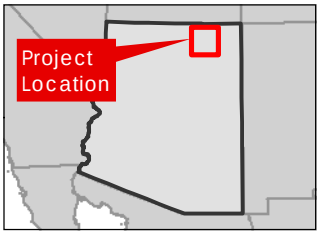
Mr. Mychal Yellowman
Manager Permitting Branch
Indian Program and Washington Program Mines
Program Support Division, Western Region
Federal Office of Surface Mining Reclamation and Enforcement
1999 Broadway, Suite 3320
Denver, CO 80202

Ms. Harrilene J Yazzie,
Supervisory Environmental Protection Specialist
Bureau of Indian Affairs – Navajo Region
Division of Environmental, Cultural and Safety Management
P.O. Box 1060
Gallup, NM 87301

Mr. Chip Lewis
Acting Regional Environmental Office
Western Regional Office
2600 North Central Avenue
4th Floor Mailroom
Phoenix, AZ 85004

V:\20371\Active\203706045\03_data\gis_cad\gis\mxds\BA_BE\Figure_1_Vicinity Map.mxd Revised: 2016-08-25 By: cgallegos





Notes

1. Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 Feet
2. Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

Legend

- Kayenta Mine Permit Area
- Coal Resource Area

Land Status

- Navajo National Monument (National Park Service)
- Hopi Indian Res.
- Navajo Indian Res.

0 3 6 miles

1:500,000 (at original document size of 8.5x11)

Stantec

Project Location	203706045
T35N R19E, T37N R18E, T36N R18E Navajo County, AZ	Prepared by CLG on 2016-08-25 Technical Review by SL on 2016-08-25 Independent Review by DK on 2016-08-25

Client/Project

PWCC
Kayenta Mine SMCRA Permit
BA/BE

Figure No.

1

Title

Vicinity Map

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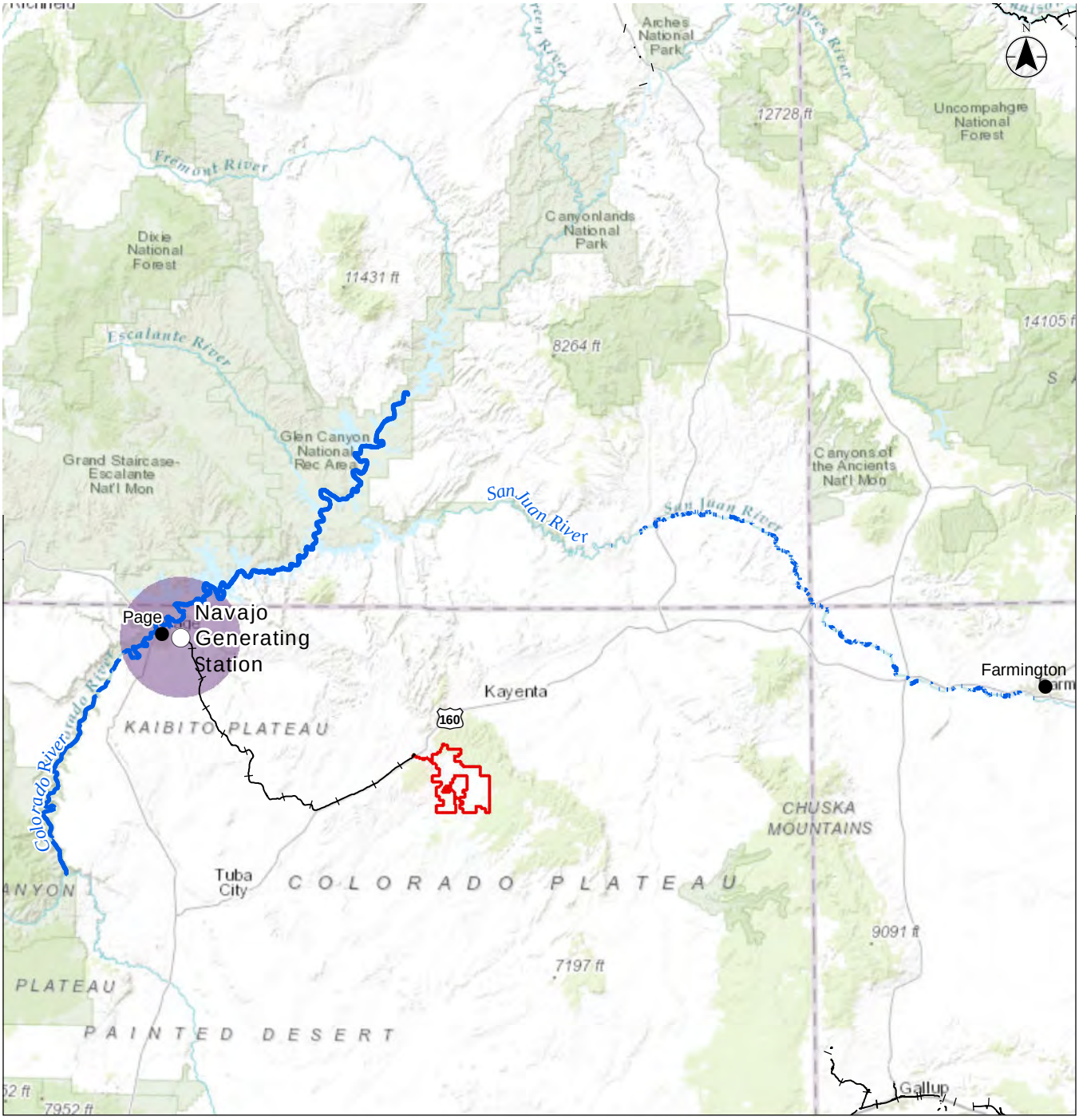

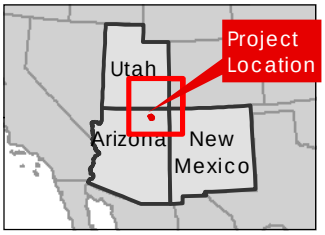

Legend

- City
- Navajo Generating Station (NGS)
- Railroad
- Potential Affected River Segment
- NGS Prelim Deposition Area (20km)
- Kayenta Mine Permit Area

0 10 20 miles

1:2,000,000 (at original document size of 8.5x11)

Stantec

Notes

1. Coordinate System: NAD 1983 StatePlane Arizona East FIPS 0201 Feet
2. Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Project Location	203706045
T35N R19E, T37N R18E, T36N R18E Navajo County, AZ	Prepared by CLG on 2016-08-26 Technical Review by NL on 2016-08-26 Independent Review by GB on 2016-08-26

Client/Project

PWCC
Kayenta Mine SMCRA Permit
BA/BE

Figure No.

2

Title

Preliminary Action Area

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United States Department of the Interior

Fish and Wildlife Service
Arizona Ecological Services Office
9828 N. 31st Avenue Ste C3
Phoenix, AZ 85051
Telephone: (602) 242-0210 Fax: (602) 242-2513

AESO/SE
02EAAZ00-2016-I-0614

September 20, 2016

Memorandum

To: Kayenta Mine Permit Coordinator, Office of Surface Mining, Reclamation and Enforcement (Attn: Amy McGregor)

From: Field Supervisor

Subject: Kayenta Mine Five Year Permit Renewal – Revised Species List Confirmation

Thank you for your correspondence of August 29, 2016, received in our office September 9, requesting our review of the list of species to be considered during Endangered Species Act (Act) section 7 consultation on the subject action, located on the Navajo Nation and Hopi Tribe's Reservation, in Navajo and Coconino counties, Arizona. The list, referenced in your letter as Table 1, includes threatened and endangered species, critical habitat, species proposed to be listed, or critical habitat proposed to be designated, under the Act of 1973, as amended (16 U.S.C. 1531 et seq.).

We recommend you add the following species, as it occurs in the specified preliminary action area:

- Welsh's milkweed (*Asclepias welshii*), listed threatened October 28, 1987 (52 FR 41435) with critical habitat

We recommend you remove the following species, as they do not occur in the action area:

- Roundtail chub DPS
- Northern Mexican gartersnake (*Thamnophis eques megalops*)

We recommend you revise the status of these species, as follows:

- California condor, designated as a nonessential experimental population in northern Arizona and southern Utah, October 16, 1996 (61FR54044)
- Western yellow-billed cuckoo, proposed critical habitat, August 15, 2014 (79FR48548)
- Fickeisen plains cactus, designated critical habitat, August 18, 2016 (81FR55266)

We also recommend you revise *Federal Register* citations as follows:

- Southwestern willow flycatcher, designated critical habitat, January 3, 2013 (78FR344)
- Western yellow-billed cuckoo, listing (79FR59992)
- Fickeisen plains cactus, listing (78FR60608)

In addition to species listed under the Act, we recommend you consider species protected under the Migratory Bird Treaty Act (MBTA), and bald and golden eagles, protected under the Bald and Golden Eagle Protection Act (Eagle Act). The MBTA prohibits the taking, killing, possession, transportation, and importation of migratory birds (see Section 10.13, Title 50 of the Code of Federal Regulations), their eggs, parts, and nests, except when authorized by the FWS. The Eagle Act prohibits anyone, without a FWS permit, from taking (including disturbing) eagles, and including their parts, nests, or eggs. If you think migratory birds and/or eagles will be affected by this project, we recommend seeking our technical assistance to identify available conservation measures that you may be able to incorporate into your project.

In keeping with our tribal trust responsibility, when we enter into consultation on a proposed action that may affect an Indian tribe, we provide for participation of the Bureau of Indian Affairs (BIA) in the consultation; by copy of this memorandum, we are notifying the following tribes. We are notifying the Hopi Tribe and Navajo Nation because the proposed project is located on their tribal trust land. We are notifying the Hualapai and San Juan Southern Paiute tribes, Kaibab Band of Paiute Indians and the Pueblo of Zuni because of their cultural connection to Glen Canyon. And we are notifying tribes with Central Arizona Project (CAP) allocations because of the connection of the project, through the Navajo Generating Station, to the CAP. We encourage you to coordinate with the BIA and any affected tribe, as appropriate. We also recommend that you coordinate with the game and fish agencies of Arizona, New Mexico and Utah, as appropriate.

Thank you for the opportunity to comment on the proposed project. In future communication regarding this project, please refer to consultation number 02EAAZ00-2016-I-0614. If you need more assistance or have any questions, please contact John Nystedt (928-556-2160) or Brenda Smith (556-2157) of our Flagstaff Office. Thank you for your continued efforts to conserve threatened and endangered species.

Brenda H. Smith

for Steven L. Spangle

cc (electronic):

Environmental Protection Department, Ak-Chin Indian Community, Maricopa, AZ
Office of the General Counsel, Fort McDowell Yavapai Nation, Fountain Hills, AZ
Office of the General Counsel, Gila River Indian Community, Sacaton, AZ
General Counsel, Hopi Tribe, Kykotsmovi, AZ
Cultural Resources Department, Hualapai Tribe, Peach Springs, AZ
Cultural Resources, Kaibab Band of Paiute Indians, Fredonia, AZ
Department of Justice, Navajo Nation, Window Rock, AZ
Attorney General, Pascua Yaqui Tribe, Tucson, AZ
Office of the General Counsel, Salt River Pima-Maricopa Indian Community, Scottsdale, AZ
Office of the Attorney General, San Carlos Apache Tribe, San Carlos, AZ
President, San Juan Southern Paiute Tribe, Tuba City, AZ
Office of Attorney General, Tohono O'odham Nation, Sells, AZ
Director, Environmental Protection, Tonto Apache Tribe, Payson, AZ
Attorney General, White Mountain Apache Tribe, Whiteriver, AZ
Attorney General, Yavapai-Apache Nation, Camp Verde, AZ
Heritage and Historic Preservation Office, Pueblo of Zuni, Zuni, NM
Branch Chief, Environmental Quality Services, Western Regional Office, Bureau of Indian Affairs, Phoenix, AZ
Archaeologist, Western Regional Office, Bureau of Indian Affairs, Phoenix, AZ
Chief, Habitat Branch, Arizona Game and Fish Department, Phoenix, AZ
Regional Supervisor, Arizona Game and Fish Department, Flagstaff, AZ
Director, New Mexico Department of Game and Fish, Santa Fe, NM (Attn: Chief, Conservation Services)
Chief, Habitat Branch, Utah Division of Wildlife Resources, Salt Lake City, UT
Regional Supervisor, Utah Division of Wildlife Resources, Price, UT
Field Supervisor, Fish and Wildlife Service, Albuquerque, NM
Field Supervisor, Fish and Wildlife Service, Salt Lake City, UT
Assistant Field Supervisor, Fish and Wildlife Service, Flagstaff, AZ

W:\John Nystedt\OSM-KayentaMineRenewSppListConfirm160920f.docx:cgg

Appendix F

Groundwater Pumping Modeling Report

Prediction of the Effects of Pumping from the Peabody Wellfield to Support Mining through 2019 and Subsequent Reclamation, Kayenta Mine and Former Black Mesa Mine, Northeastern Arizona

Prepared for:

Peabody Western Coal Company

By:

Tetra Tech, Inc.

Louisville, Colorado 80027

2016

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Figure 9 Simulated change in water level in the N Aquifer in 2038, relative to 2010. A: Peabody and community pumping. B: Peabody pumping only. The contour interval is 50 feet with supplemental contours for 1, 5, 10, 20, and 30 feet

Figure 10 Comparison of EA Pumping Scenarios

Prediction of the Effects of Pumping from the Peabody Wellfield to Support Mining through 2019 and Subsequent Reclamation, Kayenta Mine and Former Black Mesa Mine, Northeastern Arizona

1.0 Introduction

The Office of Surface Mining Reclamation and Enforcement (OSM) determined an Environmental Assessment (EA) is needed to support their decision on Peabody Western Coal Company's application to renew the surface coal mining and reclamation permit for the Kayenta Mine for a 5-year term. When approved, the new term will extend from July 7, 2015 through July 6, 2020. The EA assumes mining will end in late December 2019 when authorizations for the Navajo Generating Station (NGS) begin to expire. The NGS is the sole customer for coal produced by the Kayenta Mine. The EA assumes final reclamation of the mine would begin in December 2019 and extend through the end of the permit term (July 6, 2020), and beyond for approximately 13 additional years after mining ceases. In support of this assessment, Tetra Tech performed simulations of expected conditions in the D and N aquifers as the result of the required water use by Peabody during the permit renewal term and beyond. The assessment considers all previous use of the D and N aquifers including municipal, agricultural, and industrial use.

This assessment is based on an assessment performed in 2010 that considered the effects of mining through 2025, and reclamation through 2038. The earlier assessment was used by the OSM in an EA prepared in support of the previous permit renewal and published in 2011 (2011 EA).The present assessment addresses the effects of pumping a substantially smaller quantity of water than assumed in the 2010 evaluation, and therefore is quite conservative. The 2010 predictions were performed using a PWCC three-dimensional flow model of the D and N aquifers in the Black Mesa Basin (PWCC, 1999). This model was calibrated using data available through 1996. Before the 2011 EA simulations were conducted, model validation was performed to determine if the model continued to calculate water-level changes in close agreement with measured changes in the BM-series monitoring wells through 2009. Previous validation checks have concluded that the agreement between simulated and measured water-level changes in these wells had remained good, and that additional model calibration has not been needed.

The following discussion describes the model validation results using data through 2009. Comments are also provided on measured changes in water levels in the BM-series monitoring wells through 2015, available from a U.S. Geological Survey (USGS) web page (http://maps.waterdata.usgs.gov/mapper/). Next, the simulation results from the 2010 assessment

used in the 2011 EA are described. Finally, the 2010 and current pumping scenarios for the 2016 EA are compared, and reasonable inferences are drawn from the 2010 assessment based on the current estimates of future PWCC pumping. Additional simulation of the current pumping scenarios was not necessary, based on the limited effects determined from the 2010 pumping estimates and the significant reduction in the volume of water that is now estimated to support mining through 2019.

2.0 Model validation

The ability of the 3-D model to accurately simulate water-level changes beyond 1996 (end of calibration period) was tested using available updated pumping and water-level data through 2009. Annual pumpage data from each of the PWCC production wells were used in the simulations. Also, water-level data from the BM-series monitoring wells and annual community pumping data were obtained from USGS through the end of 2009.

Validation runs were performed using the four different models presented in PWCC (1999). These four models are comprised of two different recharge rates and two different upland evapotranspiration rates. The only changes made to the model for the period between 1997 and 2009 were the updated pumping rates for the PWCC production and community wells.

Figures 1 through 6 show the simulated water-level changes in the four models and the observed changes at the BM-series monitoring wells through the end of 2009. At BM-1 the agreements of the two models using the full recharge values are better than for the two models using half the full recharge values; the base case (high ET, 100% recharge) provides the best fit to the data. All four of the models predicted more drawdown in BM-1 for the calibration period than was actually observed. The base-case model simulates approximately 4 feet of drawdown, while less than 1 foot has been measured. More recent measurements than shown (available through the USGS web site cited above) suggest that water levels at BM-1 may respond to local recharge events, but do not show recovery from the reduction of PWCC's pumping that occurred at the beginning of 2006.

At BM-2, the predicted drawdowns for the four models are about 15 feet less than the total drawdown observed over the simulation period. The base case and low upland discharge models provide the best fit to measured data. From approximately 1990 until approximately 2006, measured drawdown was occurring more rapidly than predicted drawdown. The simulations show a small response to the reduction in pumping by PWCC in 2006. Water-level measurements since 2009 show that the rate of drawdown has decreased but that water levels have not yet started to rise.

The comparison of simulated and measured values is more difficult at BM-3 because of the impacts of variable local pumping and the resultant high variability of water levels in the well. The four models approximate the measured water level changes equally well. Although variability in the measured values makes comparison with the simulated values uncertain, the

four models appear to simulate a slightly greater rate of drawdown than the measured values from end of calibration through 2009. Effects of reduced pumpage by PWCC are not apparent in the data. The simulations show a very slight decrease in the rate of drawdown beginning in about 2007 or 2008. The more recent data show that the general trend of increasing drawdown through approximately 2009 or 2010 has ended, but that water levels are not rising.

