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. OSMRE must make a determination that the BNCC operation has been designed to minimize impact within the permit area and prevent material damage outside the permit area. OSMRE must also evaluate that the monitoring program has been appropriately designed to provide the surface water quantity and quality information necessary to assess potential impacts per 30 CFR 780.21(g).

5.1 Minimization of Impact

BNCC outlines impact minimization procedures in the Hydrologic reclamation plan (BNCC 2011, Section 12.11). Minimization of impacts to the hydrologic balance is focused on reducing the disturbance footprint to the extent practical via contemporaneous reclamation. Additionally, local areas of acid forming material are managed through proper chemical characterization and placement, including blending and mixing, of overburden materials. The amount of upgradient surface water commingled with disturbed area drainage is limited utilizing best management practices (BMPs) to contain or divert upgradient flows. Upgradient flows diverted around active mining pits and into downgradient natural channels or upgradient impoundments have been established to contain upstream water runoff. Migration of sediment during storm events is limited utilizing BMPs to contain or treat flows via impoundments downgradient of the mine site. BNCC also minimizes potential effects to the surface water and alluvial groundwater quantity by instituting stream buffer zones when practical to limit disturbances in channel reaches unaffected by mining. OSMRE finds that the mining operation has been designed to minimize impacts within the permit boundary.

5.2 Monitoring Program

A surface water monitoring plan is provided in the PAP, Chapter 7, Section 7.4. BNCCs surface water monitoring program was established to monitor surface water quantity and quality at locations where major watercourses enter and leave the permit area. The monitoring program provides the basis for assessment of the impact of mining on the surface water resource and has been developed to collect water quantity and quality information for use in the identification of potential impacts to the prevailing hydrologic regime. The plan identifies the parameters to be monitored, sampling frequency, and site locations. The permit application also complies with NPDES Permit No. NN0028193 (BNCC 2011, Section 7.4). Current surface monitoring locations can be seen on Figure 17. A list of surface water sampling parameters is found in Navajo Mine PAP, Chapter 7, Table 7-10, and includes pH, TDS, TSS, conductivity, settleable solids, total sediment, aluminum, arsenic, boron, calcium, cadmium, chloride, fluoride, total and dissolved iron, lead, total and dissolved manganese, nitrate, potassium, selenium, sulfate, sodium, bicarbonate, and carbonate (BNCC 2011). Additionally, each sample is accompanied with a cation/anion balance for quality assurance. OSMRE finds that the surface water monitoring program has supplied sufficient information to support the required evaluation for material damage potential in this CHIA.

A groundwater monitoring plan is provided in the Navajo Mine PAP, Chapter 6, Section 6.6. BNCCs groundwater monitoring program was established to monitor groundwater quantity and quality in alluvial systems, the Fruitland formation, and the PCS. The monitoring program provides the basis for assessment of mining impact on groundwater resources and has been developed to collect water quantity and quality information for use in the identification of potential impacts to the prevailing hydrologic regime. The plan identifies the parameters to be monitored, sampling frequency, and site locations (BNCC 2011, Section 6.6). Current groundwater monitoring locations are illustrated on Figure 19. A list of groundwater sampling parameters is found in the Navajo Mine PAP, Chapter 6, Table 6-4, and includes TDS, conductivity, pH, water level, calcium, magnesium, sodium, potassium, carbonate, bicarbonate, sulfate, chloride, fluoride, and selenium. Additionally, each sample is accompanied with a cation/anion balance for quality assurance. Additional monitoring parameters, are only used if the reference criteria are exceeded, and are found in the Navajo Mine PAP, Chapter 6, Section 6.6.13.2 and footnote 1 of Table 6.5 Additional monitoring parameters include iron, manganese, nitrate, and boron. Table 6.5 lists the reference criteria. OSMRE finds that the groundwater monitoring program has supplied sufficient information to support the required evaluation for material damage potential in this CHIA.

5.2.1.1 Monitoring Program Updates

Monitoring programs are periodically updated to enhance the available data sets for predictive analysis. OSMRE recently approved enhancements to the hydrologic monitoring program proposed by BNCC. Monitoring program enhancements are outlined below (BNCC 2012):

Surface Water:

1. Chinde Wash
    a. One continuous flow gauge will be installed upstream, off lease in the proximity of agricultural fields.
    b. One continuous flow gauge will be installed on-lease, downstream of the "big fill"
2. Cottonwood Arroyo
    a. Four upstream flow gauges will be installed (one each) along the North Fork, Middle Fork and two branches of the South Fork
        i. Above mentioned upstream gauges will be installed at the outfall of culverts along the proposed Burnham Road re-route
    b. One downstream flow gauge will be installed on an already existing cable structure across the channel; periodic channel surveys will confirm accurate channel cross section
    c. All stations will consist of flow meters to sample flow quantity and water samplers for water quality analysis
3. Implementation Schedule
    a. Chinde gauges upon approval of off-lease monitoring
    b. Cottonwood upstream gauges dependent on permit approval and construction schedule of Burnham Road re-route; proposed for June 2012 (North Fork) and October 2012 (Middle and South Fork)
    c. Cottonwood downstream monitoring scheduled for completion in May 2012

Groundwater:

1. Bitsui Area – used on part to evaluate the Area I groundwater model
    a. Existing well Bitsui-2 will be used for #8 seam groundwater level monitoring and for groundwater sampling.
    b. Existing wells KF84-16 and KF83-1 will be used for monitoring #8 seam groundwater levels.
2. Chinde Wash Area
    a. One off-lease, upstream pre-packed well (CA-1) will be installed via hand augur
    b. CA-2 will be installed near the lease boundary as a well to monitor water quality of Chinde Arroyo up gradient of mining activities.
    c. One off-lease, downstream pre-packed well (CA-6) may be installed via hand augur; this will be replaced by a drilled well once final approvals have been acquired
    d. Three piezometers (CA-3, CA-4, CA-5) will be installed in the "big fill" wetland area
    e. All Chinde wells and piezometers will be monitored quarterly for a period of two years, followed by an assessment of continued monitoring frequency.
3. Cottonwood Arroyo Area
    a. A new alluvial well (proposed CWA-4) will be installed to replace the hand-dug, dry well QACW-2B along the main Cottonwood Arroyo just south of Dixon.

b. A new alluvial well (proposed CWA-1) will be installed to replace the abandoned well GM-17 along the North Fork of the Cottonwood Arroyo just inside the lease boundary.
c. Two new alluvial wells (proposed CWA-2 and CWA-3) will be installed along the Main Fork and South Fork, respectively, of the Cottonwood Arroyo near the lease boundary.
d. Two new Fruitland wells (proposed KF-1 #3 and KF-1 #8) will be installed on the northwest side of Area IV North near the lease boundary. These will be used to evaluate Area IV north groundwater model predictions of drawdown, recharge and TDS transport. Monitoring of the No. 3 and No. 8 coal seam should provide information about potential impacts prior to influences on the alluvial water system, which will be protective of downstream alluvial users on the Cottonwood and Chaco.

4. Groundwater Reference Criteria
    a. Criteria will be recalculated using the entire set of baseline data from *10/17/2011*
    b. Reference criteria will be established for QACW-2
    c. QACW-2B is a dry, unsuitable hand-dug well and will be replaced by well CWA-4; new reference criteria will be developed for well CWA-4
    d. GM-17 well will be replaced by proposed well CWA-1; local variation in natural soil properties precludes comparing these two wells as being chemically equivalent so new reference criteria will be developed for CWA-1
    e. Reference criteria are based on the median + 2 median absolute deviations for the baseline monitoring data through year 2001; detection values are calculated as the product of 0.5 and the detection limit
    f. Reference Criteria have been established for well QACW-2 as requested; detection values were calculated as the product of 0.5 and the detection limit.
5. Implementation Schedule
    a. All replacement wells, with the exception of CA-6, are scheduled to be installed during April and May of 2012
    b. Chinde downstream drilled well CA-6 will be installed when necessary approvals are acquired
    c. Well development is scheduled to be completed during June, 2012
    d. The monitoring plan revision to the permit is planned for submittal in August, 2012

Modifications to the Chinde alluvial monitoring are particularly important in light of the potential mining related impacts to this system discussed in section 5.3.7.1.2.2. The objective of these new monitoring locations is to characterize and monitor hydrogeologic conditions of the Chinde Alluvium as follows:

The first monitoring location would be a drive point well that would be installed down-gradient of the NAPI fields and up-gradient of the wetland east of the mine lease. The purpose of this monitoring location would be to assess the groundwater quality immediately down-gradient of NAPI.

- The second monitoring location would be a well installed adjacent to the wetland east and up-gradient of the mining activities. The purpose of this well would be to monitor water quality immediately up-gradient of mining activities.
- The third monitoring location would be a well installed in the Chinde Wash down-gradient of existing well QAC-1. The purpose of this well would be to monitor water quality down-gradient of the mine. Since this monitoring location is located off-lease it is anticipated that installation will be delayed due to the approvals that must be obtained. BNCC is proposing that a drive point be installed prior to well installation to expedite the collection of data. Once the necessary approvals are acquired for the monitoring location, the drive point will be removed and replaced with a monitoring well.
- The remaining three new monitoring locations would be installed in the wetland immediately up-gradient of the Big Fill. The purpose of these is to monitor potential impacts of the wetland on

alluvial water quality, and to monitor groundwater elevations and enable groundwater flow direction to be determined.

BNCC proposes to sample these six new monitoring locations for a period of two years, after which BNCC will discuss with OSMRE the efficacy of continued monitoring of the new monitoring wells. These proposed additions are outlined in Table 6 and approximate locations are shown in Figure 22.

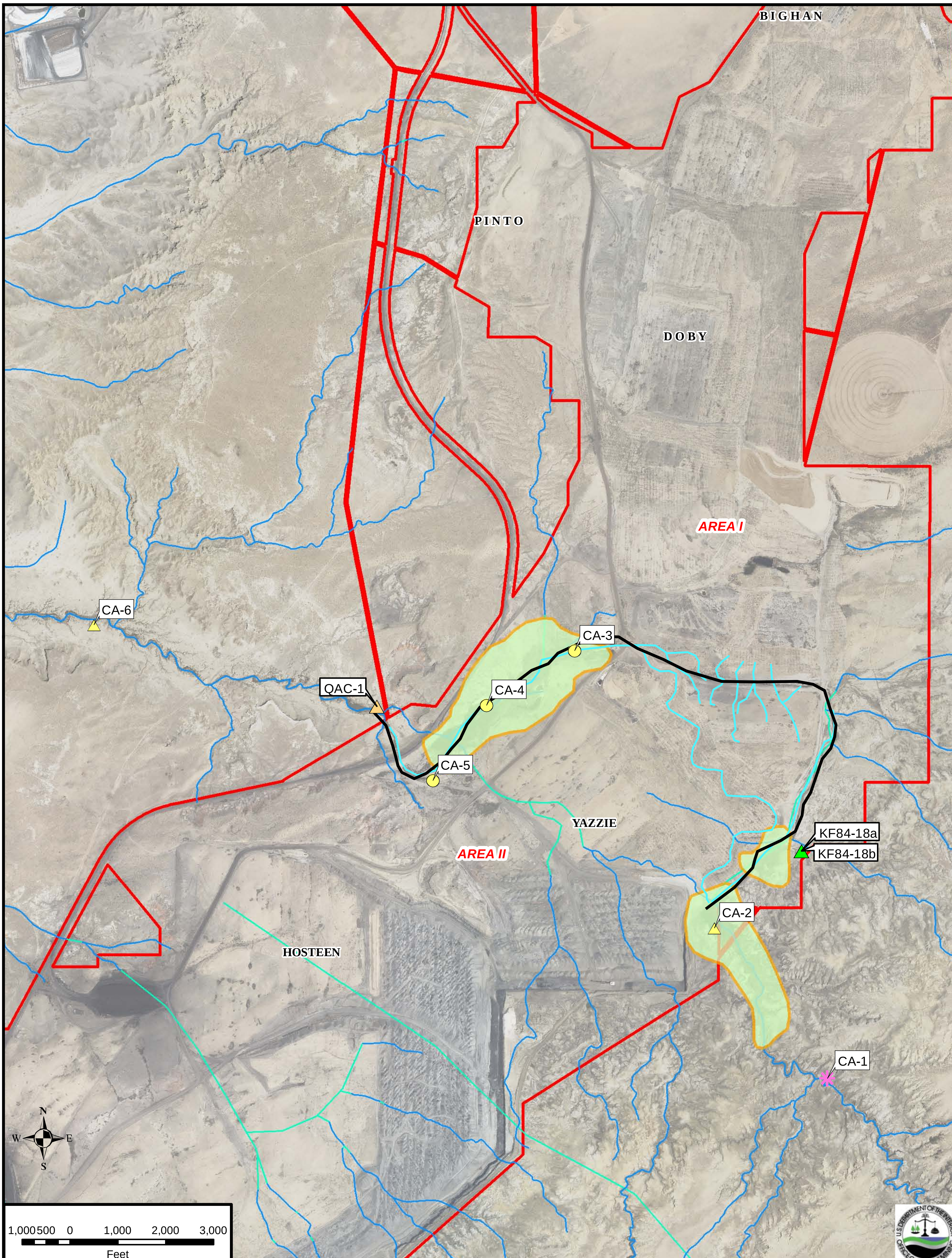
Table 6: Proposed Chinde Alluvium Monitoring (BNCC 2012)

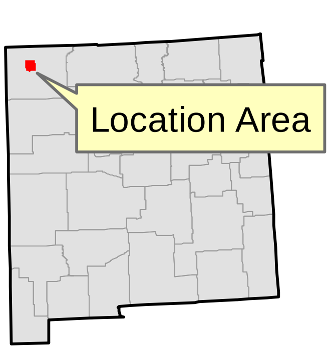
Target Unit	Well Designation	General Location	Monitoring Type	Screen Interval	Sampling Frequency
Top of competent bedrock	CA-1	Chinde Wash – downgradient of NAPI	Drive Point	Dependent on refusal	Quarterly
Alluvium	CA-2	Chinde Wash – adjacent to wetland east of mine lease	Monitoring Well	Varies – 5' above the water table plus thickness of aquifer	
	CA-3*	Chinde Wash – wetland on lease			
	CA-4*				
	CA-5*				
	CA-6	Chinde Wash – downgradient of mine lease	Drivepoint/ Monitoring well	Dependent on refusal/ Varies – 5' above the water table plus thickness of aquifer	

*Water level measurements only

5.3 Impact Assessment

The assessment presented in Chapter 5 of this document considers available quantity and quality information related to surface water and groundwater potentially affected by BNCC operations. The assessment approach used for each resource is outlined in Table 7. Impact assessment relied upon analysis of monitoring data, several models, relevant published and unpublished reports and papers, experience from past mining and reclamation operations at Navajo Mine and other mines located along the western rim of the San Juan Watershed, as well as observations made by BNCC and OSMRE staff during the day-to-day operations and regulation of the mine. Impacts are designated as negligible, minor, moderate or major as defined in Table 7. Table 7 also outlines current minimize techniques and updates to the BNCC monitoring program.