Little change has occurred in water-level measurements in BM-4. A decline in water levels of approximately 1 foot occurred between 1998 and the beginning of 2003, but levels increased back to pre-1998 levels, and then began to decline again. The cause for the short-term decrease is not known. The four models were beginning to simulate a small (<0.1 foot) amount of drawdown at this well through 2009. Data collected since 2010 indicate a more recent rise in water levels.

The 13 years of water level data (since the end of the calibration dataset through 2009) at BM-5 are approximated very well by the four models, although the agreement of the full recharge/low ET model is not quite as good as the other three. The rate of drawdown at the well has decreased slightly since PWCC pumping decreased at the end of 2005. The models match this change well. The more recent measurements indicate that recovery began in 2012.

At BM-6, the full recharge/low ET model simulates about 20 percent less total drawdown than that measured over the simulation period, and less than the other three models. The rates of change calculated by the other three models agree quite well with the measured rate of change, although the base-case (full recharge/ET) and the half-recharge, low upland discharge models provide the best overall fit to the calibration data. The reduction in PWCC's pumping at the beginning of 2006 is apparent in the data and the simulation results, with the models having a slightly earlier and slightly faster recovery than the measurements. From the end of the calibration through 2009, the base-case and half-recharge, low upland ET models continue to provide the best fit to the measured drawdown. The agreement between measured drawdown and the predicted drawdowns calculated from these two models over this time period indicates that the two models should reliably predict drawdown for many years. The measurements after 2009 show that recovery is still continuing, with a total recovery to date of approximately 20 ft.

The four models matched the observed water-level changes at the six BM monitoring wells reasonably well. The base-case model provides the best overall fit. The comparisons indicate the models can be used to predict the effects of pumping by PWCC within the groundwater basin.

3.0 2011 EA model simulations

The 3D model was used to perform simulations for the 2011 EA. In these simulations, actual pumping rates for the PWCC well field were used through June 2010, and estimated future pumping rates were used for the period from July 2010 through June 2038. Table 1 shows the PWCC pumping schedule for the 2011 EA simulation. The 2011 EA simulation assumed that

mining would occur through June 2025, and that reclamation would occur over the subsequent 13-year period.

The model dataset used for the 2011 EA used actual community pumping rates through 2009. Future community pumping rates were projected based on an evaluation performed using data through 1986, which found that community pumping would likely increase at a rate of 2.7 percent on average (PWCC, 1999). More recent data show that the rate of growth has decreased over the last 10 to 15 years. The forecast for community water usage was estimated at approximately 4,500 af/y for 2009, but the reported usage was approximately 2,840 af/y (Macy and others, 2012). Thus, the model used higher community pumping rates for the period of 2010 through 2038 than will occur unless there is significant community growth.

3.1 Water Levels

Figures 7 through 9 show the simulated changes in water levels in the N Aquifer for July 2015, July 2025, and July 2038, respectively. The predicted water-level changes are shown relative to a July 1, 2010 baseline. The maps at the top (A) of each of these figures show the predicted water-level change in the N aquifer as the result of all pumping (community and PWCC), and the maps at the bottom (B) show the simulated water-level change caused by PWCC's pumping alone. Because PWCC's pumping was reduced in December 2005 after many years of pumping at rates approximately four times higher than has occurred since then, the predicted water levels have risen (indicated as water-level change values that are greater than zero) throughout the period of the simulation in the central part of the basin. In 2015, the simulated water level recovery near the PWCC lease area is between 20 and 30 feet during this 5-year time period. [Note that this recovery is the simulated rise in water levels after July 2010; recovery also occurred between December 2005 and July 2010, when the pumping rate was reduced, but is not shown on these figures.] Near some of the PWCC production wells, the simulated recovery is greater. The simulated recovery decreases to small values near the boundary between confined and unconfined conditions in the N aquifer, as the total water-level change prior to 2005 was also small near this boundary. The greatest differences in simulated water-level changes shown on Figures 7 through 9 are near the communities where local pumping is predicted to cause continued drawdown. [Recall that the community pumping used in the predictions is greater than is likely to actually occur, and that the drawdown caused by community pumping will likely be less than predicted.]

By 2025, the water-level recovery is predicted to be more than 30 feet (relative to 2010 levels) within most of the central part of the basin. Recovery will continue until 2038 (and beyond), so that water levels in the central part of the basin are predicted to recover more than 50 feet. These predicted recoveries are in addition to the recoveries that occurred in the period from the end of 2005 to July 2010.

3.2 Water Supply Evaluation

Table 2 shows the total drawdown (relative to a July 2010 baseline) for selected community wells in 2015, 2025, and 2038. In most wells, the simulated drawdown (with combined community and PWCC pumping) increases with time. However, the drawdown caused by PWCC's pumping is estimated to decrease with time. The predicted increases in drawdown are caused by local community pumping. In all instances but one, groundwater is predicted to be above the top of the screened intervals by hundreds of feet. At Rough Rock, the water level was only 40 feet above the top of the screen interval when first measured. The model predicted that PWCC's pumping causes only 2 feet of drawdown in this well since the beginning of Peabody's use of the N aquifer. Pumping by PWCC has caused minor drawdown in these wells, but has not limited the ability of these wells to produce water. With the reduction in pumping that occurred at the end of 2005, the effects of PWCC's pumping have become smaller.

3.3 Surface Water Impacts

Predicted 2015 reduction of groundwater discharge to streams due to PWCC's pumping is greatest at Begashibito Wash (see Table 3). The total predicted 2010 to 2015 reduction in groundwater discharge is 3.8 acre-ft per year (af/y), where 3.4 af/y is due to PWCC pumping, and 0.4 af/y is from community pumping. When pumping effects from 2110 to 2025 are calculated, the estimated decrease in groundwater discharge is 12.1 af/y, of which 1.6 af/y is from community pumping. The combined predicted total 2015 and 2025 percent reductions in groundwater discharge to Begashibito Wash are 0.18 percent and 0.56 percent, respectively, from 2010 values. The simulated discharge for 1955 was 2,178 af/y (not shown in table). Total reduction in groundwater discharge since 1955 is predicted to be approximately 24 af/y in 2025, a 1.1 percent reduction in pre-mining groundwater discharge. The total (since 1955) effect on Begashibito Wash discharge in 2038 is a reduction of 23.1 af/y, or a 1.06 percent decline, indicating that discharge rates are predicted to begin to increase before 2038 as recovery from the 2006 reduction in pumping rates continues. The total decline attributable to PWCC in 2038 is 0.88 percent. Nearly all of this effect is attributable to pumping prior to 2006, even though the effects will occur in the future.

The further the point of groundwater discharge from the PWCC well field, the less the reduction in groundwater discharge due to PWCC pumping is and the higher the percentage due to community pumping is. For example at Pasture Canyon, near Tuba City, the predicted 2025 reduction in discharge from 2010 rates is 45 af/y, and from 1955 rates is 94 af/y (not shown in the table), all of which is attributed to community pumping.

3.4 Effects of D Aquifer Leakage through the Carmel

Concern has been expressed that pumping of water from the N Aquifer will increase the amount of water moving from the overlying D Aquifer through the intervening Carmel Formation, and cause an impact on the quality of water in the N aquifer. In the vicinity of the leasehold, water levels in the D aquifer are 100 to 250 feet higher than in the N aquifer. Thus, there is natural

downward movement of water from the D to the N aquifer. The large difference in water levels suggests that hydraulic conductivity of the Carmel is low, and therefore the rate of downward movement is slow. Drawdown in the N aquifer caused by pumping of water from the N aquifer will increase the rate of water movement in proportion to the increase in water-level change. Thus, several hundred feet of drawdown in the N aquifer could increase the leakage rate several fold. Whether this is important depends on the magnitude of leakage prior to any pumping. If the pre-pumping leakage rates were very small, increasing it several fold would still produce a small leakage rate, and have little effect on water quality.

To quantify this effect, the program ZONEBDGT (Harbaugh, 1990) was used to calculate flow within the N aquifer within the model, using fluxes calculated from a predictive run using the base-case 3D model and the pumping schedule described in Table 1. Based on ZONEBDGT calculations and mixing equations, the change in sulfate concentrations in several different areas within the N aquifer basin was calculated. The results are shown in Table 4 and reflect the cumulative effect of pumping by PWCC between 1956 and 2038. Because of the small amount of leakage through the Carmel under natural conditions (indicated by the low TDS levels in the N aquifer even after leakage from the D aquifer for thousands of years), the increase in leakage due to pumping is predicted to cause very minor changes in the chemistry of the N Aquifer water. Where natural leakage is believed to be higher (in the eastern part of the basin) based on water chemistry data, approximately 70 years of pumping is predicted to cause an increase in sulfate concentrations of about 0.5%. In all other areas, the increase is predicted to be less than 0.2 percent.

4.0 Comparison of 2010 EA and 2016 EA Pumping Scenarios

Table 1 provides the PWCC pumping schedule that provides the assumptions used in the simulations for the 2011 EA. That evaluation envisioned mining occurring through June 2025, followed by reclamation activities. For the 2016 EA, the mining period is a shorter period, through 2019, followed by a thirteen-year period for reclamation (Table 5). Differences between the schedules presented in the two tables include information on actual pumping through 2015, differences in the assumed end of mining, and predicted pumping rates through the end of mining and during reclamation.

Figure 10 illustrates the two different pumping scenarios, beginning in 2010. The 2011 EA used a predicted annual usage of 1,236 af through June 2025. The predicted usage for the 2016 EA is slightly less, 1,200 af, for the period January 2016 through December 2019. Pumping to support reclamation and other needs was predicted to be 505 af/y for three years, and 444 af/y for another 10 years for the 2011 EA. The current estimates are 500 af/y and 100 af/y for the same periods after mining ends. As a result of these differences, the two scenarios are similar through 2019, but in later years, the pumping under the 2016 EA scenario are significantly less than simulated for the 2011 EA. Because actual pumping rates for the period prior to 2016 were greater than the estimate of 1,236 af/y used in the 2011 EA, the total pumping volumes from July 2010 through

the end of 2019 are approximately 7% higher in the 2016 EA pumping estimate than in the 2011 EA [11,742 af (2011 EA) and 12,537 af (2016 EA)]. However, for the period from January 2020 through July 2038, the volume in the 2016 EA scenario is about one-fifth of the 2011 EA value [12,753 af (2011 EA) and 2,500 af (2016 EA)].

5.0 Estimates of 2016 EA-Scenario Pumping Effects

In this section, the comparison of the two EA pumping scenarios is used together with the results from the 2011 EA model predictions presented earlier to estimate the effects of the 2016 EA-scenario pumping. Because of the similarities in total pumping through the end of 2019, one would expect that, if both pumping scenarios were simulated, the results would be similar through 2019. Beyond 2019, recovery would occur at a faster rate for the 2016 EA scenario.

5.1 Water Levels

Figure 7 provides the distribution of water-level change between 2010 and 2015. In the vicinity of the leasehold and in most of the confined area, water levels rose by more than 20 ft. During this period, the 2016 EA pumping volume was greater than used in the 2011 EA modeling simulation, and therefore a slightly smaller recovery of water levels near the leasehold should be expected. The effects of community pumping should be nearly unchanged. Recovery will continue near the leasehold through the end of 2019 in both scenarios.

After the cessation of mining at the end of 2019, under the 2016 EA scenario, the rate of recovery of water levels in the vicinity of the leasehold and in the confined area will increase. Recovery will be faster under the 2016 EA scenario, because the volumes of water used for mine reclamation are projected to be smaller than were used for the 2011 EA simulation. For example, in the 2011 EA simulation, there were approximately 18 ft of recovery from PWCC pumping effects at Rocky Ridge in the 13 years following the end of mining (2025 to 2038); at Forest Lake, there were approximately 32 ft of recovery over the same period. Using these results, the recovery in the 2016 EA scenario during the 13 years of reclamation would likely be more than 25 ft (Rocky Ridge) and 40 ft (Forest Lake), because (1) the total pumping period was shorter, and (2) the water used during the reclamation period is less.

In summary, the effects of pumping on water levels under the 2016 EA scenario will be similar to those under the 2011 EA scenario through 2019. After 2019, recovery will continue from the reduction of pumping at the end of 2005, but will begin earlier and be faster than simulated for the 2011 EA.

5.2 Water Supply Evaluation

The 2011 EA simulation showed that water levels at community wells near the leasehold would rise as recovery occurred from the reduction in pumping that occurred at the end of 2005 (even with continued mining through 2025), but that levels in wells further away would decline because of pumping of those wells to supply community needs (Table 2). With cessation of mining at the end of 2025, the rates of recovery at the wells from PWCC pumping increased, as

would be expected. There were hundreds of feet of water above the top of the open intervals, except at Rough Rock, where the initial excess water column was only about 40 ft, and the contribution of PWCC's pumping to drawdown is minimal.

If pumping were to occur in accordance with the 2016 EA scenario, results would be similar to the 2011 EA scenario through the end of 2019. Following the reduction in pumping at the beginning of 2020, water levels in the community wells would recover more quickly from PWCC pumping than in the 2011 EA scenario, but not all would experience rising water levels because of continued local pumping. Hundreds of feet of water will remain above the top of the open intervals, except at Rough Rock.

5.3 Surface Water Impacts

With the 2011 EA scenario, the predicted impact of PWCC's pumping on surface-water flow at the streams through 2038 was a small percentage of the original flow rate. The largest effect was at Begashibito Wash, where the effect of PWCC's pumping was an approximately 0.9% reduction. The effect of reducing the pumping to support the actual mining operations at the end of 2019 rather than at the end of 2025 will be to reduce the effect on the streams a small amount, because the predicted effect is primarily the result of past pumping. Because of the distance to the areas of discharge into the streams and because the streams are located in the unconfined area, a long time (decades) would be required for the effects of reducing the pumping to affect the streamflow.

5.4 Effects of D Aquifer Leakage through the Carmel

Table 4 shows that it is unlikely that there would be observable effects of PWCC's 2011 EA pumping on the water quality of the N Aquifer caused by increases in flow rates through the Carmel. The reduced pumping in the 2016 EA scenario would decrease the flow rate through the Carmel beyond 2020, and therefore also reduce the theoretical effect on the water chemistry.

6.0 Summary

The amount of pumping being considered in the 2016 EA is similar to that in the 2011 EA through the end of 2019, and significantly smaller in later years. Modeling has shown that the pre-2006 pumping caused widespread drawdown throughout the confined area, but only minor effects on streamflow or water quality in the N aquifer. Because the pumping rate was significantly reduced beginning in 2006, water levels have been recovering from the effects of PWCC's pumping within a significant part of the confined area, and will begin to recover in coming years in the more distant areas that have experienced smaller amounts of drawdown. The primary effect of the continuation of pumping to support mining since 2006 has been to slow the rate of recovery of water levels. Under the pumping envisioned in the 2016 EA, recovery will be faster than previously evaluated in the 2011 EA, and the effects of PWCC's pumping on the aquifer will be smaller.

7.0 References

GeoTrans, Inc., 2006. *A Three-Dimensional Flow Model of the D and N Aquifers, Black Mesa Basin, Arizona, Draft Supplement 2*, for Peabody Western Coal Company.

Harbaugh, A.W., 1990. *A computer program for calculating subregional water budgets using results from the U.S. Geological Survey modular three-dimensional ground-water flow model*: U.S. Geological Survey Open-File Report 90-392, 46 p.

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PWCC, 1999. *A Three-Dimensional Flow Model of the D and N Aquifers, Black Mesa Basin, Arizona*, prepared for Peabody Western Coal Company by HSI GeoTrans and Waterstone September 1999.