Legend

- Existing Alluvial Monitoring Well
- Existing Fruitland Well
- Proposed Monitoring Well
- Proposed Piezometers
- Proposed Drive Point
- Wetlands
- Original Diversion
- Natural Stream Channel Design
- Permit Area
- Coal Lease Area
- Natural Stream[1]
- Artificial Canal/Ditch[1]

Data Sources:
Aerial Photography (San Juan County) 2009
[1] USGS National Hydrography Dataset

Navajo Mine CHIA Chinde Diversion and Monitoring Locations

Figure 22

Table 7: Impact Assessment and Designation Methodology

<table>
<tr><th colspan="2">Water Resource</th><th>Fruitland & PCS Quantity</th><th>Alluvial Quantity</th><th>Surface Water Quantity</th><th>Fruitland & PCS Quality</th><th>Alluvial Quality</th><th>Surface Water Quality</th></tr>
<tr><td colspan="2">Assessment Approach</td><td>Evaluation of potentiometric surface contour maps</td><td>Comparison of water levels at individual wells over-time</td><td>SEDCAD modeling- pre- and post-mining; Percent of HUC12 Watersheds controlled with impoundments</td><td>Comparison of baseline water quality to potentially impacted or non-baseline wells, including spoil and CCB wells</td><td colspan="2">Comparison baseline (upstream/pre-mining) water quality to non-baseline (during and post-mining/downstream) water quality and comparison to applicable Water Quality Standards</td></tr>
<tr><td rowspan="4">Impact Designation</td><td>Major</td><td>Changes in water level contours that are significantly less than baseline levels</td><td>Changes in water levels that are consistently (>60% of the time) below baseline fluctuations as Characterized by the Median minus 2 MAD</td><td>Impounded areas relative to HUC 12 watersheds or change in peak flows relative to baseline are >60%</td><td colspan="3">Changes in water quality that consistently (>60%) exceed baseline fluctuations as Characterized by the Median plus 2 MAD</td></tr>
<tr><td>Moderate</td><td>Changes in water level contours that are moderately less than baseline levels</td><td>Changes in water levels that are regularly (30%-60%) below baseline fluctuations as Characterized by the Median minus 2 MAD</td><td>Impounded areas relative to HUC 12 watersheds or change in peak flows relative to baseline are between 30% and 60%</td><td colspan="3">Changes in water quality that regularly (30-60%) exceed baseline fluctuations as Characterized by the Median plus 2 MAD</td></tr>
<tr><td>Minor</td><td>Changes in water level contours that are slightly less than baseline levels</td><td>Changes in water levels that are occasionally (10%-30%) below baseline fluctuations as Characterized by the Median minus 2 MAD</td><td>Impounded areas relative to HUC 12 watersheds or change in peak flows relative to baseline are between 10% and 30%</td><td colspan="3">Changes in water quality that occasionally (10%-30%) exceed baseline fluctuations as Characterized by the Median plus 2 MAD</td></tr>
<tr><td>Negligible</td><td colspan="2">Impacts to Groundwater that is not capable of providing a sustainable water supply for use or that are similar to baseline fluctuations</td><td>Impounded areas relative to HUC 12 watersheds or change in peak flows are <10% (considered within baseline)</td><td colspan="3">Impacts to water quality that are within baseline fluctuations (<10%) as Characterized by the Median plus 2 MAD or Impacts to Groundwater that is not capable of providing a sustainable water supply for use or that are similar to baseline fluctuations</td></tr>
<tr><td colspan="2">Impact Mitigation</td><td>Contemporaneous Reclamation</td><td colspan="2">Contemporaneous Reclamation; reclamation of approximate original contour (AOC); mining limited to ephemeral channels; stream buffer zones</td><td>Contemporaneous Reclamation; mixing of overburden/ backfill materials; material classification and handling procedures</td><td>Contemporaneous Reclamation; mining limited to ephemeral channels; stream buffer zones</td><td>Contemporaneous Reclamation; mining limited to ephemeral channels; stream buffer zones; Sedimentation Ponds</td></tr>
<tr><td colspan="2">Monitoring Program Updates</td><td>Submittal of 5 yr Potentiometric Surface Contour Maps</td><td>Addition of new monitoring stations</td><td>Addition of new monitoring stations</td><td>Additional coal seam well in area IV north</td><td>Addition of new monitoring stations</td><td>Addition of new monitoring stations</td></tr>
</table>

5.3.1 Potential Cumulative Impact between BNCC and El Segundo Mine

El Segundo coal mine is located approximately 70 miles southeast from the southern tip of the Navajo Mine lease boundary. The proposed lease area is divided into two subwatersheds by the continental divide, and is crossed by several unnamed ephemeral arroyos. The western portion of the lease area ultimately drains into the Chaco River through an unnamed, ephemeral channel that drains to Laguna Castillo before flowing into a named drainage, Kim-me-ni-oli Wash, and into the Chaco River. The ephemeral arroyos passing through the lease area flow only in direct response to storm events, or discharges derived from NAPI. The drainage area for the main western drainage as it leaves the lease area is approximately 24.7 square miles of which about 6.1 square miles (25%) of the total watershed are proposed to be disturbed by mining. The effects of mining relative to surface water quantity is limited to the interception of surface flows, which has potential to impact the stock watering capability of rangelands (NMEMNRD 2008).

The El Segundo mine lies approximately 70 miles away from the Navajo Mine and the Chaco River is an ephemeral, losing stream. Therefore, only under tremendous regional storm conditions is it possible for surface water flows from the El Segundo Mine to reach the Chaco River in the vicinity of the Navajo Mine and comingle with surface waters that have crossed the BNCC lease. Overall, El Segundo Mine covers less than one percent of the total Chaco Watershed. The surface water runoff generated from the small percentage of the Chaco Watershed is imperceptible relative to the total runoff volume generated from the entire Chaco Watershed. Therefore, OSMRE concludes that surface water cumulative impacts to the Chaco River from the El Segundo Mine are negligible.

5.3.2 Potential Impact of BNCC operations on NAPI

NAPI uses surface water sourced from the San Juan River upstream of BNCC mining operations. Additionally, NAPI operations are located upstream of BNCC operations. Therefore, given the surface water flow directions, BNCC operations are determined to have negligible surface water impacts on NAPI operations.

However, NAPI operations have been documented to have significant impact on BNCC operations. NAPI impacts include direct discharges of water from irrigation canals and indirect discharges from irrigation return flows. NAPI direct discharges are a result of an oversupply of water in the canal that is released directly to a wash. Discharge events for the streams are highly variable, occur quickly, and can last up to 12 hours causing significant erosion and sediment transport in the channel (BNCC 2011, Section 11.6). The indirect NAPI related discharges are a result of return flows to the wash caused by the infiltrating irrigation water. The indirect NAPI related discharges result in leaching of the unconfined geologic surface formations and soils. The impacts of the NAPI activities on the baseline channel hydrologic balance are expressed as highly variable increases in flow and discharge.