TABLES

Table 1. PWCC Pumping Schedule for the 2010 EA

Period	Pumping
1956 through June 2010	Actual
July 2010 through June 2025	1236 af/y (928 Kayenta Mine, 247 Black Mesa well maintenance, 61 public supply)
July 2025 through June 2028	505 af/y (430 Kayenta reclamation, 247 Black Mesa maintenance, 75 public supply)
July 2028 through June 2038	444 af/y (444 maintenance [247 Black Mesa, 197 Kayenta mine], public water derived from the maintenance pumping)

Table 2. Simulated Drawdown (relative to 2010) at Selected Community Wells Caused by Combined Pumping and by Peabody's Pumping, and Remaining Water Column

a. 2015

Community	Well	Initial DTW (ft)	Simulated Drawdown (ft)	PWCC Allocation (%)	PWCC Allocation (ft)	Depth to N or Top of Open Interval	Remaining Excess Water Column (ft)
Chilchinibito	PM3	405.0	-9	126%	-11	1136	742
Forest Lake NTUA 1	4T-523	1096.0	-22	116%	-26	1870	800
Kayenta West	8T-541	227.0	14	-47%	-6	700	479
Keams Canyon	PM2	292.5	3	49%	1	900	606
Kykotsmovi	PM1	220.0	23	13%	3	880	657
Pinon	PM6	743.6	3	-79%	-3	1870	1129
Rocky Ridge	PM2	432.0	-3	254%	-6	1442	1016
Rough Rock	10R-111	170.0	1	16%	0	210	40

b. 2025

Community	Well	Initial DTW (ft)	Simulated Drawdown (ft)	PWCC Allocation (%)	PWCC Allocation (ft)	Depth to N or Top of Open Interval	Remaining Excess Water Column (ft)
Chilchinibito	PM3	405.0	-13	197%	-25	1136	756
Forest Lake NTUA 1	4T-523	1096.0	-40	128%	-51	1870	825
Kayenta West	8T-541	227.0	37	-37%	-13	700	486
Keams Canyon	PM2	292.5	12	14%	2	900	606
Kykotsmovi	PM1	220.0	53	7%	3	880	657
Pinon	PM6	743.6	10	-152%	-15	1870	1141
Rocky Ridge	PM2	432.0	-9	229%	-21	1442	1031
Rough Rock	10R-111	170.0	2	6%	0	210	40

c. 2038

Community	Well	Initial DTW (ft)	Simulated Drawdown (ft)	PWCC Allocation (%)	PWCC Allocation (ft)	Depth to N or Top of Open Interval	Remaining Excess Water Column (ft)
Chilchinibito	PM3	405.0	-10	400%	-38	1136	769
Forest Lake NTUA 1	4T-523	1096.0	-58	141%	-82	1870	856
Kayenta West	8T-541	227.0	69	-25%	-17	700	490
Keams Canyon	PM2	292.5	29	1%	0	900	607
Kykotsmovi	PM1	220.0	96	-1%	-1	880	661
Pinon	PM6	743.6	30	-96%	-29	1870	1155
Rocky Ridge	PM2	432.0	-13	290%	-39	1442	1049
Rough Rock	10R-111	170.0	3	-1%	0	210	40

Table 3. Predicted decrease in discharge (af/yr) to washes in the vicinity of the Black Mesa Complex after July 2010.

a. 2015

Pumping	2010 All	2010 Non-PWCC	2015 All	2015 Non-PWCC	Change due to Pumping All	Change due to Pumping Non-PWCC	Change due to Pumping PWCC	% total All	% total PWCC
Chinle Wash	498.8	498.8	498.8	498.8	0.0	0.0	0.0	0.00	0.00
Laguna Creek	2,440.6	2,450.6	2,418.3	2,427.8	22.2	22.9	-0.6	0.91	-0.03
Pasture Canyon	377.6	377.6	363.1	363.1	14.5	14.5	0.0	3.84	0.000
Moenkopi Wash	4,279.6	4,302.1	4,277.0	4,301.4	2.7	0.7	1.9	0.06	0.05
Dinebito Wash	514.8	515.3	514.6	515.2	0.2	0.1	0.1	0.04	0.02
Oraibi Wash	455.4	456.0	454.4	455.2	1.0	0.8	0.2	0.21	0.04
Polacca Wash	429.8	431.0	427.3	428.9	2.4	2.2	0.3	0.57	0.06
Jaidito Wash	2,011.4	2,015.6	2,007.3	2,012.9	4.1	2.7	1.4	0.20	0.07
Begashibito Wash	2,166.0	2,177.0	2,162.2	2,176.6	3.8	0.4	3.4	0.18	0.16

b. 2025

Pumping	2010 All	2010 Non-PWCC	2025 All	2025 Non-PWCC	Change due to Pumping All	Change due to Pumping Non-PWCC	Change due to Pumping PWCC	% total All	% total PWCC
Chinle Wash	498.8	498.8	498.8	498.8	0.0	0.0	0.0	0.01	0.00
Laguna Creek	2,440.6	2,450.6	2,385.8	2,395.1	54.8	55.5	-0.8	2.24	-0.03
Pasture Canyon	377.6	377.6	332.8	332.8	44.8	44.8	0.0	11.86	0.000
Moenkopi Wash	4,279.6	4,302.1	4,274.9	4,299.6	4.7	2.4	2.3	0.11	0.05
Dinebito Wash	514.8	515.3	514.2	515.0	0.6	0.3	0.3	0.13	0.07
Oraibi Wash	455.4	456.0	452.6	453.9	2.7	2.1	0.6	0.60	0.14
Polacca Wash	429.8	431.0	422.9	424.8	6.9	6.2	0.7	1.60	0.15
Jaidito Wash	2,011.4	2,015.6	1,999.0	2,007.4	12.4	8.2	4.2	0.62	0.21
Begashibito Wash	2,166.0	2,177.0	2,153.9	2,175.4	12.1	1.6	10.5	0.56	0.49

c. 2038

Pumping	2010 All	2010 Non-PWCC	2038 All	2038 Non-PWCC	Change due to Pumping All	Change due to Pumping Non-PWCC	Change due to Pumping PWCC	% total All	% total PWCC
Chinle Wash	498.8	498.8	498.7	498.7	0.1	0.1	0.0	0.02	0.00
Laguna Creek	2,440.6	2,450.6	2,336.7	2,347.6	103.8	103.1	0.8	4.26	0.03
Pasture Canyon	377.6	377.6	294.4	294.4	83.2	83.2	0.0	22.02	0.000
Moenkopi Wash	4,279.6	4,302.1	4,273.0	4,296.8	6.6	5.2	1.4	0.16	0.03
Dinebito Wash	514.8	515.3	513.6	514.6	1.2	0.7	0.6	0.24	0.11
Oraibi Wash	455.4	456.0	450.1	451.6	5.3	4.4	1.0	1.17	0.21
Polacca Wash	429.8	431.0	418.0	419.4	11.7	11.6	0.1	2.73	0.03
Jaidito Wash	2,011.4	2,015.6	1,987.1	1,998.0	24.3	17.6	6.6	1.21	0.33
Begashibito Wash	2,166.0	2,177.0	2,142.9	2,172.9	23.1	4.1	19.0	1.07	0.88

Table 4. Maximum predicted sulfate concentrations (mg/L) resulting from PWCC pumping, 1956-2038.

Subarea	Initial Concentration (mg/L)		Final Concentration (mg/L)	Change
	D Aquifer	Navajo sandstone	Navajo sandstone	
Northeast	250	70	70.056	0.080%
East	850	100	100.498	0.498%
Hopi Buttes	360	50	50.113	0.226%
Forest Lake	1000	100	100.057	0.057%
Kitsillie	75	30	30.002	0.007%
Pinon	200	5	5.006	0.122%
Rocky Ridge	250	10	10.012	0.118%
Preston Mesa	400	10	10.000	0.000%
Leasehold	400	30	30.016	0.054%
Pinon to Kitsillie	1000	20	20.036	0.178%
Surrounding leasehold	100	45	45.002	0.004%
Red Lake to Tuba City	400	50	50.012	0.024%
Hotevilla to Kabito	200	35	35.006	0.016%
Pinon to Rocky Ridge	210	140	140.003	0.002%

Table 5. PWCC Pumping Schedule for the 2016 EA

Period	Pumping
1956 through 2015	Actual
2016 through 2019	1,200 af/y
2020 through 2022	500 af/y
2023 through 2032	100 af/y

FIGURES

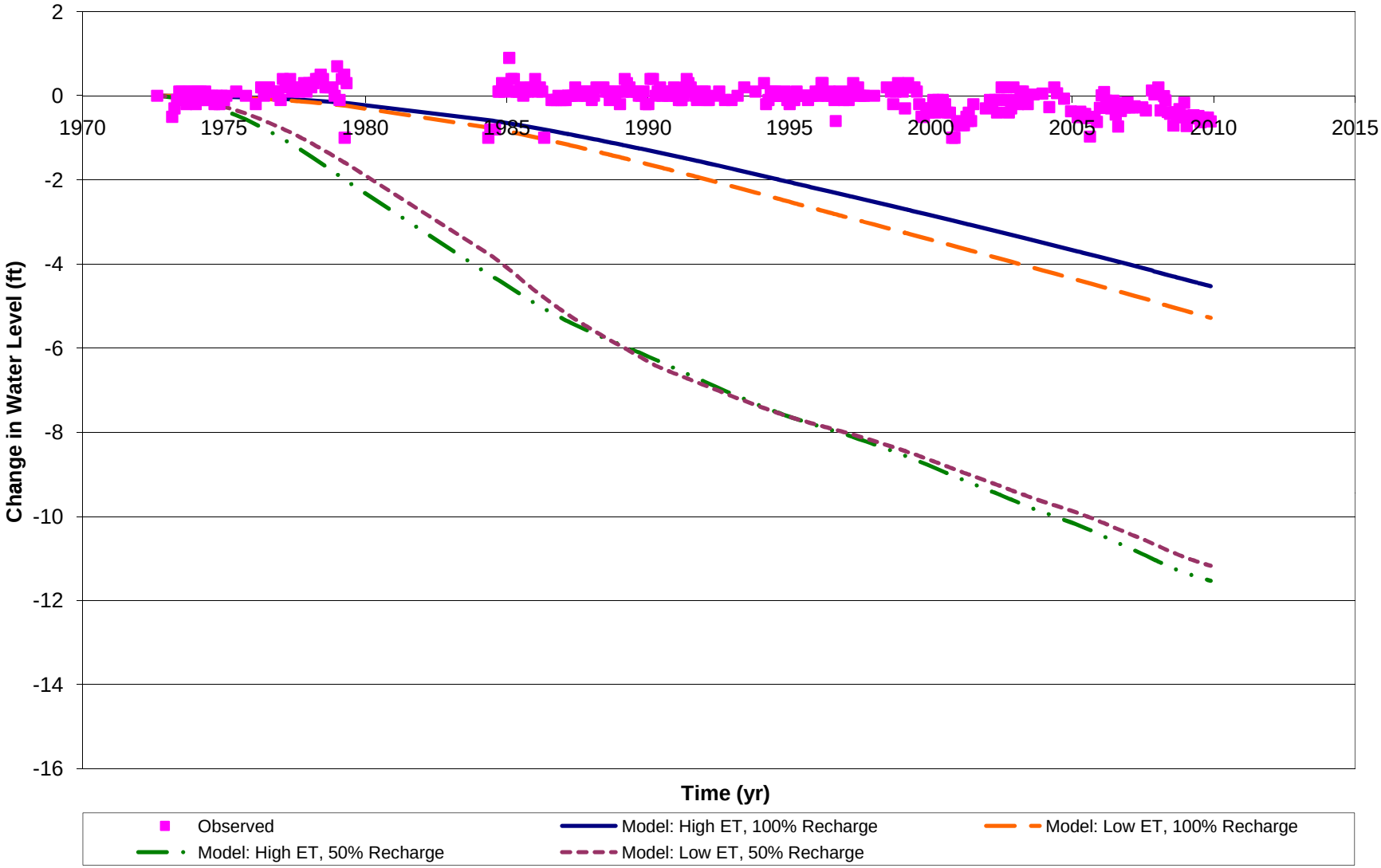


Figure 1. Comparison of Change in Water Level at BM-1

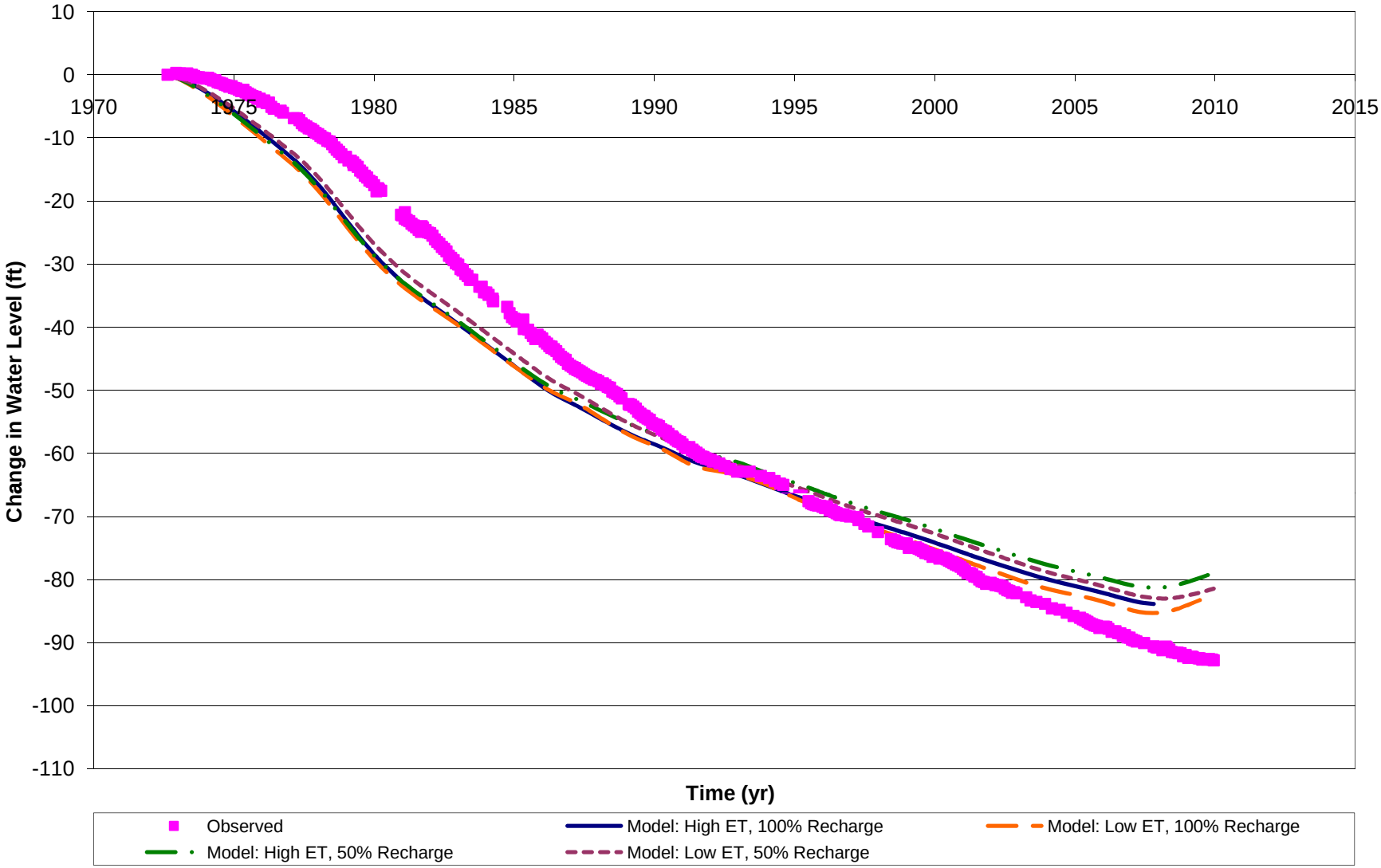


Figure 2. Comparison of Change in Water Level at BM-2

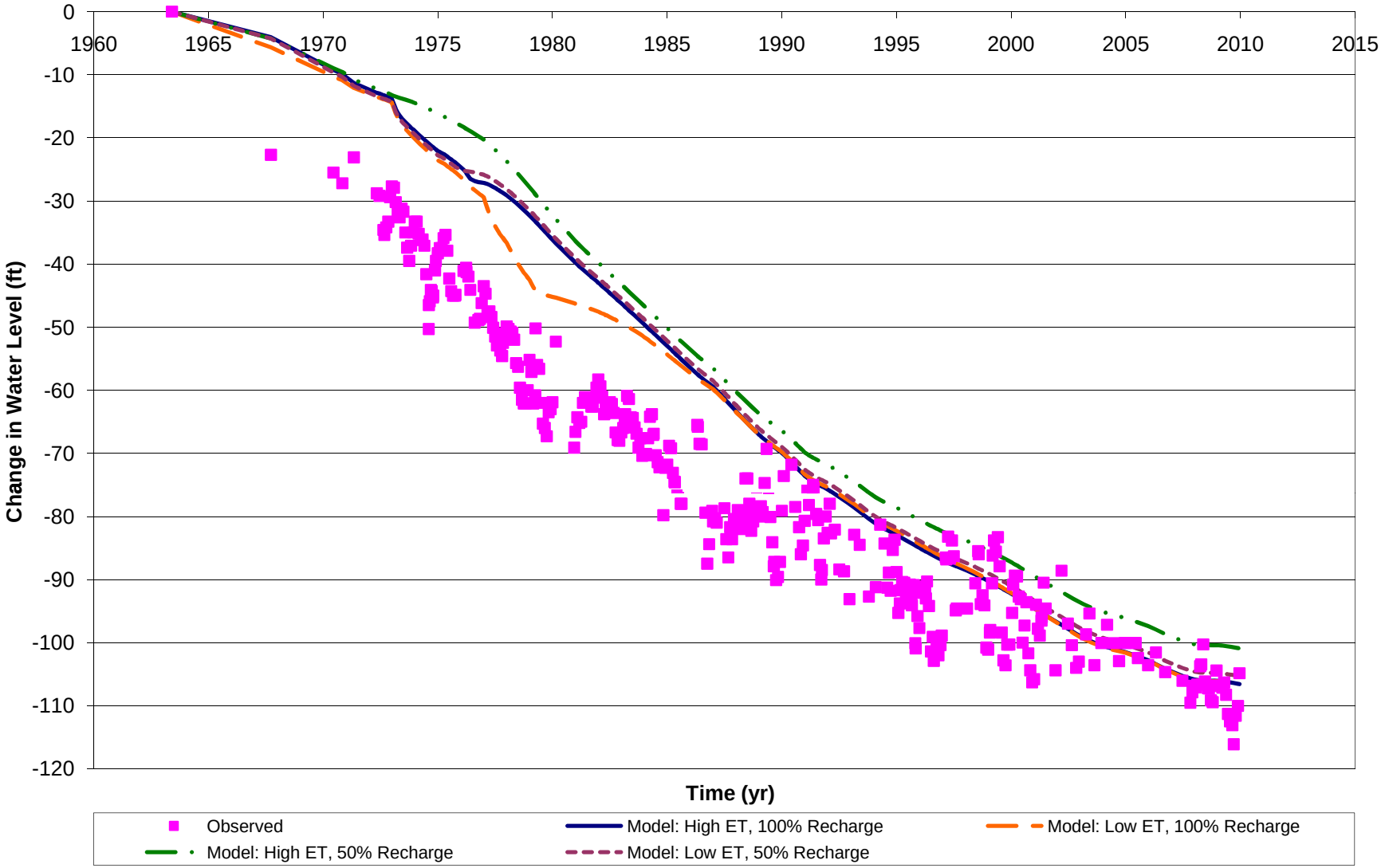


Figure 3. Comparison of Change in Water Level at BM-3

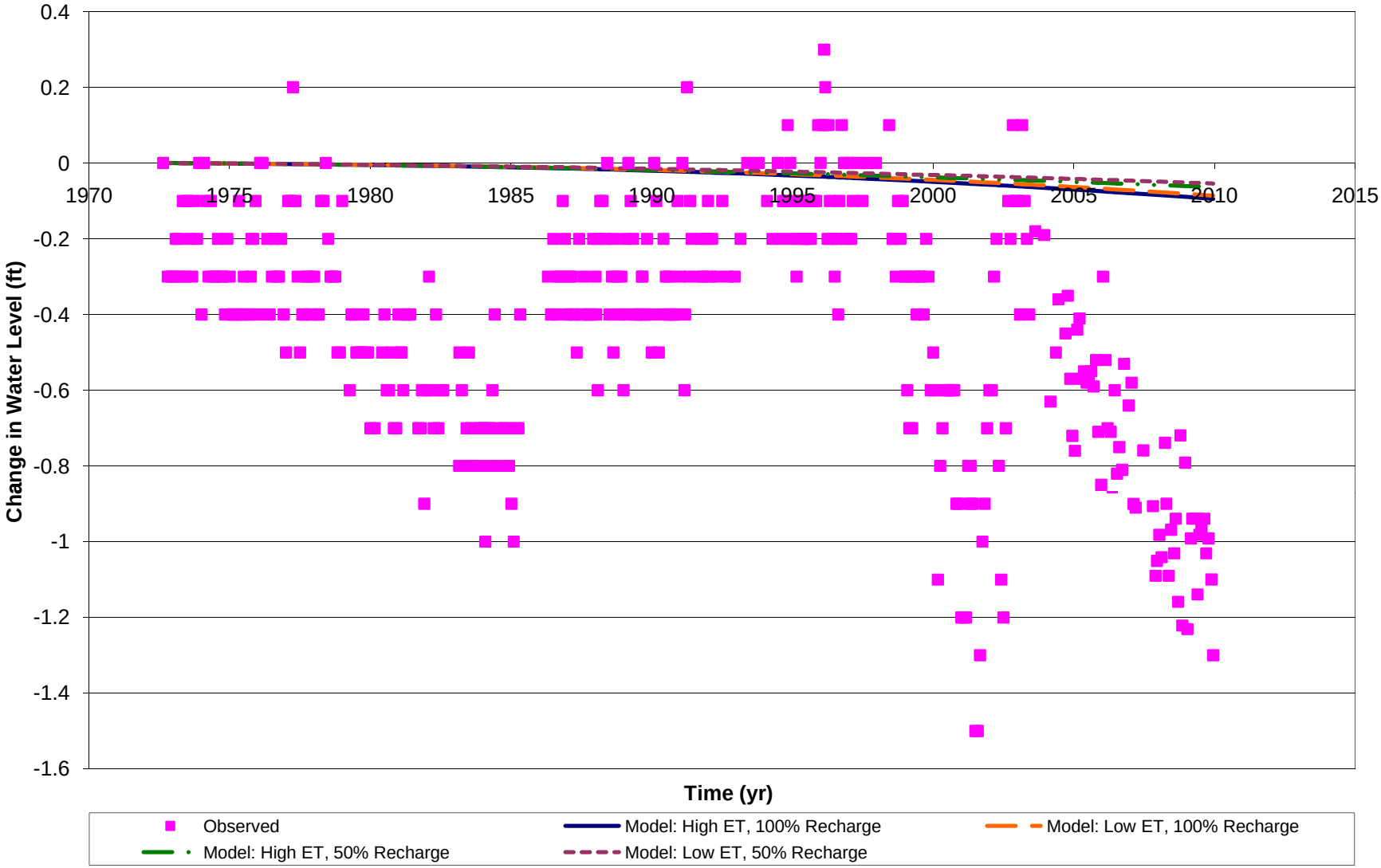


Figure 4. Comparison of Change in Water Level at BM-4

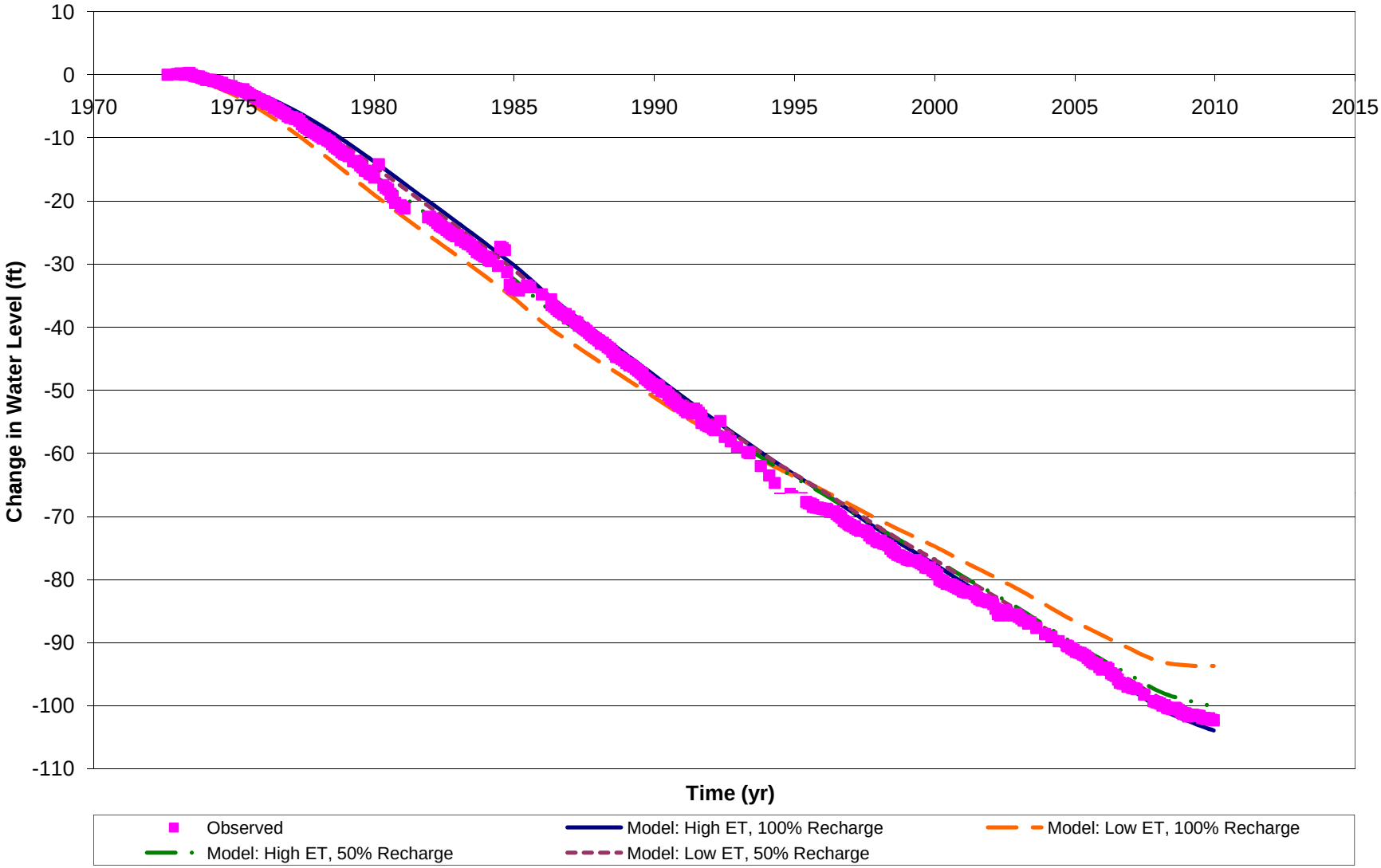


Figure 5. Comparison of Change in Water Level at BM-5

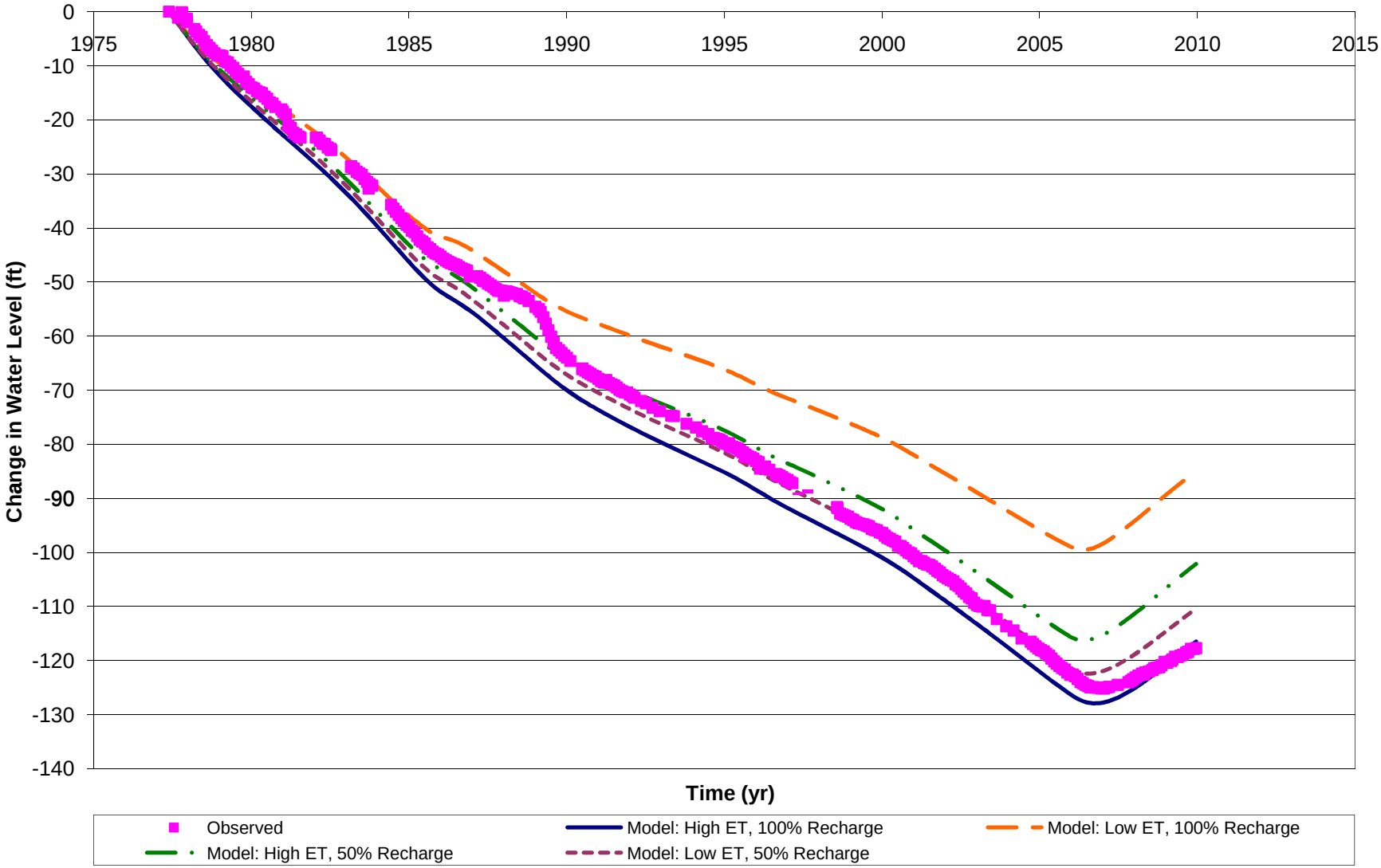
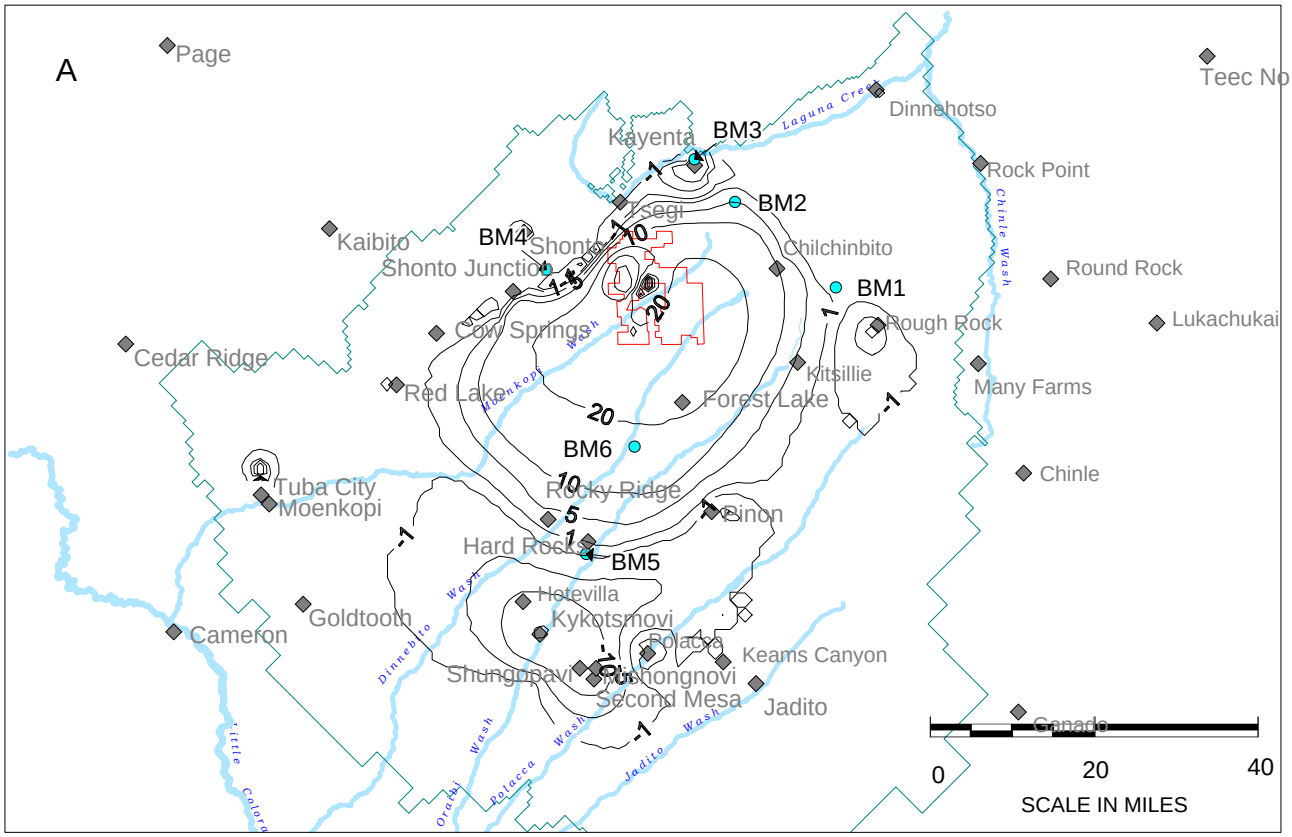


Figure 6. Comparison of Change in Water Level at BM-6



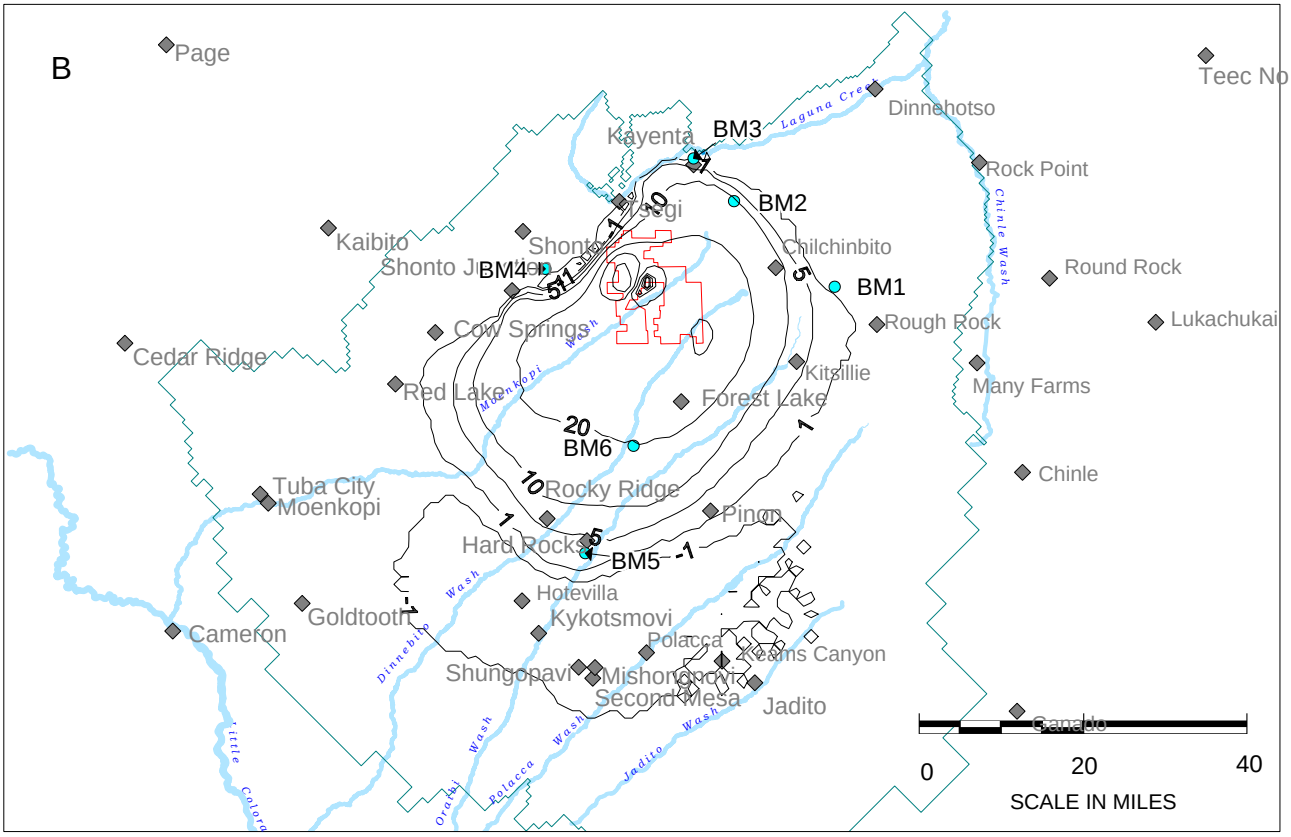
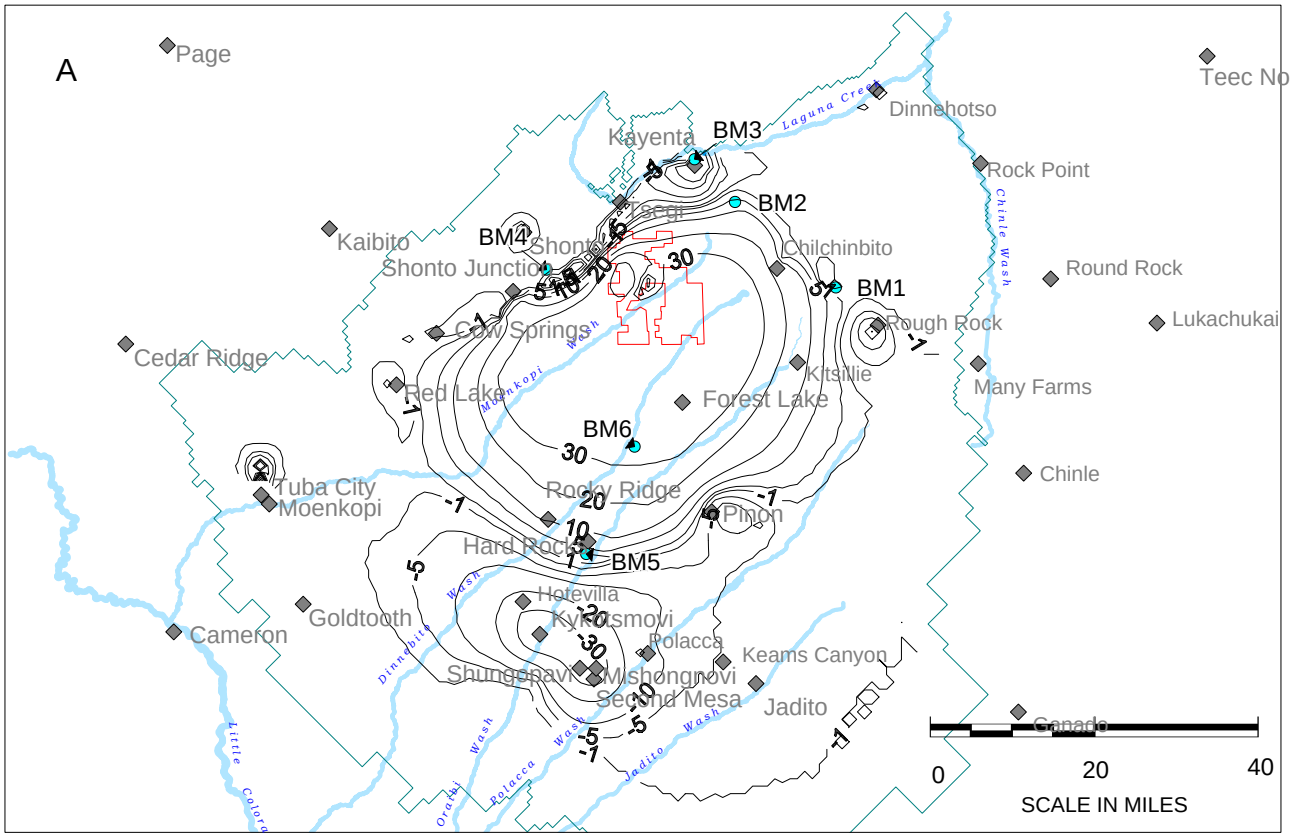