5.3.3 Potential Impact of BNCC Operations on Morgan Lake and APS

Water from the San Juan River is pumped to Morgan Lake for use as cooling water at the APS Four Corners Generating Station and also for use in dust suppression and reclamation irrigation activities associated with the BNCC permit area. BNCC typically diverts and consumes 825 acre-feet annually; APS typically diverts 35,421acre-feet and consumes 28,611 acre-feet annually (United States of America 2011, Table L-1). The total volume of water in Morgan Lake is approximately 39,200 acre-feet at normal storage and 42,800 acre-feet at maximum storage. Variation between normal storage and maximum storage in Morgan Lake encompasses a difference of 3,600 acre-feet, or 10% of the normal storage. A comparison of total (BNCC and APS) diversion and consumption to the Morgan Lake volume shows that at normal storage roughly 90% of the Morgan Lake volume is diverted every year, of which roughly 75% is consumed. Of these total diversion and consumption percentages only 2% is due to BNCC operations. BNCC annual diversion and consumption from Morgan Lake is less than the difference between normal and maximum storage of Morgan Lake, therefore, the impact of BNCC operations on Morgan Lake water quantity is negligible. The contribution to Morgan Lake from tributaries which traverse the BNCC permit is also considered to be negligible.

Given the total (BNCC and APS) diversion rate from the San Juan River into Morgan Lake, which results in approximately 90% of the normal storage volume being replaced on an annual basis, and the negligible flow contribution to Morgan Lake from tributaries which traverse the BNCC permit, quality impacts associated with these tributaries are considered to be negligible. BNCC diversion and consumption is roughly 2% of the total APS diversion and 3% of the total APS consumption, therefore BNCC operations are not expected to adversely impact the water availability for APS operations. Quality impacts to Morgan Lake associated with BNCC operations are considered to be negligible, and BNCC operations should not impact Morgan Lake water quality, such that, it would not be suitable for use in APS operations.

5.3.4 **Chaco River**

There are periods when precipitation runoff from the drainages that normally flow across the areas intersected by mining will not make it to the Chaco River during operations, but will either be intercepted by the mine pits or captured in temporary pit protection ponds (highwall impoundments) located up gradient of mining. Once reclamation is completed within the mining area, precipitation runoff from these reclaimed areas will flow through channels in the reconstructed topography and then to the Chaco River.

5.3.4.1 **Surface Water Quantity**

The Chaco River is an ephemeral drainage up until the last 12.5 miles of the stream where runoff from Morgan Lake has caused it to be perennial. All of the primary drainages of interest at the Navajo Mine except for Bitsui Wash drain into the Chaco River. Water monitoring historically occurred along two USGS gage stations along the Chaco River, station #09367950 near Waterflow, NM and station #09367938 near Burnham, NM. The locations of these two water monitoring stations are illustrated in Figure 8. The stations were actively monitored for stream flow and select water quality parameters from 1977-1994 and from 1977-1982, respectively. Station #09367938 exhibits the original ephemeral nature of the Chaco River, which existed prior to the construction of Morgan Lake, whereas Station #09367950 is downstream of the confluence with the Morgan Lake drainage where the river flows perennially. USGS station 09367938 is considered to be representative of baseline conditions within the Chaco River as it is upstream of the Navajo Mine lease.

Precipitation runoff from reclaimed areas may be reduced somewhat from pre-mine levels due to any of the following factors: lower slopes, enhanced vegetative growth, engineered traditional or geomorphic drainage designs, and the use of sediment-control BMPs that operate to retain water in the reclaimed areas reducing storm-water runoff to the channels. Although some perennial flow occurs along the final stretch of the river, all of the large flow events occur in response to precipitation. From Figure 23, it is apparent that the flow in response to these heavy precipitation events increases as you move downstream in nearly all cases, therefore there is not a substantial loss in surface water flows within the Chaco River downstream of mining and impacts of the BNCC mining operation on Chaco River surface water quantity is considered to be negligible.

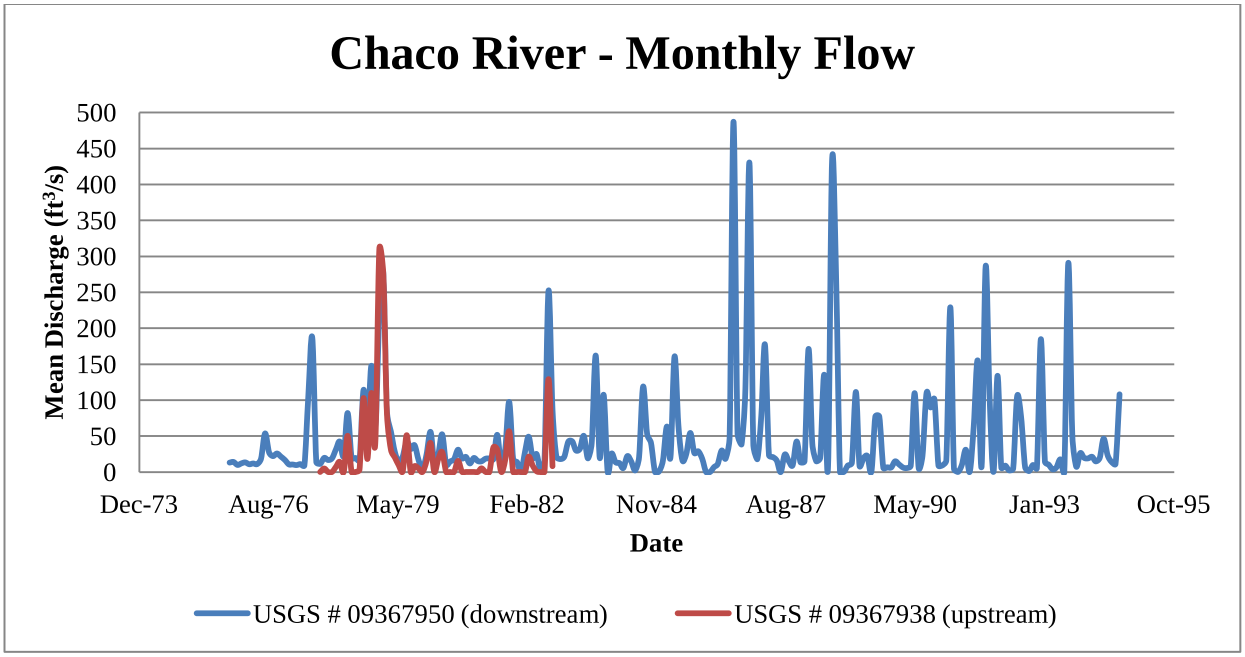


Figure 23: Monthly Flow along the Chaco River

5.3.4.2 Surface Water Quality

Surface water quality data is available on the Chaco at two historic USGS monitoring stations which bracket all Chaco River tributaries traversing the lease area; 09367950 downstream of the Morgan Lake discharge point and 09367938 upstream of No Name Wash confluence (Figure 8). USGS station 09367938 is considered to be representative of baseline conditions within the Chaco River as it is upstream of the Navajo Mine lease. Water quality data was collected by the USGS at 09367938 from July of 1977 to August of 1982.