Figure 7. Simulated change in water level in the N Aquifer in 2015, relative to 2010.
A: Peabody and community pumping. B: Peabody pumping only.
The contour interval is 50 feet with supplemental contours for 1, 5, 10, 20, and 30 feet.



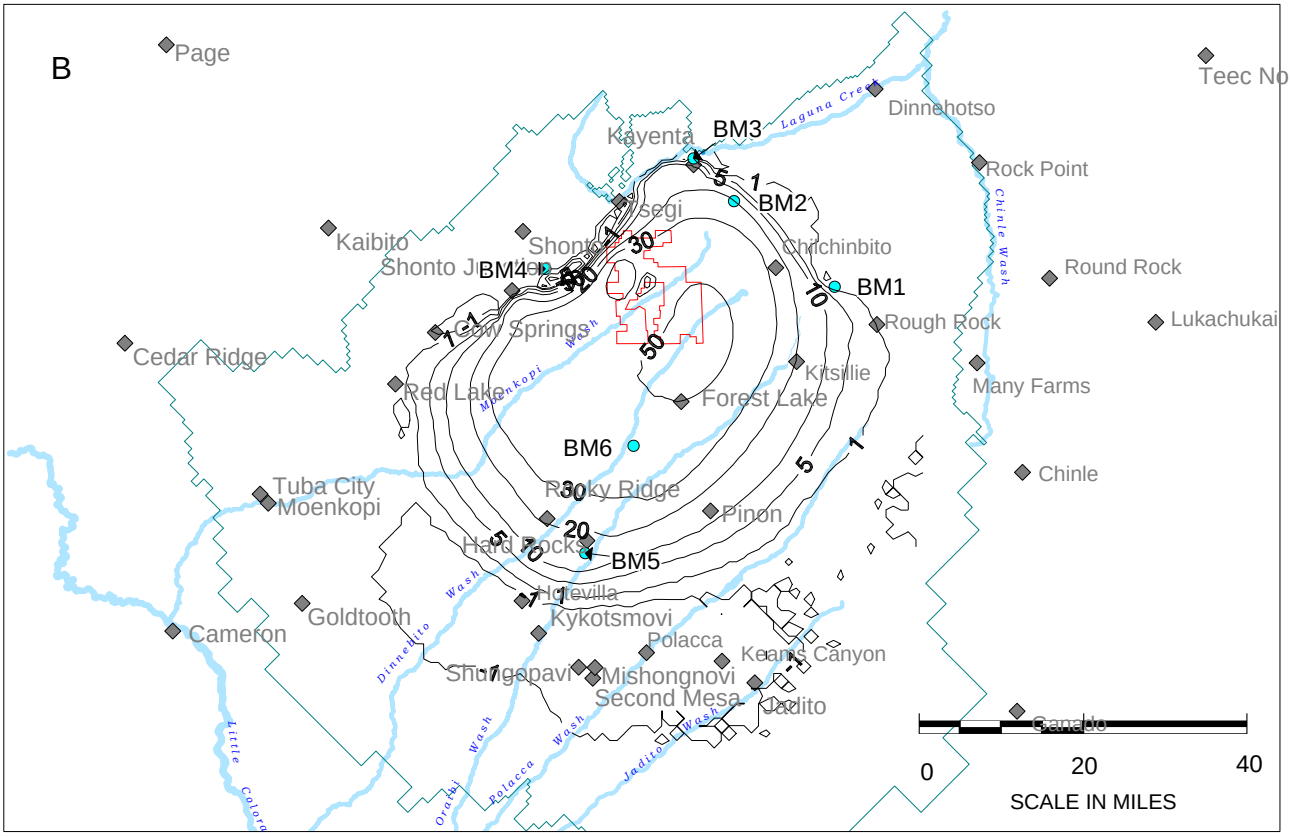


Figure 8. Simulated change in water level in the N Aquifer in 2025, relative to 2010.
A: Peabody and community pumping. B: Peabody pumping only.
The contour interval is 50 feet with supplemental contours for 1, 5, 10, 20, and 30 feet.

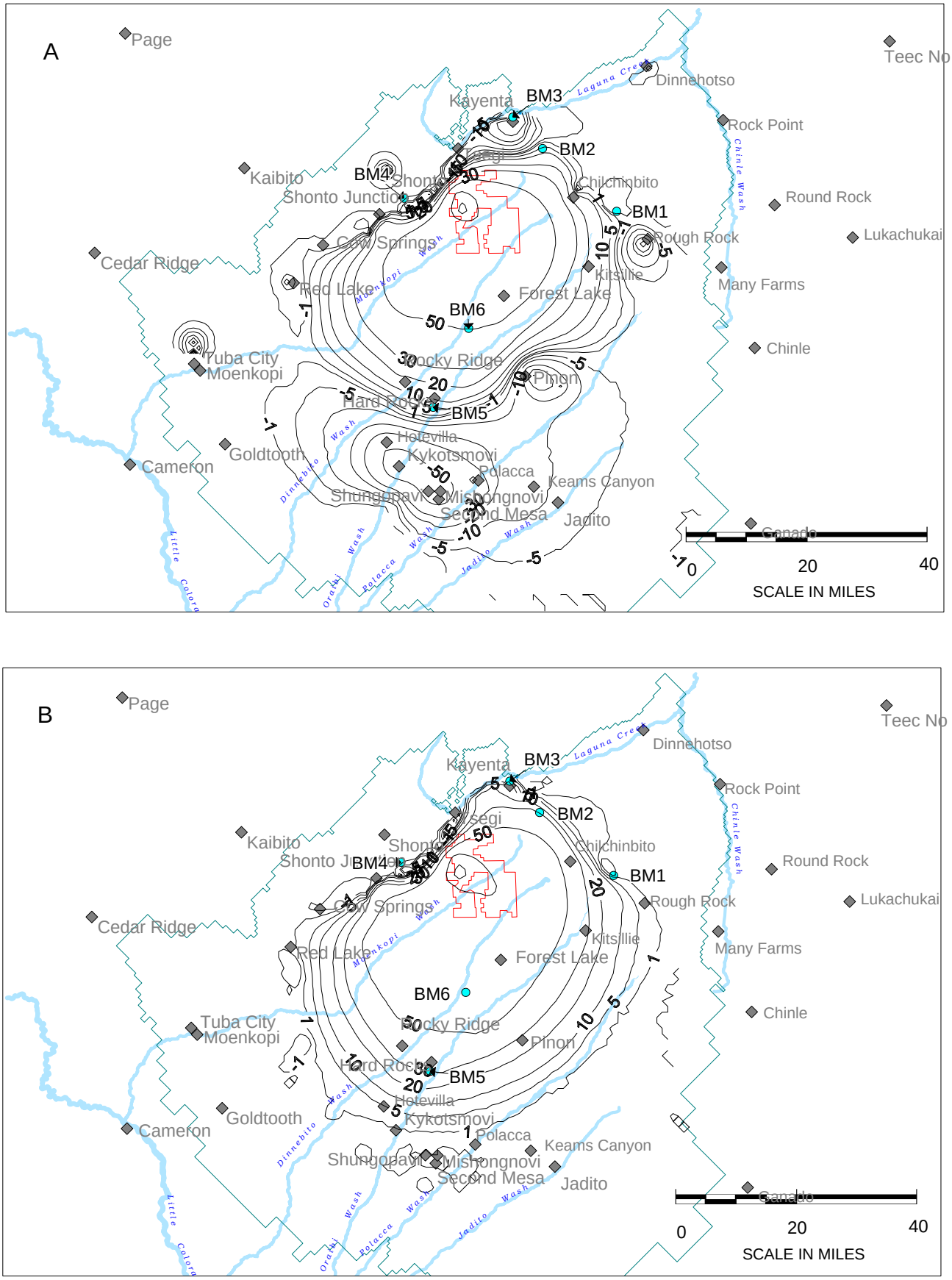


Figure 9. Simulated change in water level in the N Aquifer in 2038, relative to 2010.
A: Peabody and community pumping. B: Peabody pumping only.
The contour interval is 50 feet with supplemental contours for 1, 5, 10, 20, and 30 feet.

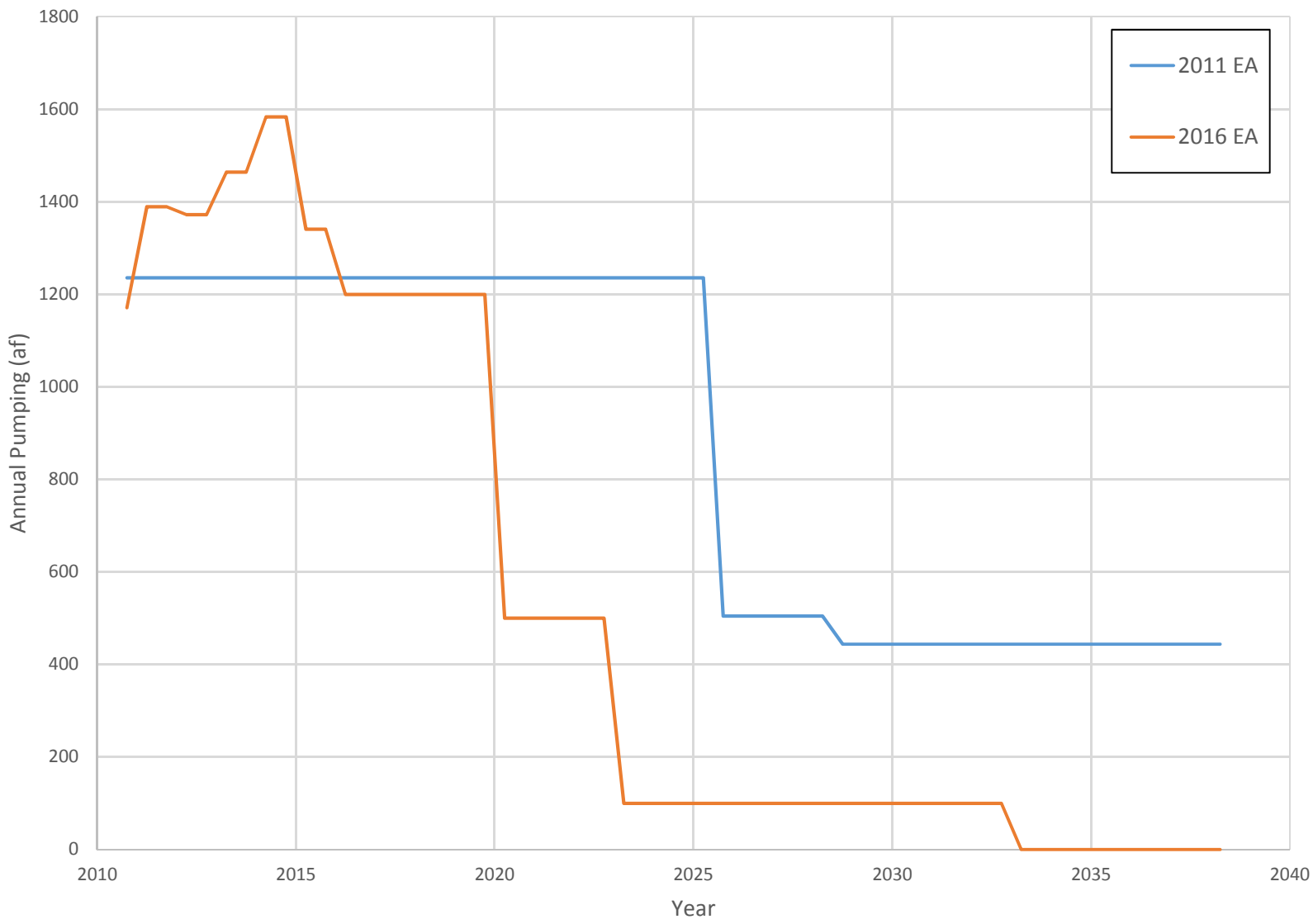


Figure 10. Comparison of EA Pumping Scenarios
1800
1600
1400
1200
1000
800
600
400
200
0
Annual Pumping (af)
2010
2015
2020
2025
2030
2035
2040
Year
2011 EA
2016 EA

Appendix G

USFWS and Navajo Concurrence Letters

United States Department of the Interior

Fish and Wildlife Service
Arizona Ecological Services Office
9828 N. 31st Avenue Ste C3
Phoenix, AZ 85051
Telephone: (602) 242-0210 Fax: (602) 242-2513

AESO/SE
02EAAZ00-2016-I-0614

September 19, 2017

Memorandum

To: Mychal Yellowman, Manager, Indian Programs Branch, Office of Surface Mining, Denver, Colorado

From: Field Supervisor

Subject: Kayenta Mine Permit Renewal – Permit Number AZ-0001E

Thank you for your correspondence of August 14, 2017, received on August 15, 2017. This letter documents our review of the Kayenta Mine Permit Renewal, in Navajo County, Arizona, in compliance with section 7 of the Endangered Species Act of 1973 (ESA) as amended (16 U.S.C. 1531 et seq.). The Office of Surface Mining (OSM) is requesting concurrence with the determinations that the proposed project may affect, but is not likely to adversely affect the bonytail chub (*Gila elegans*) and its critical habitat, Brady pincushion cactus (*Pediocactus bradyi*), Colorado pikeminnow (*Ptychocheilus lucius*) and its critical habitat, Fickeisen plains cactus (*Pediocactus peeblesianus* var. *fickeiseniae*), humpback chub (*Gila cypha*) and its critical habitat, Mexican spotted owl (*Strix occidentalis lucida*), Navajo sedge (*Carex specuicola*) and its critical habitat, razorback sucker (*Xyrauchen texanus*) and its critical habitat, southwestern willow flycatcher (*Empidonax traillii extimus*) and its critical habitat, Welsh's milkweed (*Asclepias welshii*) and its critical habitat, and western yellow-billed cuckoo (*Coccyzus americanus*). We concur with your determinations and provide our rationales below.

Your conclusion also included the determinations that there would be "no effect" on the black-footed ferret (*Mustela nigripes*), California condor (*Gymnogyps californianus*) and its critical habitat, Fickeisen plains cactus critical habitat, Mexican spotted owl critical habitat, and western yellow-billed cuckoo critical habitat. Listed species or designated critical habitat with "no effect" determinations do not require review from the Fish and Wildlife Service, and are not addressed further.

You also concluded that the proposed project will not impair reproductive success of, or harm the bald eagle (*Haliaeetus leucocephalus*) or golden eagle (*Aquila chrysaetos*). The bald eagle was removed from the Federal List of Threatened and Endangered Wildlife and Plants (list) effective August 8, 2007. Since the bald eagle has been delisted, and the golden eagle is not on the list, there is no need to consult under section 7 of the ESA, and effects to these species will

not be considered in this document. However, our evaluation of the Kayenta Mine Permit Renewal with respect to the Bald and Golden Eagle Protection Act is included in Appendix A. This consultation is based on your letter, the accompanying August 7, 2017 BA, environmental risk assessments developed for the Navajo Generating Station (NGS) Environmental Impact Statement, and conversations between my staff, OSM, BOR and the Navajo Nation.