USGS station 09367950 is used to assess the non-baseline or downstream, conditions within the Chaco River as it is downstream of the Navajo Mine lease, however it is not necessarily considered to be representative of mining impacts as it is also downstream of the Morgan Lake discharge point, which is known to have significant impact on the Chaco River quantity turning the normally ephemeral drainage into a perennial drainage at this point. Additionally, between 2 USGS stations the Chaco river moves from traveling over an established Quaternary Alluvium Deposit to running over the outcrop of the Mesa Verde Aquifer (Cliff House Sandstone, Menefee Formation, Point Lookout Sandstone formation) before discharging into the San Juan River (Figure 5). The Chaco River is a known discharge area for the Mesa Verde Aquifer within the San Juan Watershed. There is very sparse water quality data for this aquifer in the San Juan Watershed, specifically within the discharge zone to the Chaco River adjacent to the Navajo Mine. However, the data available to the west of the Navajo Mine indicate that the dissolved-solids concentration ranges from about 1,000 to over 4,000 milligrams per liter (Robson and Banta 1995). However, despite these potential non-mining impacts, in light of the fact that no other downstream data exists on the Chaco River data from USGS 09367950 will be used for the assessment. Water quality data was collected by the USGS at 09367950 from October of 1969 to August of 1989.

While USGS 09367950 is downstream of the BNCC permit, it is also downstream of the APS operations and the Morgan Lake discharge; therefore it is impossible to differentiate BNCC impact from these other potential sources. Nevertheless, analysis will be done using data from this station as data collected upstream of the APS operation and Morgan Lake discharge is not available.

Downstream data was found to have relatively high variability relative to baseline data where the median percent relative standard deviation for all constituents was 96 percent as compared to 44 percent. The NNEPA criterion for pH was exceeded for 1 sample where the pH was 11.3. Mercury exceeded the NNEPA fish consumption criteria for 85 percent of all samples. Cadmium exceeded NNEPA secondary human contact, fish consumption, and livestock criteria for 8 percent of all samples. NNEPA acute aquatic and wildlife habitat criteria were exceeded for cadmium, chromium, copper, mercury, selenium, and zinc for 8, 100, 25, 17, 8, and 8 percent of all samples respectively. NNEPA chronic aquatic and wildlife habitat criteria were exceeded for cadmium, copper, mercury, selenium, and zinc for 100, 25, 100, 85, and 8 percent of all samples respectively. Livestock criteria for boron, chloride, fluoride, sulfate and TDS were exceeded for 23, 1, 46, 24, and 5 percent of all samples. The median cadmium, mercury and selenium concentrations were 1.2, 300, and 3 times greater than NNEPA chronic aquatic and wildlife habitat standards. The median chromium concentration was 1.6 times greater than NNEPA acute aquatic and wildlife habitat standards. The median mercury value also exceeds the NNEPA fish consumption criteria. All other median values are below all criteria indicating that the criteria exceedances are generally more characteristic of the high variability in the data set as compared to the general water quality. Therefore surface water quality within the Chaco River as compared to NNEPA and other relevant criteria is appropriate for the designated post-mining land use of livestock grazing. However, elevated levels of cadmium, chromium, mercury, and selenium were found relative to aquatic and wildlife habitat and fish consumption NNEPA criteria. There were no exceedances of the SMCRA dissolved iron standard.

The comparison to baseline median plus 2 MAD from the upstream station USGS 09367938 showed the following; minor impacts for manganese where 15% of all samples exceeded baseline; moderate impacts for barium, cadmium, fluoride, radium, and selenium where 35, 31, 54, 1, 38, and 58 percent of all samples exceeded baseline; major impacts for boron, sulfate, TDS and conductivity where 96, 94, 100, and 96 percent of all samples exceeded baseline. Of these the median concentrations of boron, chloride, fluoride, nitrate, selenium, sulfate, TDS, and conductivity all exceeded the baseline median plus 2 MAD. The median concentrations for all of these criteria except selenium and nitrate, however, were below the relevant use criteria. Impacts for all other constituents were determined to be negligible. Therefore while the impact designation can be considerable for certain constituents it does not appear to transfer to a significant impairment of use. Surface water quality within the Chaco River is generally appropriate for the designated post-mining land use of livestock grazing, except for possible concerns over nitrate concentrations. Additional potential concerns exist regarding selenium concentrations relative to aquatic and wildlife habitat use.

5.3.4.3 **Chaco River Alluvium**

Groundwater use in the groundwater CIA is limited in extent and is mostly derived from wells completed within surficial valley-fill deposits of Quaternary age, or alluvium. Water derived from alluvial wells is predominantly used for livestock watering. Baseline alluvial water quality was found to be a poor source for livestock watering use. This is especially apparent when considering sulfate and TDS concentrations. No downstream alluvial data is available for comparison.

5.3.5 **Historic Mining Area North of the BNCC permit**

5.3.5.1 **Surface Water**

The increased application of surface water from NAPI has impacted the area hydrology and water quality. NAPI impacts in this area consist of indirect discharges from irrigation return flows. The indirect NAPI related discharges are a result of return flows caused by infiltrating irrigation water. The impacts of the NAPI activities on the baseline channel hydrologic balance are expressed as highly variable increases in flow and discharge. The indirect NAPI related discharges result in leaching of the unconfined geologic surface formations and soils. NAPI impacts increase the already highly variable hydrologic balance and further decrease the potential for changes to the hydrologic balance as a result of mining (BNCC 2011, Section 11.6).

The historic mining area north of the BNCC permit area includes the Watson, Bitsui, Dodge, and Custer pits, of these only the Custer pit area is within the surface water CIA. The Custer Pit area is within the Morgan Lake-Chaco River HUC12 watershed along with the Bighan Pit area. The Bighan Pit area is within the BNCC permit area therefore the characterization of impact to water quantity for the Morgan Lake-Chaco River HUC12 watershed is included below in Section 5.3.7.1.1. There are no major tributaries to the Chaco River which traverse this area, and no surface water data is available for this area within the surface water CIA.

5.3.5.2 Alluvium

There are not any current uses of the alluvium in this area; however, there have been historic uses of alluvium in the area for livestock watering (BNCC 2011, Section 11.6). Within this area two alluvial wells exist along drainages that are tributary to Morgan Lake; water quantity data was collected from 1996 to 2000 at Custer-1 located along the western lease boundary, and Custer-4 located within the BNCC lease area close to the eastern lease boundary. Two additional alluvial wells exist along Bitsui Wash; data was collected from GM-7 from 1975 to 1976 and no data is available at GM-37. Data collected at GM-7 represents the only alluvial quality data available for this area, however, it is located upstream of mining and was used for baseline characterization. Therefore no assessment of alluvial quality is presented in this discussion.

The Custer wells were not monitored prior to mining impacts in the area, and can therefore not be used for baseline characterization. Therefore, alluvial quantity assessment at these locations cannot rely upon comparison of pre to post mining conditions. Alluvial quantity was assessed using two metrics: the percent of all sampling events which were dry and the water elevation in feet above Mean Sea Level (MSL). Water elevation was not collected for all samples; however, inference of water presence was based on the presence of water quality data. Therefore the total number of samples used to calculate the percent of dry sampling events is often higher than the number of samples used for the water elevation comparisons. Alluvium at Custer-1 and 4 was found to be dry for 75% of all sampling events, and only two water elevation data points are available for each well as shown in Figure 24. While data in the area is limited it is reasonable to assume that changes in groundwater levels will not preclude use as they are steadily increasing over time, therefore the impact is designated to be negligible.