Description of the Proposed Action

A complete description of the proposed action is found in the 2017 BA. The proposed action is to renew the permit for Peabody Western Coal Company's Kayenta Mine, which would authorize continued mining in coal resource areas N-9, J-19, and J-21, as well as reclaiming areas previously mined. About 842 acres would be disturbed by mining in the three areas, which total 11,091 acres of the 44,073 acres that comprise the permanent permit area for the Kayenta Mine. Coal from the mining operation is delivered by electric railroad to the NGS near Page, Coconino County, Arizona, 83 miles northwest. Water that is used for mining-related purposes would be withdrawn from the Navajo (N) Aquifer at an average rate of 1,236 acre-feet per year. The Kayenta Mine is located on land leased within the boundaries of the Hopi and Navajo Indian Reservations, about 125 miles northeast of Flagstaff, Arizona, near the northern edge of Black Mesa within the protracted boundaries of Townships 35 through 37 North, Ranges 17 through 19 East, Navajo County, Arizona. The action area for the proposed action includes the permit area and the extent of the confined and unconfined portions of the N-Aquifer as depicted on Figure 4 of the BA.

Conservation measures incorporated into the proposal include monitoring Mexican spotted owls within two miles of the lease boundary, beginning two years prior to scheduled disturbance and continuing until three years after the disturbance (OSM's 2008 BA for the Black Mesa Complex, section 6.3.3). The BA also proposes conservation measures to benefit Colorado pikeminnow in the San Juan River, razorback sucker in the Colorado River below Glen Canyon Dam and the San Juan River, and humpback chub in the Colorado River below Glen Canyon Dam. These measures would (1) support emergency rapid response to address non-native fish management in the Grand Canyon area of the Colorado River and (2) support transport of Colorado pikeminnow and razorback sucker above the waterfall barrier in the San Juan River.

Our analysis of the direct and indirect effects of mining activities at Kayenta Mine includes the interrelated and interdependent effects that will result from continued coal-burning operations at NGS for the period 2015 to 2020. The interrelated chemical deposition effects from NGS plant stack and secondary emissions would potentially affect the following areas: (1) lands and waters 20 km (12.4-mi) from the NGS plant site (Near Field); (2) the lower Colorado River below Glen Canyon Dam to the confluence of the Colorado and Little Colorado rivers (Southwest Gap); (3) the Upper Colorado River above Lake Powell to its confluence with the Green River (Northeast Gap); and (4) the San Juan River from State Route 371 Bridge in Farmington, New Mexico, downstream to the San Juan arm of Lake Powell in Arizona (San Juan). These four areas constitute the Colorado River Region study area for the evaluation of effects of the proposed action.

DETERMINATION OF EFFECTS

We concur with your determination that the proposed action may affect, but is not likely to adversely affect, the bonytail chub and its critical habitat, Brady pincushion cactus, Colorado pikeminnow and its critical habitat, Fickeisen plains cactus, humpback chub and its critical habitat, Mexican spotted owl, Navajo sedge and its critical habitat, razorback sucker and its critical habitat, southwestern willow flycatcher and its critical habitat, Welsh's milkweed and its critical habitat, and western yellow-billed cuckoo for the following reasons:

Bonytail chub

- Chemical deposition from NGS emissions over five years would contribute less than 0.000034 micrograms per gram (μg/g) wet weight of mercury to body tissue of any life stage of this species. This tissue burden is well below a concentration that could result in any detectable changes to survivorship, reproduction or behavior. Therefore, effects on the bonytail chub from the indirect effects of coal burning would be insignificant.
- Chemical deposition from NGS emissions over five years would result in no detectable change to water quality. Therefore, effects on the water primary constituent element of designated critical habitat would be insignificant. No other primary constituent elements of critical habitat would be affected.

Brady pincushion cactus

- An ecological risk assessment indicated that deposition from NGS emissions over five years would result in a hazard quotient (HQ) of 0.05 for exposure to chemicals of potential ecological concern. This level is far below the threshold (HQ > 1) at which there could be potential for adverse ecological effects. Therefore, effects on this species from the indirect effects of coal burning would be insignificant.

Colorado pikeminnow

- Chemical deposition from NGS emissions over five years would contribute less than 0.000034 mg/kg wet weight of mercury to body tissue of any life stage of this species. This tissue burden is well below a concentration that could result in any detectable changes to survivorship, reproduction or behavior. Therefore, effects on the Colorado pikeminnow from the indirect effects of coal burning would be insignificant.
- The ecological risk assessment for the San Juan River (Ramboll Environ 2016) indicated that selenium contributions from NGS emissions over a 55-year period would result in critical body residue HQ for Colorado pikeminnow of 0.0001 for selenium. This is well below a concentration that could result in any detectable changes to survivorship, reproduction, or behavior (an HQ >1).
- Chemical deposition from NGS emissions over five years would result in no detectable change to water quality. Therefore, effects on the water primary constituent element of designated critical habitat would be insignificant. No other primary constituent elements of critical habitat would be affected.

Fickeisen plains cactus

- An ecological risk assessment indicated that deposition from NGS emissions over five years would result in a HQ of 0.05 for exposure to chemicals of potential ecological

concern. This level is far below the threshold (HQ > 1) at which there could be potential for adverse ecological effects. Therefore, effects on this species from the indirect effects of coal burning would be insignificant.

Humpback chub

- Chemical deposition from NGS emissions over five years would contribute less than 0.000034 mg/kg wet weight of mercury to body tissue of any life stage of this species. This tissue burden is below a concentration that could result in any detectable changes to survivorship, reproduction or behavior. Therefore, effects on the humpback chub from the indirect effects of coal burning would be insignificant.
- Chemical deposition from NGS emissions over five years would result in no detectable change to water quality. Therefore, effects on the water primary constituent element of designated critical habitat would be insignificant. No other primary constituent elements of critical habitat would be affected.

Mexican spotted owl

- Mexican spotted owls occur in the vicinity of the Kayenta Mine. The closest mining and mining-related activities would occur in the N-9 area, greater than or equal to one-and-a-half miles from the nearest protected activity center (PAC). Therefore, any effects on the Mexican spotted owl from project-generated noise would be discountable.
- Bright lights mounted on draglines, which allow them to operate at night, could have an effect on nocturnal spotted owl activities. However, the intensity of light from the draglines will attenuate over the distance between mining activities and owl habitat, and topography and vegetation will also act to filter the light. Based on the distance between PACs and the mining area and the intervening topography and vegetation, effects associated with lighting would be insignificant.
- Mining and mining-related activity will not alter Mexican spotted owl habitat.

Navajo sedge with critical habitat

- Peabody pumps water from the N aquifer, the source of water for seeps and springs in the action area and that provide habitat for this species. Based on the lack of measurable decreases in monitored spring flow and the small modeled change in groundwater discharge associated with mine-related groundwater pumping, the effects on Navajo sedge are insignificant.
- Designated critical habitat for Navajo sedge is located about 20 miles northwest of the Kayenta Mine, which is within the N-Aquifer study area but not within any of the known spring groups and washes affected by groundwater pumping. Therefore, any effects on primary constituent elements would be insignificant and discountable.

Razorback sucker

- Chemical deposition from NGS emissions over five years would contribute less than 0.000034 μg/g wet weight of mercury to body tissue of any life stage of this species. This tissue burden is below a concentration that could result in any detectable changes to survivorship, reproduction or behavior. Therefore, effects on the razorback sucker from the indirect effects of coal burning would be insignificant.

- The ecological risk assessment for the San Juan River (Ramboll Environ 2016) indicated that selenium contributions from NGS emissions over a 55-year period would result in critical body residue HQs for razorback sucker of 0.0001 for selenium. This is well below a concentration that could result in any detectable changes to survivorship, reproduction, or behavior (an HQ >1).
- Chemical deposition from NGS emissions over five years would result in no detectable change to water quality. Therefore, effects on the water primary constituent element of designated critical habitat would be insignificant. No other primary constituent elements of critical habitat would be affected.

Southwestern willow flycatcher

- Riparian habitat suitable for breeding is not present on the Kayenta Mine permit area. Riparian vegetation, primarily in the form of tamarisk, occurs as narrow or small patches in several ephemeral washes that lack surface flows or saturated soil during the breeding season. This vegetation could potentially be used by migrant willow flycatchers. No tamarisk would be removed with the continuation of mining operations. Therefore, effects associated with noise and mining-related activities on migrant southwestern willow flycatchers would be insignificant.
- Off-mine and on the Navajo Nation, there may be some limited suitable breeding habitat associated with washes that will be affected by ground-water pumping by Peabody (D. Mikesic, personal communication). Peabody pumps water from the N-Aquifer, which provides base flow to various drainages surrounding Black Mesa. Based on the small amount of monitored decreases in groundwater levels and the small modeled change in groundwater discharge associated with mine-related groundwater pumping, the effects to flycatcher habitat are considered insignificant.
- Designated critical habitat for the southwestern willow flycatcher is located along the San Juan River about 120 miles east-northeast of the NGS. As determined in the San Juan River Study, the NGS would contribute a very small percentage (<0.05) of mercury to the San Juan River (EPRI 2016), which would not result in a measurable change to any primary constituent elements. Therefore, effects on critical habitat from the indirect effects of coal burning would be insignificant.

Welsh's milkweed

- An ecological risk assessment indicated that deposition from NGS emissions over five years would result in a HQ of 0.05 for exposure to chemicals of potential ecological concern. This level is far below the threshold (HQ > 1) at which there is any potential for adverse ecological effects. Therefore, effects on Welsh's milkweed from the indirect effects of coal burning would be insignificant.
- Designated critical habitat for Welsh's milkweed is located about 75 miles west of the NGS, considerably outside the identified deposition area. Therefore, any effects on primary constituent elements would be insignificant and discountable.

Western yellow-billed cuckoo

- The only known records for this species in the action area are more than 50 miles northeast of the NGS plant along the San Juan River. An ecological risk assessment indicated that deposition from NGS emissions would result in a maximum HQ of less

than 0.1 for exposure to chemicals of potential ecological concern. This level is far below the threshold (HQ > 1) at which there is any potential for adverse ecological effects. Therefore, effects on western yellow-billed cuckoo from the indirect effects of coal burning would be insignificant.

When the Fish and Wildlife Service (FWS) enters consultation on a proposed action for which the Bureau of Indian Affairs is a consultation participant, we treat affected American Indian Tribes as license or permit applicants entitled to full participation in the consultation process. This includes, but is not limited to, invitation to meetings between FWS and the action agencies, opportunities to provide pertinent scientific data and review the administrative record, and opportunities to review biological assessments and related documents. In keeping with our trust responsibilities to Tribes, by copy of this memorandum, we are notifying the Hopi Tribe and Navajo Nation, which may be affected by this proposed action.

Thank you for your continued coordination. No further section 7 consultation is required for this project at this time. Should project plans change, or if information on the distribution or abundance of listed species or critical habitat becomes available, this determination may need to be reconsidered. In all future correspondence on this project, please refer to the consultation number 02EAAZ00-2016-I-0614. Should you require further assistance or if you have any questions, please contact John Nystedt at (928) 556-2160 or Brenda Smith at 556-2157 of our Flagstaff Suboffice.

Brenda H. Smith

for Steven L. Spangle

cc (electronic copy):

Chairman, Hopi Tribe, Kykotsmovi, AZ (Attn: C. Honyumptewa, Natural Resources Department)
President, Navajo Nation, Window Rock, AZ (Attn: Bidtah Becker, Natural Resources Division)
Director, Navajo Nation Department of Fish and Wildlife, Window Rock, AZ
Director, Navajo Regional Office, Bureau of Indian Affairs, Gallup, NM
Director, Western Regional Office, Bureau of Indian Affairs, Phoenix, AZ
NEPA Coordinator, Environmental Services, Navajo Regional Office, Bureau of Indian Affairs, Gallup, NM (Attn: H. Yazzie)
Environmental Specialist, Environmental Services, Western Regional Office, Bureau of Indian Affairs, Phoenix, AZ (Attn: C. Lewis)
Chief, Environmental Resources Management Division, Bureau of Reclamation, Phoenix, AZ (Attn: Sandra Eto)
Director, Environmental Services, Colorado/Western, Peabody Energy, Flagstaff, AZ (Attn: Brian Dunfee)
Chief, Division of Endangered Species, Fish and Wildlife Service, Albuquerque, NM (Attn: S. Jacobsen) (ARD-ES)
Tribal Liaison, Southwest Region, Fish and Wildlife Service, Albuquerque, NM (ARD-EA)
Assistant Field Supervisor, Fish and Wildlife Service, Flagstaff, AZ
Fish and Wildlife Biologist, Fish and Wildlife Service, Flagstaff, AZ (Attn: S. Hedwall)

LITERATURE CITED

Ramboll Environ US Corporation. 2016. NGS San Juan River Ecological Risk Assessment; Environmental Impact Statement summary report for the Navajo Generation Station. Project 06-03922. 585pp.

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APPENDIX A – TECHNICAL ASSISTANCE

This appendix contains our evaluation regarding the likelihood of take of bald eagles (*Haliaeetus leucocephalus*) and golden eagles (*Aquila chrysaetos*) from implementation of the Office of Surface Mining's proposed Kayenta Mine Permit Renewal.

The final rule to remove the bald eagle from the Federal List of Threatened and Endangered Species was published in the Federal Register on July 9, 2007, and took effect on August 8, 2007. However, bald eagles continue to be protected by the Bald and Golden Eagle Protection Act (Eagle Act) as are golden eagles. The Eagle Act prohibits anyone, without a permit issued by the Secretary of the Interior, from taking eagles, including their parts, nests, or eggs. "Take" is defined under the Eagle Act as "to pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest or disturb" eagles. Disturb means to agitate or bother a bald or golden eagle to a degree that causes, or is likely to cause, based upon the best scientific information available, 1) injury to an eagle, 2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or 3) nest abandonment by substantially interfering with normal breeding, feeding, or sheltering behavior (USDI 2007).

We believe mining and mining-related activities associated with the Kayenta Mine are not likely to result in take of eagles for the following reasons:

<u>Bald Eagle</u>

- This species occurs at the Kayenta Mine as a rare winter transient. Impacts of mining and mining-related activities on bald eagles foraging over the Kayenta Mine are not expected to rise to the level of take.
- Mining activities are not proposed to occur closer than one-and-a-half miles from potential roosting habitat (drainages with mixed conifer woodland vegetation). Based on this distance and the intervening topography and vegetation, the impacts of sound and light (from dragline floodlights) are not expected to rise to the level of take.

<u>Golden Eagle</u>

- This species is a sparse permanent resident on Black Mesa and is observed periodically over the Kayenta Mine, but there is no potential nesting habitat within a mile of the mine. Reclaimed mine lands offer potential foraging habitat. Impacts of mining and mining-related activities on golden eagles foraging over the Kayenta Mine are not expected to rise to the level of take.

We recommend that any observations of bald or golden eagles be reported to the Zoologist, Natural Heritage Program, Navajo Nation Fish and Wildlife Department, at (928) 871-7070.

LITERATURE CITED

U.S. Department of the Interior (USDI), Fish and Wildlife Service. 2007. Protection of Eagles and Authorizations under the Bald and Golden Eagle Protection Act for Take of Eagles; Final Rule. Federal Register 72(107):31132-31140. June 5, 2007.

NNDFW Review No. 16stan101

BIOLOGICAL RESOURCES COMPLIANCE FORM
NAVAJO NATION DEPARTMENT OF FISH AND WILDLIFE
P.O. BOX 1480, WINDOW ROCK, ARIZONA 86515-1480

It is the Department's opinion the project described below, with applicable conditions, is in compliance with Tribal and Federal laws protecting biological resources including the Navajo Endangered Species and Environmental Policy Codes, U.S. Endangered Species, Migratory Bird Treaty, Eagle Protection and National Environmental Policy Acts. This form does not preclude or replace consultation with the U.S. Fish and Wildlife Service if a Federally-listed species is affected.

PROJECT NAME & NO.: Kayenta Mine Permit Renewal

DESCRIPTION: The OSMRE proposes the renewal of permit AZ-0001E to continue mining operations at Kayenta Mine in Coal Resources Areas N-9, J-19, and J-21 from July 2015 through July 2020. The renewal of this permit does not include any revisions to the mining and operations plan or the addition of any new mining areas.

LOCATION: Kayenta Mine, Kayenta and Forest Lake Chapters, Navajo County, Arizona

REPRESENTATIVE: Alex Birchfield, U.S. Office of Surface Mining Reclamation and Enforcement (OSMRE)

ACTION AGENCY: Bureau of Indian Affairs and Navajo Nation

B.R. REPORT TITLE / DATE / PREPARER: BE-Kayenta Mine Permit Renewal/23 AUG 2017/Stantec Consulting

SIGNIFICANT BIOLOGICAL RESOURCES FOUND: Area 1 & 3.

POTENTIAL IMPACTS

NESL SPECIES POTENTIALLY IMPACTED: NA

FEDERALLY-LISTED SPECIES AFFECTED: Carex specuicola (Navajo Sedge) G3, Threatened. The BE concludes that mine related pumping of the N aquifer may affect, but is not likely to affect the species.

OTHER SIGNIFICANT IMPACTS TO BIOLOGICAL RESOURCES: NA

AVOIDANCE / MITIGATION MEASURES: NA

CONDITIONS OF COMPLIANCE*: NA

FORM PREPARED BY / DATE: Pamela A. Kyselka/21 SEP 2017

COPIES TO: (add categories as necessary)

☐ _____ ☐ _____

2 NTC § 164 Recommendation:	Signature	Date
☒Approval ☐Conditional Approval (with memo) ☐Disapproval (with memo) ☐Categorical Exclusion (with request letter) ☐None (with memo)	Gloria M. Tom, Director, Navajo Nation Department of Fish and Wildlife	9/25/17

*I understand and accept the conditions of compliance, and acknowledge that lack of signature may be grounds for the Department not recommending the above described project for approval to the Tribal Decision-maker.