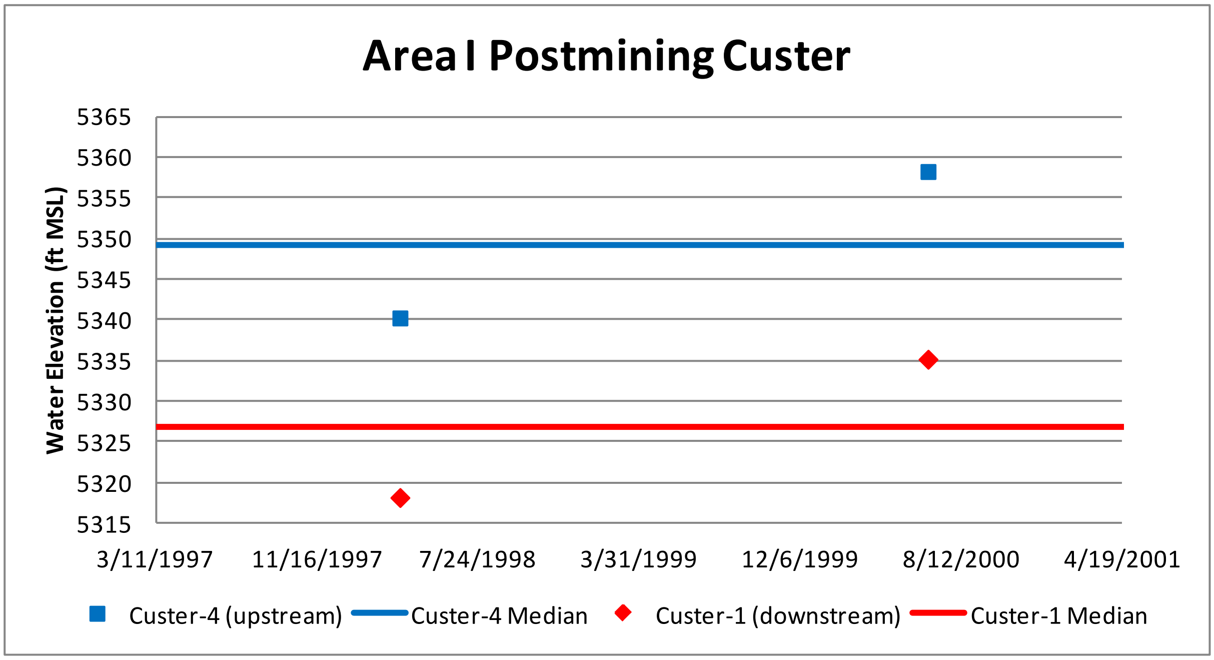


Figure 24: Custer Water Elevations

5.3.5.3 Fruitland Formation and PCS

The mine pits remained dry throughout this area except on rare occasions when surface flows were captured. Groundwater seeps were rarely observed along highwalls as any groundwater in the Fruitland overburden and coals was most likely consumed by evaporation (BNCC 2011). The few seeps that were observed during mining were at locations where the highwall was near NAPI irrigation plots. The projected and observed impacts to the water quantity within the Fruitland Formation and the coal seam aquifers resulting from coal mining have been minimal to date. There are no current uses for the Fruitland formation in or adjacent to this area and no foreseeable uses other than oil and gas extraction, therefore impacts to the Fruitland formation resulting from the historic mining activity are not expected to disturb water users. Additionally, the observed impacts to the Fruitland do not extend outside of the immediate areas surrounding the mine pits and subsequent reclaimed areas and the unit is generally not capable of providing a sustainable water supply (BNCC 2011, Section 11.6). Therefore for the purpose of this assessment, the impacts to the Fruitland groundwater quantity are considered to be negligible.

Spoil leaching tests were performed in support of the PHC assessment for the Navajo Mine SMCRA permit revision. The spoil leaching test results show a considerable range in the concentrations of TDS and sulfate, which are the primary constituents of concern with respect to spoil leachate. The leaching test results are fairly consistent with the results for the Bitsui #5 spoil well completed in the mine spoils in the Bitsui Pit, located in this historic mining area. The Bitsui Pit was backfilled in the 1980s and is the only pit where saturation of mine spoils has been observed. Arsenic and selenium were below detection in most of the leaching test results and in the Bitsui 5 spoil well. Fluoride is also lower in the spoil water leachate than in the coal water and is attenuated in flow through mine spoil. Boron and manganese concentrations are also elevated in mine spoil water (BNCC 2011, Section 11.6). A post-reclamation increase in TDS and sulfate concentrations in mine spoil backfill may result in increased TDS and sulfate concentrations in the coal seams adjacent to the historic mining areas. Spoil leaching test results found an increase in TDS concentrations in spoil water leachate ranging from 400 to 2,700 mg/l and an increase in sulfate concentrations in spoil water leachate ranging from 630 to 2,580 mg/l (BNCC 2011, Appendix 11-

VV). Spoil data within this area is generally consistent with spoil data within the BNCC permit area, for a detailed assessment of spoil data relative to baseline within the permit area see Section 5.3.7.2.2.

The PCS is a well-cemented, low-permeability, marine sand and is the first water-bearing unit below the Fruitland Formation. The PCS is approximately 110 to 120 ft thick and follows the structure of the Fruitland Formation, dipping to the east at approximately 2 degrees, although the structure varies locally. The PCS conformably overlies the Lewis Shale, with the contact marked by a zone of interbedded sandstones and mudstones in the lower part of the PCS (Stone, Hydrogeology and Water Resources of San Juan Basin, New Mexico 1983). It outcrops just west of the mine lease and east of the Chaco River. The PCS is a marginal water resource due to low permeability, poor water quality, gas production, and low yields. The PCS is also a natural gas reservoir in the San Juan Watershed. Stone et al. (1983) state that the PCS cannot be considered a major aquifer and it is important only because it is the water-bearing horizon immediately underlying the coals in the Fruitland Formation. There is no non-baseline PCS data available in the area; therefore there will be no comparison of non-baseline PCS quality to baseline conditions.

Since there are no current uses for the Fruitland or PCS formations in or adjacent to this historic mining area and no foreseeable uses other than oil and gas extraction, impacts are not expected to disturb water users. Additionally, the observed impacts do not extend outside of the immediate areas surrounding the reclaimed areas and the units are generally not capable of providing sustainable water supply (BNCC 2011, Section 11.6). Therefore for the purpose of this assessment, the impacts to the Fruitland groundwater quantity are considered to be negligible.

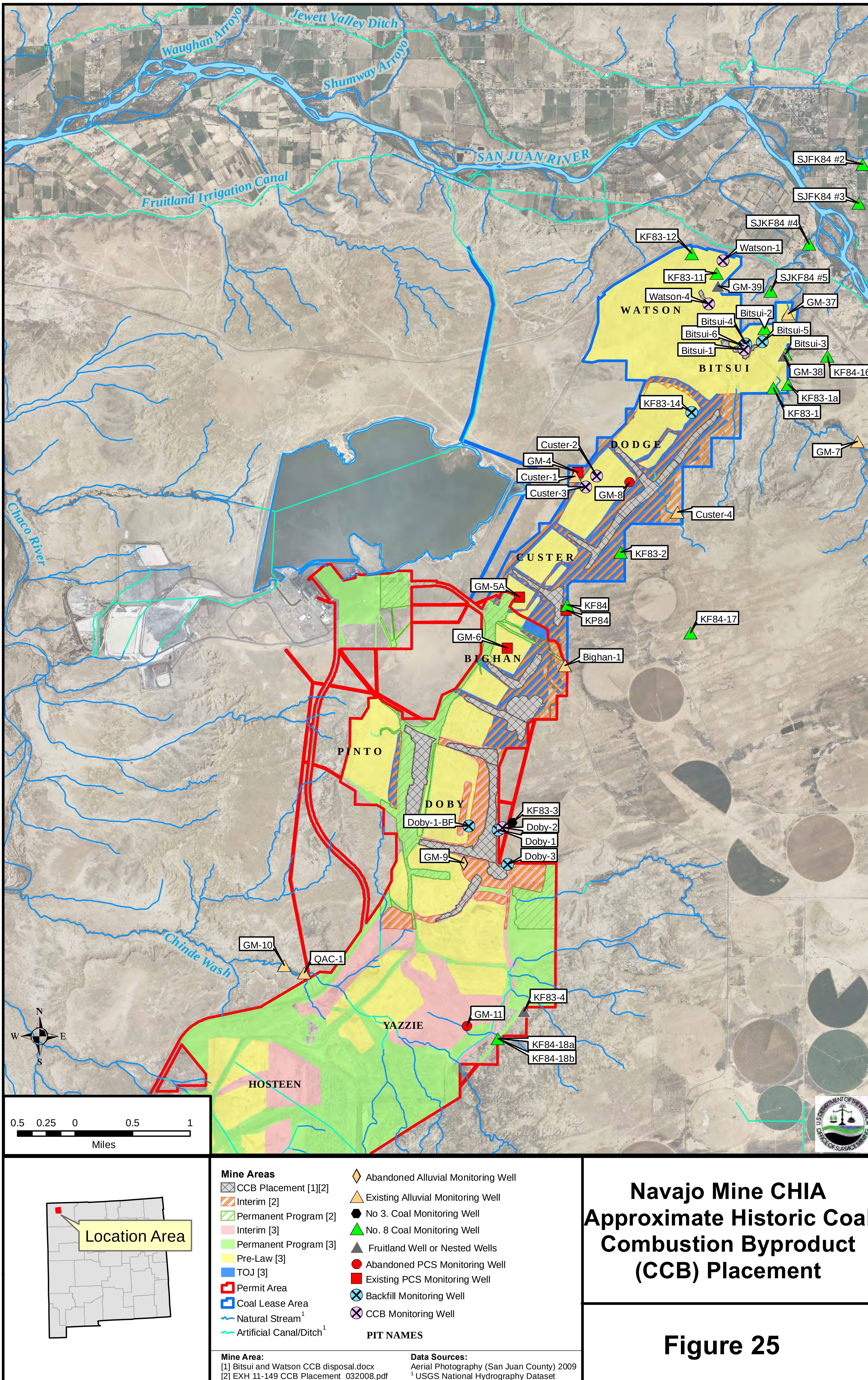
5.3.5.3.1 CCB Disposal

Under the Navajo Mine's fuel supply contract with Arizona Public Service, the Navajo Mine accepted CCBs from the Four Corners Power Plant units 4 and 5 for disposal in final pits and ramps from 1971 to 2008. CCBs disposed of at Navajo Mine included: fly ash, scrubber sludge, and bottom ash. CCBs from the Four Corners Power Plant were placed in mined-out pits and ramps of the Navajo Mine to help achieve approximate original contours (AOC) (BHP Billiton 2010, Ch. 11). The CCB disposal designs considered the natural conditions prevalent in the area and precautions were taken when engineering the disposal and reclamation.

CCB disposal predominantly occurred within this historic mining area north of the BNCC permit, and can be seen on Figure 25. Additionally, the only saturated CCB pit, Bitsui, is located within this historic area, therefore CCB analysis is discussed under this section. No baseline Fruitland coal data is available for this area, however, baseline Fruitland data from upgradient wells located within the BNCC lease area is used for comparison.

The variability of CCB data is relatively similar to that of the baseline Fruitland coal within the permit where the median %RSDs was 46. A comparison of CCB wells to the Median + 2MAD for baseline Fruitland coals within the BNCC lease showed the following; negligible impact for chloride; minor impacts for conductivity and manganese where 20 and 26 percent of all samples exceeded baseline respectively; moderate impacts for total iron and TDS where 40 and 59 percent of all samples exceeded baseline respectively; major impacts for pH, boron, selenium, fluoride and sulfate were 70, 100, 82, 63 and 100 percent of all samples exceeded baseline respectively. Of these the median concentrations for boron, selenium, fluoride, sulfate, and TDS exceeded the baseline Median + 2MAD where they were 13, 4, 1.1, 150 and 1.25 times larger respectively. Median pH was within the livestock criteria range, and no individual sample was below 6.5. However, 16 percent of pH samples were above 9. The median concentrations for selenium were below the livestock criteria; however, median concentrations for boron, fluoride, sulfate, and TDS exceeded livestock criteria where they were 2, 1.3, 6 and 5 times larger respectively. Therefore, within CCB disposal areas boron, fluoride, sulfate and TDS are all considered to be of concern relative to baseline and livestock criteria.

While high levels of constituents of concern exist within the CCB wells in the historic mining area, there are no current uses for the Fruitland formation in or adjacent to this area and no foreseeable uses other than oil and gas extraction. Therefore in order for the historic CCB disposal to have significant impact to use, CCB leachate would need to have sufficient mobility to reach alluvial users within the vicinity of the historic disposal sites at significant concentrations. Modeling was conducted by OSMRE and BNCC to assess the impact of historic CCB placement relative to nearby alluvial systems, which could have impact to current and reasonably foreseeable uses. Modeling showed that it is unlikely that any significant future effects will ensue from the CCB disposal at the Navajo Mine because of the very slow groundwater movement and the attenuation of contaminants of concern as they migrate through the subsurface. Detailed CCB analysis can be found in Appendix G, including CCB placement locations, CCB leachate studies and groundwater modeling. Based on analysis found in Appendix G, OSMRE concludes that potential impacts to water users from CCB disposal at the Navajo Mine are negligible.



Navajo Mine CHIA Approximate Historic Coal Combustion Byproduct (CCB) Placement

Figure 25

5.3.6 Navajo Mine

5.3.6.1 Surface Water Quantity

Changes in peak flows due to the presence of upstream containment berms, diversions and highwall impoundments, coupled with retention of water within pits and down gradient sediment ponds will reduce peak flows downgradient of the mine during operations. As areas are reclaimed, it is predicted that there will be better retention of surface water runoff within the lease area compared with pre-mining conditions, due to lower slopes and the placement of topsoil materials with more permeable textures than occurred naturally in pre-mine conditions.

It is anticipated that post-mining flows will be ephemeral in all of the streams within the lease area due to the limited precipitation regime and the marginal development of alluvium as a water supply, unless activity from the upgradient NAPI continues to generate intermittent or perennial flows. NAPI impacts have resulted in the perennial and intermittent flows in Chinde and Cottonwood respectively. Future development of NAPI may continue further east and south of existing development into the headwaters of Cottonwood (BNCC 2011). The expanded NAPI irrigation plots would be far removed from mining within Area III or Area IV North.

There are periods when precipitation runoff from the drainages that normally flow across the areas intersected by mining will not make it to the Chaco River during operations, but will either be intercepted by the mine pits or captured in temporary pit protection ponds (highwall impoundments) located up gradient of mining. Precipitation runoff collected in the pits or in the pit protection ponds may be utilized for dust suppression and other mine needs, or will naturally diminish from evaporation and seepage. Once reclamation is completed within the mining area, precipitation runoff from these reclaimed areas will flow through channels in the reconstructed topography and then to the Chaco River. Precipitation runoff from reclaimed areas may be reduced somewhat from pre-mine levels due to any of the following factors: lower slopes, enhanced vegetative growth, engineered traditional or geomorphic drainage designs, and the use of sediment-control BMPs that operate to retain water in the reclaimed areas reducing storm-water runoff to the channels.