Representative's signature Date

Appendix H

OSMRE Responses to Public Comments

No.	Comment Summary	Resource or Topic	OSMRE Response
1	The damage to the land, air, water, and people is not acknowledged or completed in the EA.	General	The environmental effects of the proposed Renewal are disclosed and documented in the EA Chapter 4 Environmental Consequences, both for the Proposed Action and for the No Action alternative. Resource areas analyzed include but are not limited to geologic resources, soil resources, landforms and topography, air and climate resources, water resources, land use and recreation, and health and safety. Further, the cumulative effects of the permit renewal, along with those of other reasonably foreseeable actions, are disclosed and documented in EA Chapter 5 Cumulative Impacts.
2	The presentation at the public meetings was inadequate. Public meetings should take place after educating the public for a couple of days.	Public Involvement	Pursuant to CFR, Title 30, Chapter VII, Subchapter E, Part 750 and Subchapter G, Parts 773 and 774, PWCC published a public notice (Appendix A of the EA) in the Navajo Times and the Navajo Hopi Observer of PWCC's filing of an application for the Renewal. In accordance with 30 CFR 773.6(a)(1), the notices were published once a week for four consecutive weeks beginning on April 8, 2015 and ending on April 30, 2015. The public comment period continued for an additional 30 days beyond April 30, and ended on June 1, 2015. OSMRE received two comments on the application and two requests for an informal conference. OSMRE hosted two open houses for the EA in conjunction with informal conferences for the proposed Kayenta Mine Renewal Application. The open houses and informal conferences were held at the following dates and times: • September 5, 2017, 6 – 8 p.m. (Arizona Time), Veteran's Center, Highway 264, milepost 375.5, Kykotsmovi, Arizona (Hopi language interpreter was present). • September 6, 2017, 10 a.m. – noon (Navajo Nation Time), Forest Lake Chapter House, 17 miles north of Pinon Conoco, Pinon, Arizona (Navajo language interpreter was present). The public meetings were held in what is termed an "open house" format in which summary information is presented on posters displayed throughout the meeting room. Personnel from OSMRE, the Hopi Tribe Office of Mining and Mineral Resources, the Navajo Nation Minerals Department, Stantec (the contractor who prepared the EA for OSMRE) and PWCC were present at both public meetings to answer any questions and/or explain to individuals from the public any information that was not understood. In addition, a Hopi interpreter was available for the Hopi public meeting and a Navajo interpreter was available for the Navajo public meeting to help facilitate communications with members of those respective Tribes. The EA has been available on the OSMRE website for public review beginning August 17, 2017 and paper copies have been available at the Navajo Nation Minerals Department; Hopi Tribe, Office of Mining and Mineral Resources; OSMRE, Western Region; and Forest Lake Chapter House.
3	I support the extension of the mine through 2020, but no further.	General	The Renewal considered in this EA is for the period July 16, 2015 to July 15, 2020. If the Renewal is approved by OSMRE, the mine will only be authorized to mine coal until July 15, 2020.

No.	Comment Summary	Resource or Topic	OSMRE Response
4	The EA does not consider the health impact on people and the environment.	General	See response to comment 1. The risks of human health hazards are disclosed in Chapter 3, Section 3.17 Health and Safety of the EA. An HHRA for the Kayenta Mine was completed in 2016 (Flatirons Toxicology 2016) and a separate HHRA was prepared for the NGS (Ramboll Environ 2015). The potential direct and indirect effects on human health of the proposed Permit renewal are disclosed in Chapter 4, Section 4.17 of the EA. While the only potentially significant health risk from mining is inhalation of dust and vehicle emissions, the HHRA determined that for the Proposed Action, the direct effects on human health would be negligible. The indirect effects of burning the coal on human health and safety were also determined by the 2015 HHRA prepared for the NGS to be negligible. The cumulative effects on human health and safety of the proposed Permit Renewal are disclosed in Chapter 5, Section 5.16. The total cumulative hypothetical cancer risk estimates, including baseline, Proposed Action, and other cumulative sources, are well within acceptable EPA cancer risk standards and would result in a negligible project contribution to cumulative effects on human health and safety.
5	The Navajo Nation and the US must look at renewable sources of energy.	General	An alternative to consider renewable energy resources in place of coal would not meet the Purpose and Need for the action considered in this EA and therefore would be outside the scope of this EA. The Purpose and Need for this EA reflects OSMRE's scope of authority over permit renewal applications. OSMRE must decide whether to approve or disapprove renewal of the subject permit application (AZ-0001E) based only on the criteria listed at 30 CFR 774.15(c)(1).
6	The information regarding compensation to local land users is incorrect. Compensations are not paid supposed to be paid yearly but every five years. However, the payments have been delayed.	Socioeconomics	The compensation has been revised in the final EA to reflect the five-year schedule. However, PWCC's payments to local land users is not under OSMRE jurisdiction and control and are not subject to change under the Renewal; therefore, this portion of the comment is out of scope of the EA.
7	There needs to be an independent study of water drawdown due to mining separate from PWCC's study.	Water	The groundwater study independently performed by PWCC contractors involved detailed review of comprehensive geologic and hydrologic data collected from the N-Aquifer over several decades, and has been reviewed by the OSMRE, Navajo Nation and Hopi Tribes. The study took a hard look at the effects of groundwater pumping on the N-Aquifer using data collected by PWCC and the USGS under a cooperative monitoring program in place since the mid-1970s. The model was originally calibrated using all available data through 1996, and was validated using available data through 2009 by comparing drawdown measured in USGS monitoring wells (BM-series wells) with model predictions. The validation work resulted in good agreement between simulated and measured water levels in the BM-series wells, and showed that additional calibration was not needed. OSMRE believes the groundwater model provides scientifically sound and reasonable predictions of the effects of PWCC's pumping from the N-Aquifer. Accordingly, OSMRE sees no benefit from undertaking new studies of water drawdown due to PWCC's past and proposed continued pumping of the N-Aquifer for the purpose and need of this EA.

No.	Comment Summary	Resource or Topic	OSMRE Response
8	Bioaccumulation of heavy metals in soil and plants needs to be considered as part of reclamation.	Reclamation	EA Section 4.3.1, p. 4-9 (modified not a direct quote): OSMRE guidelines for reclamation programs and projects identify soil conditions considered acceptable or suitable during reclamation, including soil pH and acid-forming spoils, sodic zones, and toxic substance occurrence in soil. From EA Section 3.3, p. 3-6: Suspect concentrations of plant-available selenium were historically shown to occur in shale and coal overburden strata. Based upon the results of selenium analysis in plants and soils at a representative cross-section of sites where accumulator plants were found, the soils in which they were growing are not seleniferous (PAP, Ramboll Environ 2016a). These site-specific studies demonstrated that selenium would pose no harm to successful reclamation and therefore, in 2006, this parameter was removed from the list of suitability criteria used for evaluating topsoil and graded spoil. Baseline soil lead concentrations (less than 10 milligrams per kilogram [mg/kg]) were at the low end of the typical background range (Flatirons Toxicology 2016). For the direct effects study area and indirect effects study areas, SIRs (Ramboll Environ 2016a, 2016b) and ERAs (Ramboll Environ U.S. Corp [Ramboll Environ] 2016a, 2016b) were developed. The SIRs included collection of baseline data with respect to heavy metals in soils. The ERAs included analysis of the effects of heavy metals in soils on vegetation and the effects on higher trophic level organisms, e.g. mammals and birds, including from ingestion of plants. The ERAs are discussed in greater detail in the following sections of the EA; Vegetation (3.8, 4.8 and 5.8), Wildlife and Fish (3.9, 4.9 and 5.9). HHRAs were also conducted and included analysis of the effects of heavy metals in soils on humans including from ingestion of plants. See response to comment 4 for details on the HHRAs.
9	CCR is leaking into the Carmel Formation and eventually into the Navajo Aquifer. The EA needs to be extended or delayed to make sure CCR regulations are complied with before signing of the FONSI.	Water	Studies conducted by the USGS (Truini and Longsworth 2003; Truini and Macy 2006) suggest leakage of water from the D-Aquifer to the N-Aquifer "has been occurring for thousands of years". Based on this study, the USGS determined that leakage is most likely to occur in the southern part of Black Mesa (EA Section 3.7.2.4, p. 3-43) where the Carmel is relatively thin (less than 120 feet thick) . However, the NGS and associated CCR disposal area is not located in this portion of Black Mesa. The containment of CCR at the NGS, and site conditions and measures protective of leaching to groundwater, are detailed in the EA Section 3.7.4. Also, 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. Annual groundwater monitoring and triggers for corrective actions will be developed and implemented per the schedule and requirements set out in the CCR rule (EA Section 3.7.4, p. 3-49). Therefore, OSMRE believes CCR is adequately described and analyzed in the EA and delaying the FONSI is not appropriate.

No.	Comment Summary	Resource or Topic	OSMRE Response
10	The comment period needs to be extended.	Public Involvement	See response to comment 2. The OSMRE has determined that the current, 30-day timeframe affords the public sufficient time and opportunity in which to review and submit comments pertaining to the EA.
11	The Sipapu needs to be added to Section 3.7.3.7 Ceremonial Water Use (Hopi Tribe) and 3.7.3.8 Groundwater Recharge and Unique Waters (Hopi Tribe).	Water	A Hopi Ethnographic Report was prepared to support the NGS-KMC DEIS (Anthropological Research and HCPO 2016; see EA Chapter 7 for complete reference). The Hopi Tribe did not identify impacts to the Hopi Sipapu (Sipapuni). This traditional resource is outside of the potentially directly or indirectly affected area related to the Renewal. Therefore, it will not be included in the analysis.
12	The EA ignores N-Aquifer water leakage and assumes no leakage from the N-Aquifer to the C-Aquifer.	Water	The two prominent water bearing formations in the C-Aquifer (Kaibab Limestone and Coconino Sandstone) are separated from the N-Aquifer by 1,800 feet of siltstone and claystone in the Chinle and Moenkopi Formations. Because of the thickness and low permeability of the rocks in the Chinle and Moenkopi Formations, and distance below the bottom of the N-Aquifer to the C-Aquifer, hydraulic communication between the N and C-Aquifers is appreciably restricted, and leakage from the N-Aquifer into the C-Aquifer was assumed to be negligible.
13	Executive Order 13166 requires federal agencies ensure people with limited English proficiency can meaningfully access their programs and activities. OSMRE did not do that.	General	See response to comment 2. Personnel from OSMRE, the Hopi Tribe Office of Mining and Mineral Resources, the Navajo Nation Minerals Department, Stantec (the contractor who prepared the EA for OSMRE) and PWCC were present at both public meetings to answer any questions and/or explain to individuals from the public any information that was not understood. Hopi and Navajo interpreters were available for the Hopi and Navajo public meetings, respectively, to translate this information for those with limited English proficiency.
14	The translators at the public meetings were not trained to interpret technical language such as that in the EA.	General	OSMRE understands that the technical language in the EA may not have equivalent words or phrases in Hopi or Navajo. OSMRE made its best effort at providing meaningful translation to the extent possible.
15	SMCRA regulations prohibit mining on or near a cemetery. Black Mesa is a cemetery that mandates protection, not just mitigation.	Cultural Resources	Although human burials exist within the Lease Area, neither the Hopi Tribe nor the Navajo Nation has designated any lands within CRAs as cemeteries, as that term is used in SMCRA. Nonetheless, surface mining activities that affect known or unidentified burials within the Lease Area are subject to the requirements of the NHPA, Section 6, NAGPRA, SMCRA, and tribal laws and policies. OSMRE has completed Section 106 consultation for the entire study area through the BMAP, and no further consultation would be required for the Renewal. Under SMCRA, mining is limited or prohibited at cemeteries. Also under SMCRA, cemeteries can either be avoided by 100 feet or relocated in accordance with local laws. Furthermore, the Kayenta Mine SMCRA permit carries terms and conditions that address proper management of unanticipated finds of historic and cultural resources, including associated human remains. Therefore, when places where human bodies are interred are encountered at the Kayenta Mine, the mine operator ceases disturbing activities, and works with OSMRE, the Navajo Nation Tribal Historic Preservation Officer, and any lineal descendants prior to any relocation. Relocations are conducted in accordance with applicable laws and policies. Once a burial has been reinterred through adequate consultation, OSMRE allows mining to proceed under the permit.

No.	Comment Summary	Resource or Topic	OSMRE Response
16	By failing to require PWCC to post a groundwater reclamation plan and bond, OSMRE has failed to exercise a precautionary measure to protect a priceless resource, our sole source drinking water.	Water	SMCRA does not specifically require an operator of a surface coal mine to post a groundwater reclamation bond. However, SMCRA does require operators to develop a determination of the probable hydrologic consequences (PHC) of the mining plans (30 CFR 780.21) and a hydrologic reclamation plan (30 CFR 816.41) that ensures impacts to the hydrologic balance are minimized by the mining operation. In addition, the rules require OSMRE develop a cumulative hydrologic impact assessment based on information submitted by the operator in the permit application package. The rules also require the operator to develop a groundwater monitoring program and submit monitoring data to OSMRE and other agencies as appropriate. Finally, the USGS continues to collect additional monitoring data pertinent to the N-Aquifer under a cooperative monitoring program funded by PWCC, the BIA and the Navajo Nation. OSMRE's 2011 CHIA provides a detailed analysis of the potential impacts of PWCC's withdrawals from the N-Aquifer, concluded no material damage to the N-Aquifer has occurred from past withdrawals, and continued pumping from the N-Aquifer through the permit renewal term will not cause material damage. OSMRE believes sufficient precautionary measures have been in place and will continue to remain in place to protect the N-Aquifer.
17	PWCC's cessation of operations on December 22, 2019 must be treated as a significant permit revision and processed as a new application, not a permit renewal with a right of successive renewal	General	Pursuant to Section 506(d)(l) of SMCRA, as amended, and 30 CFR 774.15 of the regulations promulgated thereto, any valid permit shall carry with it a right of successive renewal upon expiration with respect to areas within the boundaries of the existing permit. The Affected CRAs subject to this Renewal are entirely within the Kayenta Mine Permit Area. The proposed Renewal application does not include any revisions to the mining and operations plan or the addition of any new mining areas and is therefore under 30 CFR 774.15(b)(2)(4) is not subject to processing as a permit revision. For the proposed Renewal period, coal-mining operations would be assumed to continue at the recent historical pace of approximately 8 mtpy and existing facilities would be used for ongoing operations. The only mine facilities that would be constructed as part of the mining in CRAs N-9, J-19, and J-21 and reclamation in CRA N-11 during the Renewal period would be sediment ponds, roads, utilities, and topsoil stockpiles. Those facilities were, previously approved in the permit for these CRAs, as they are mined or reclaimed. Surface coal mining and reclamation activities in the CRAs were previously authorized under SMCRA with issuance of the Kayenta Mine permanent program permit. The future operation or cessation of NGS is uncertain at this time and therefore does not necessitate the submission of an application for revision of the mine permit at this time, and does not affect SMCRA reclamation requirements or the reclamation plan.
18	PWCC's reclamation plan is outdated and insufficient to address cessation of mine operations at the Kayenta Mine on December 22, 2019. It is imperative that OSMRE require PWCC to produce a meaningful Plan for Reclamation.	Reclamation	The reclamation plan is sufficient and unchanged from the previous renewal, and would apply to this Renewal. There are no new proposed operations that would require updating the reclamation plan.
19	OSMRE's EA fails to address mine closure and reclamation activities.	Reclamation	Mine closure and reclamation activities are summarized in the EA Appendix B and detailed in the PAP.

No.	Comment Summary	Resource or Topic	OSMRE Response
20	OSMRE must evaluate the adequacy of PWCC's Performance bond	Reclamation	All performance bonds in effect for the Kayenta Mine operation will continue in full force and effect for the renewal period per 30 CFR 774.15(b)(2)(iii). OSMRE holds the SMCRA reclamation bond, a third-party surety bond, posted by PWCC for the Kayenta Mine. The reclamation bond is described and calculated in the permit application package, Permit AZ-0001E (if approved, the renewed permit would be Permit AZ-0001F). OSMRE reviewed the reclamation bond applicable to the Kayenta Mine renewal application and that amount has been calculated to account for the reclamation required, as well as inflation, within the Affected Coal Resource Areas (CRAs) within the Permit Area. SMCRA requires an operator to post a performance bond payable to the regulatory authority in an amount sufficient "to assure the completion of the reclamation plan if the work had to be performed by the regulatory authority in the event of forfeiture." 30 USC 1259. Liability under the bond must be for the duration of the surface coal mining and reclamation operation. Id. The SMCRA reclamation bond amount is based, among other factors, on the cost for full completion of the reclamation plan giving consideration to such factors as topography, hydrology, and revegetation and the probable difficulty of reclamation completion 30 CFR 800.14(a). The SMCRA performance bond calculation is included in the Kayenta Mine Permit Application Package, Volume 11A, Chapter 24-Bonding. The EA evaluates the disturbance related to the proposed mining and reclamation of the Affected CRAs at Kayenta Mine. Providing an adequate reclamation bond is a SMCRA requirement and must be provided prior to the issuance of the SMCRA permit. It is a SMCRA requirement but an administrative component of the permit process, and does not represent or result in a physical change to the environment that would be analyzed in an EA. The EA analyzes the impacts of mining and the required reclamation requirements under SMCRA. The reclamation bond assures the requirements of SMCRA will be met if the regulatory authority must undertake the work in event of bond forfeiture. The EAs analysis of mining and associated SMCRA reclamation remain valid.
21	The EA fails to evaluate effects of Reclamation at Black Mesa. These impacts must be analyzed	Reclamation	The Renewal of the SMCRA permit of the Kayenta Mine for the Renewal period would not involve any reclamation activities at Black Mesa Mine. The former Black Mesa mine is outside the permit boundary, is not a component of permit, and is not required to be addressed as part of the five-year renewal of the current Kayenta Mine permit. Reclamation of mining disturbance at Black Mesa has occurred in accordance with applicable SMCRA standards. Reclamation activities at Black Mesa, to the extent there is any reclamation left, will occur as required by the lease or other agreements with the Navajo Nation and Hopi Tribe.

No.	Comment Summary	Resource or Topic	OSMRE Response
22	PWCC is currently using facilities at Black Mesa without a permit	General	Most of the facilities necessary for the mining operations are located within the Permit Area but some are located outside the boundaries of the Permit Area. The mine facilities outside the Permit Area have been separately authorized by OSMRE as part of the Initial Regulatory Program and are authorized for use in mining operations at Kayenta in accordance with SMCRA regulations, 30 CFR 778.22. The EA includes analysis of the direct and indirect effects from the use of all mine facilities, within and outside the Permit Area, to the extent such facilities are necessary to support the mining operations that would be continued under the proposed action. The analysis of cumulative effects includes all past and present mine facilities. The PWCC previously attempted to revise the Kayenta Mine permit boundary to encompass these facilities, but the effort was opposed by community and environmental organizations.
23	OSMRE fails to analyze a reasonable range of alternatives.	General	During the development of this EA, several potential alternatives were considered by OSMRE. NEPA does not require agencies to analyze the environmental consequences of alternatives that it has in good faith rejected as too remote, speculative, impractical, or ineffective. Three action alternatives were evaluated by OSMRE but dismissed because they were not reasonable, not economically practical, or not technically feasible (EA Section 2.5).
24	Continuation of the Kayenta Mine and NGS operations through December 22, 2019 are connected actions and must be analyzed in a single document.	NEPA	Pursuant to 40 CFR 1508.25(a)(1), actions are connected if they: automatically trigger other actions which may require environmental impact statements; cannot or will not proceed unless other actions are taken previously or simultaneously; are interdependent parts of a larger action and depend on the larger action for their justification. The renewal of the Kayenta Mine Permit for the 2015-2020 period is an independent SMCRA requirement that does not automatically trigger any action at NGS. The Kayenta Mine Permit Renewal has independent utility from NGS in that operations at Kayenta Mine including reclamation activities within the boundaries of the existing permit would proceed for the permit renewal period regardless of any potential actions taken at NGS. Justification for the Kayenta Mine Permit Renewal does not depend on any larger action. Therefore, NGS operations are neither a “connected action” nor part of the proposed action to renew the existing SMCRA permit for a five-year term. Nonetheless, the effects of coal combustion at NGS were considered in the EA as indirect effects and within the cumulative impact assessment.

No.	Comment Summary	Resource or Topic	OSMRE Response
25	OSMRE relies on an outdate CHIA and material damage criteria.	Water	The EA has been prepared by OSMRE to analyze and disclose the effects of renewing the Surface Mining Permit for the Kayenta Mine (AZ-0001E) for a five-year period ending in July 2020. OSMRE believes the 2011 CHIA is appropriate for the purpose and need of the EA. SMCRA does not require the preparation or review of a CHIA for a permit renewal, but only in conjuction with new permits and permit revisions. No permit revisions are proposed as part of the permit renewal application. An updated draft version of the CHIA has been developed (September 2016), for a significant permit revision that contemplated continued coal mining at the Kayenta Mine through 2044 (review of that revision is currently suspended). That 2016 draft CHIA was developed and made available to the public consistent with a 2014 settlement agreement in Department of the Interior, Office of Hearings and Appeals case number DV-2012-3-R. The definitions of material damage to the N-Aquifer differs between each document, but the conclusions are similar in that OSMRE finds no material damage to the N-Aquifer has occurred due to past withdrawals or are likely to occur as a result of future withdrawals under each mining scenario evaluated. Application of the 2016 material damage criteria to the renewal would not change the finding that no material damage would result from renewal of the permit.
26	Roads in and around the mine have been damaged by mining activities and need to be improved.	Transportation	Road improvement is outside of the scope of the EA and the permit renewal process.
27	Water infrastructure as part of the Many Mules project needs to include more families in the area.	Water	The Manymules water project is a Navajo Nation project that is not associated with the Kayenta Mine and therefore not within OSMRE jurisdiction. Based on the Navajo Nation Department of Water Resources' (NNDWR) July 2004 Technical Memorandum for the Black Mesa Manymules Water Supply Project, there were 177 homes identified for providing water within the proposed Manymules Project sevice area in 2002. In 2030, the number of homes that will be serviced with water from the Manymules Project is estimated to number about 351.
28	Hiring practices at the mine are substandard. The majority of hires at the mine are from New Mexico and not Arizona.	Socioeconomics	OSMRE does not have the authority to dictate hiring practices at the mine; therefore, hiring practices are out of scope of the EA.
29	Coal mining has a negative impact on the health of the people in the area.	Health and Human Safety	The effects of mining Kayenta Mine coal, and burning of Kayenta Mine coal both for household use and at the NGS, is provided in EA Section 4.17.
30	PWCC should dredge and design the J7 pond to benefit people and animals. The aquatic weeds and salt cedar needs to be cleared or reduced.	Water	The J7-DAM reservoir has been properly designed, operated, and maintained since it was built in 1973. The storage capacity of this large reservoir is 669.4 acre-feet. Routine operation and maintenance includes quarterly inspections of the dam and periodic surveys of the bottom of the reservoir to insure its capacity remains above the design requirements. If surveys determine that the capacity has been reduced due to siltation, the pond will be dredged to restore design capacity. The presence of water weeds and other vegetation along the reservoir banks serve to provide valuable habitat for wildlife and waterfowl. The J7-DAM is proposed to remain in place as a permanent impoundment after reclamation is completed and bond release is finalized.
31	Request that the comment period be extended 7-10 days	Public Involvement	See response to comment 2. The OSMRE has determined that the current, 30-day timeframe affords the public sufficient time and opportunity in which to review and submit comments pertaining to the EA.

No.	Comment Summary	Resource or Topic	OSMRE Response
32	The Navajo population has dropped in the last decade. The Kayenta Mine is a genocidal resource that is depopulating the Navajo Nation as the water litigation forces many Navajos to leave the Navajo Nation.	Socioeconomic	There is no water litigation that is within the scope of the Renewal or the EA. Also, any change in the Navajo population is beyond the scope of the Renewal or OSMRE's authority.
33	The Biological Evaluation has to include the California Condor as there has been an electrocution of one already. Power lines are part of the NGS lease agreements.	Wildlife	While California condors have been reported to strike powerlines and powerlines are part of the mine operations, no condors have been observed in the vicinity of the mine. As such, they were not included in the analysis.
34	Reading Section 3.7, page 3-23 one thinks that the ponds, seeps, and other water sources are contaminated, although there are game fish in some of them.	Water	The information provided in Section 3.7 is technical in nature and covers all water sources within and adjacent to the Kayenta Mine. Characterization of water quality in these features relies on historical measurements of several trace elements that, in large concentrations, may be considered hazardous to humans and wildlife. However, these features are not considered to be hazardous based on comparisons of historical and recent water quality monitoring data with applicable water quality standards established by the Navajo Nation and Hopi Tribes.
35	The Black Mesa pipeline uses 10,000 ac-ft/yr. The EA claims a number less than half of 10,000 ac-ft/yr.	Water	Total annual withdrawals from PWCC's N-Aquifer wellfield from 1972 through 2005 averaged 3,982.8 acre-feet. The highest annual withdrawal occurred in 1982 at 4,744.2 acre-feet.
36	The Kayenta Mine EA should recommend an immediate closure and begin reclamation.	General	The EA states that the two options possible for the permit renewal are to either: 1) approve the five-year Renewal, or 2) deny the Renewal. Based on 30 CFR 774.15(c)(1), OSMRE must approve the Renewal unless one of six criteria are met (Page 1-7 of the EA). OSMRE determined that none of the six criteria were reached.
37	The crushed rock (Red Dog) used on the roads creates a lot of dust that impacts health and air quality in the region.	Air Quality, Health and Human Safety	See response to comment 4 with respect to human health impacts from dust. Air quality is analyzed in Section 3.5, 4.5 and 5.6 Air and Climate Resources of the EA. The analysis shows that regional and near-field air quality is expected to remain in compliance with the NAAQS.

No.	Comment Summary	Resource or Topic	OSMRE Response
38	There should be more community involvement in the final reclamation. There could be more uses than just grazing and for some of the infrastructure left. Ponds should also be left in place.	Reclamation	PWCC has developed a reclamation plan in the permit application for establishing a reclaimed landscape that would minimize erosion and support post-mining land uses. No formal land use plans or policies have been developed by land management agencies specific to the Black Mesa leasehold, i.e., the Navajo and Hopi Tribes and/or the BIA. Therefore, the reclamation plan has been designed to produce lands which will be compatible with and will support the existing and historic land uses. The primary historical land use in the area has been livestock grazing—primarily sheep and goats. In recent years, the numbers of cattle and horses have increased. Other land uses include agriculture (primarily corn production in dry land, small area family plots), gathering of plant materials (for cultural, medicinal, and edible purposes), commercial trapping, various forms of outdoor recreation, and preservation of wildlife habitat. Reclamation efforts at the mine are directed toward restoring the land to be used for livestock grazing, wildlife habitat, and cultural plant use. The plan is currently implemented and is based on 25 years of reclamation operations at the Kayenta Mine. Under this plan, factors such as hill slope gradient and length, soil properties, surface-soil mechanical manipulation techniques, site characteristics, and revegetation practices are evaluated using prescribed criteria to design the surface form, soil placement, and drainage plan. With this plan, soil losses are predicted to be less than soil losses in pre- mining conditions.
39	Some of the reclamation completed is on 4-6 percent slopes that allows erosion to occur. Terraces should be built to catch the topsoil.	Reclamation	See response to comment 38.
40	The species used in reclamation are not holding the soil in place. Native grasses/species should be used to prevent erosion and for future grazing.	Reclamation	The species used in the reclamation seed mix is predominately native species. Any non-native species used are included for the stated purpose of post mining use as livestock grazing areas.
41	There needs to be better control of noxious weeds from entering the mine and spreading around the land.	Noxious weeds	PWCC would continue to control noxious weeds within the Permit Area as it has previously. This program is described in the EA Section 4.8.1.
42	The retention ponds built for the mine need to be retained as those help prevent erosion.	Reclamation	See response to comment 38.
43	PWCC should not be giving away concrete or crushed concrete as those may have heavy metals or other chemicals on them.		The donation of concrete or crushed concrete not part of the Renewal and is beyond the scope of the SMCRA permit renewal or the EA.
44	Reclamation should not include species that are not native to the area. Right now there are a lot of salt cedars and Russian olives that use a lot of water.	Reclamation/Noxious weeds	See response to comment 41.

No.	Comment Summary	Resource or Topic	OSMRE Response
45	There are a number of power plants surrounding the Navajo Nation. There are also a number of oil and gas drilling operations and mining for other resources. The cumulative impacts must include all of these.	Cumulative	Each resource analyzed in the cumulative impacts section has a CIAA assigned. All past, present, and reasonably foreseeable future actions within the CIAA for each resource is analyzed. Section 5.6 (Air and Climate Resources) describes other power plants within the CIAA and provides information on their pollutant concentrations.
46	The EA ignored the cumulative health impacts power plants, oil and gas operations, and mining in the surrounding area have.	Health and Human Safety/Cumulative	The CIAA for health and human safety is the same as for air resources and includes the same past, present, and reasonably foreseeable future action. Using analysis conducted for the HHRAs, the EA disclosed that no significant cumulative impacts to human health would occur. See response to comment 4 for details on the HHRAs.
47	PWCC needs to dig another well near where I live.	Water	The proposed Permit Renewal addressed in this EA would not result in any changes to the mine plan previously approved by OSMRE. Drilling a new well would require new applications and OSMRE and other regulatory approvals not part of the currently approved mine plan and is beyond the scope of the Purpose and Need for this EA. The Purpose and Need for this EA is limited to addressing the five-year Renewal of the Mining Permit for the period July 6, 2015 through July 5, 2020. The Proposed Action does not include any changes to the mining plan currently approved by OSMRE. All proposed activities under the Proposed Action have been previously approved by OSMRE.
48	The revegetation that has been completed has been unsuccessful due to the slope. When it rains, the vegetation washes away. Saltbush/shadscale should be planted.	Reclamation	As part of PWCC's reclamation plan approved by OSMRE, there is a specific revegetation plan. Please refer to Appendix B. Section D.5 Revegetation Plan of the EA. OSMRE has approved the seed mix and vegetation types as well as the methodologies to be utilized in reclamation. As part of that plan, PWCC monitors the success of revegetation twice per year. OSMRE also periodically inspects the revegetation efforts to determine whether it is meeting the requirements for revegetation. There may be specific locations where approved reclamation methods may need to be revised to address very localized conditions. The reclamation plan can be revised with OSMRE approval. The conditions described in the comment will be investigated by OSMRE and PWCC and if needed, changes will be made to the reclamation plan to address these specific conditions.
49	Operations at the mine need to come to a complete stop in December 2019.	General	If the Proposed Action is approved by OSMRE, all mining operations would cease on or before December 22, 2019. However, reclamation operations would continue until July 5, 2020 or until all reclamation obligations are met by PWCC. If the No Action Alternative is approved by OSMRE, all mining operations would cease immediately and reclamation operations would continue until all reclamation obligations are met by PWCC.
50	The public should be involved in the reclamation process to ensure it is completed as it was stated in 1969.	Reclamation	The Purpose and Need for this EA is limited to addressing the five-year Renewal of the Mining Permit for the period July 6, 2015 through July 5, 2020. The Proposed Action does not include any changes to the mining plan currently approved by OSMRE. All proposed activities under the Proposed Action have been previously approved by OSMRE and has been subject to public review and comment as required by SMCRA. If the comment refers to the plan for decommissioning the NGS and how the public will be involved in reviewing that plan, that process is outside the scope of the Purpose and Need for this EA.

No.	Comment Summary	Resource or Topic	OSMRE Response
51	Local residents should be hired for the reclamation process.	Socioeconomic	The potential pool of people to be employed for the decommissioning, closure, and reclamation of the NGS and the mine is outside the scope of the Purpose and Need for this EA.
52	How much water is left in the aquifer and is it is contaminated?	Water	The total storage of groundwater in the N-Aquifer has been estimated to total 450 million acre-feet (see EA Section 3.7.2.4). From 1969 through 2016, PWCC's withdrawals from the N-Aquifer wellfield totaled approximately 150,000 acre-feet, approximately 0.03 percent of the estimated total storage in the N-Aquifer. Based on the estimated total storage of the N-Aquifer, approximately 449.85 million acre-feet of water will remain at the end of 2020. There is no evidence of contamination of the N-Aquifer as a result of PWCC's withdrawals from the N-Aquifer.
53	Springs have been impacted by the drawdown of water from the aquifer from mining activities.	Water	Springs that are supported by flow from the N-Aquifer are present in areas near the confined/un-confined boundary of the N-Aquifer, and in limited areas further distant from this boundary where the Navajo Sandstone is exposed at the surface and groundwater is unconfined by rock layers above. Water elevations in the N-Aquifer where it is exposed and unconfined by overlying rocks are typically higher than the elevation of adjacent downcut channels and rock outcrop areas. In these areas, drawdown in the N-Aquifer due to PWCC's pumping does not propagate further appreciably due to the change in hydrologic characteristics that occur due to the absence of rock layers above. Several springs in the vicinity of Tuba City and Moenkopi have been monitored by the USGS for decades. Changes in spring flow at these locations are more affected by local municipal pumping due to the unconfined nature of the N-Aquifer at these locations. There is no evidence to suggest PWCC's withdrawals from the N-Aquifer have caused measurable impacts on springs that emanate from the N-Aquifer near the unconfined/confined boundary, or more distant springs that are situated in the unconfined areas of the N-Aquifer.
54	Peabody could run out of coal even with the NGS replacement lease.	Geology	The Resource Recovery and Protection Plan (R2P2) has been approved by the Bureau of Land Management (BLM) under its authority and responsibilities to determine Ultimate Maximum Recovery (UMR) on Indian Coal Mining operations. The R2P2 presents specific coal tonnage production figures by quantity, by lease area, by lease ratio and year and is included in the Kayenta Mine Permit Application Package, Volume 1, Chapter 5 - Coal Recovery and Protection Plan. The R2P2 has not changed as part of the proposed Permit Renewal addressed in this EA.
55	The 2013 NGS lease extension was just a way of reducing coal consumption so they could finish out the 50 year NGS lease. The replacement lease is a plan to tie off their liability and leave the Navajo Nation with contaminated land.	General	NGS operations are not part of the Renewal and are outside of the scope of this EA.
56	Why are there two permit applications for the Kayenta Mine?	General	One application is for the five-year Renewal of the current SMCRA permit. The other proposal is for a permit revision to allow mining at the Kayenta Mine Complex for approximately an additional 25 years starting in December 2019 (this proposal is currently suspended).
57	I would like to have informal conferences at places in our community.	General	See response to comment 2.

No.	Comment Summary	Resource or Topic	OSMRE Response
58	PWCC's PAP is incomplete and late. Newspaper clippings of proof of publication have to be attached.	General	OSMRE received the affidavits of publication from PWCC on May 12, 2015. They are incorporated into the Permit Application Package PAP when the permit renewal is approved. The affidavits of publication are not available until after newspaper publications have been published and not at the time of when PWCC submits the permit renewal application to OSMRE.
59	The bonding calculation provided in the PAP is incorrect and also has not been updated to reflect inflation.	General	See response to comment 20.
60	PWCC is behind on reclamation.	Reclamation	See response to comment 38. Per their reclamation plan, PWCC begins reclaiming areas as soon as they are mined out.
61	Water is creating gullies and soil erosion in the reclaimed areas.	Soil	See response to comment 38.
62	PWCC must follow the law.	General	PWCC is adhering to SMCRA and all related state, federal, and local laws.
63	PWCC's permit must be withdrawn and mining should stop. Reclamation should commence.	General	As described in EA Section 1.5, OSMRE must approve a complete and accurate application for a permit renewal unless it finds that at least one of six criteria (listed on EA page 1-7) exists. Under the Renewal, mining will stop in December 2019 and final reclamation will commence.