The PHC and CHIA analyses were developed with the support of site-specific data and modeling. Surface water and sediment modeling was performed using SEDCAD to model peak flows. The Navajo Mine lies primarily within four HUC12 watersheds that either intersect or contain portions of the lease area (Figure 6). The watersheds include the Morgan Lake-Chaco River, Chinde Wash-Chaco River, Coal Creek-Chaco River, and Cottonwood Arroyo watersheds. Each major tributary to the Chaco River are described by watershed in the following sections.

Surface water quantity impacts from the mine are measured according to percentages in which each watershed is affected according to two criteria:

1. Percentage of each watershed managed by surface water impoundments, diversions, and other mining related surface water management structures, and
2. The percentage that water management within the lease area affects the peak flows within each watershed (i.e. the difference between pre-mining and post-mining peak flow).

The PAP presents detailed information on BNCC water management structures, and removal of temporary structures. A summary of these structures and general hydrologic information is provided in Appendix C.

Modeling using SEDCAD 4 was implemented to assess peak flows in response to the 10-year, 6-hour storm events within each HUC 12 watershed. BNCC built SEDCAD models for all major drainages which traverse the lease area. The Chinde Wash and Cottonwood Arroyo Watersheds are both representative of HUC 12 range, as they were modeled directly in the PHC, and models have been reviewed by OSMRE; this modeling was not duplicated for purposes of this CHIA, but rather results of BNCC models presented in the PHC are used. The PHC SEDCAD modeling only evaluated specific parts of the Coal Creek and Chinde-Chaco River HUC12 watersheds within the lease area where mining has occurred. Therefore for these HUC 12 watersheds information from the PHC on the pre-mining and post-mining SEDCAD inputs (curve numbers, runoff volumes, etc.) were integrated into simplified larger watershed scale models for the purpose of this evaluation. Excerpts from the OSMRE-generated SEDCAD models showing specific routing details, curve numbers, and other pertinent information are located in Appendix E. Figure 18 shows SEDCAD subwatersheds used in OSMRE modeled HUC 12 watersheds.

5.3.6.1.1 Morgan Lake-Chaco River Watershed

As discussed previously in section 4.1.5.2.1, the impact assessment of the Morgan Lake-Chaco River watershed does not include modeling of peak flow changes due to the small contribution that activities within the permit area would have on the total watershed, because of the effect that contributing perennial flow to the watershed outfall (Chaco River) from Morgan Lake would have on the model, and because most of the permit area present in this watershed is either pre-law or termination of jurisdiction land. However, there are still a number of mine-related impoundments in this watershed that could potentially affect the hydrologic conditions.

The maximum percentage of the Morgan Lake-Chaco River watershed managed by surface impoundments at any given time is about 2.1%. As seen in Figure 26, no permanent post-mine impoundments will affect this particular watershed. All impoundments are projected to be removed by 2025. For the purpose of this assessment, the impacts from surface water impoundment water-management on the Morgan Lake-Chaco River watershed are negligible.

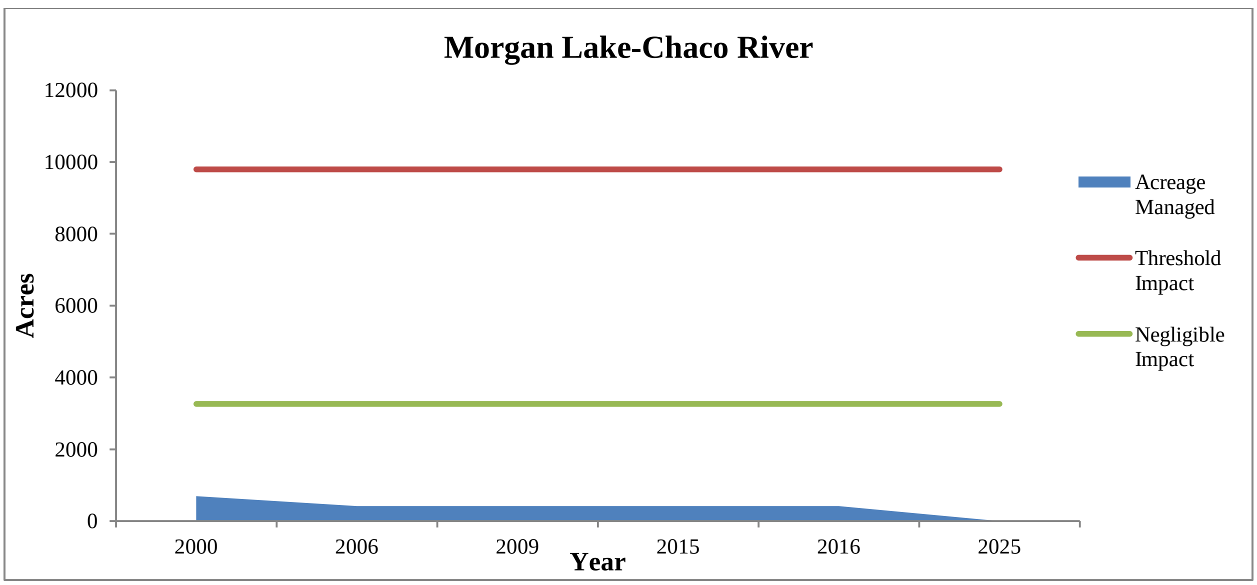


Figure 26: Percentage of the Morgan Lake-Chaco River Watershed Managed by Impoundments

5.3.6.1.2 Chinde Wash Watershed

About 3,100 acres of the Chinde Wash drainage basin is disturbed by mining activities. The post-mining Chinde Wash watershed increases in size by 1,124 acres within the lease area primarily because of changes in the drainage divide between Hosteen Wash and Chinde Wash, and the drainage divide between Dodge Diversion and Chinde Wash.

The largest hydrologic change to Chinde Wash is in the Doby reclamation area to the north, where the westward drainages from the off-lease, undisturbed surface are diverted towards the south via a post-mine channel (Doby North Channel) that runs north to south along the eastern lease boundary. The pre-mine topography had no major channel; the surface sloped down towards the west with primarily sheet flow drainages and some small channels. The post-mine channel also collects surface runoff from a portion of the reclaimed surface to the west and diverts the flow into a tributary of the Chinde Diversion.

The peak flow resulting from a 10-yr 6-hr precipitation event was predicted to decrease from a pre-mining estimate of 715 cubic feet per second (cfs) to a post-mining estimate of 705 cfs for Chinde Wash at the exit point of the watershed. Table 8 summarizes these findings. For the purpose of this assessment, this decrease in peak flow constitutes a negligible impact.

There are no impoundments within the Chinde Wash watershed, so the impacts to the hydrologic balance concerning the percentage of the watershed managed by impoundments, are negligible. Although significant activity occurred on the Chinde Wash before SMCRA was instituted in 1977, which probably impacted the stream significantly. The Chinde Diversion Channel was constructed in 1971 to divert surface water from the Chinde Wash around mining activities in Yazzie Pit. Additionally in 1973 the "Big Fill" was built for the rail crossing of the Chinde Wash. As this activity occurred prior to the issuance of a SMCRA permit, it was not subject to SMCRA regulations. The original Chinde diversion was constructed with a 1.5:1 slope or roughly twice as steep as current regulations dictate, in the 1990s the diversion channel was regraded to a 2:1 slope, still outside of current regulation standards but a significant improvement. Finally on 2009 a significant section of the Chinde diversion was replaced with a natural stream channel design which traverses the lease area to the south of the original diversion connecting the upstream and downstream wetlands. The Chinde Area has also experienced impacts from sources other than mining. Most notably in 1976 NAPI initiated commercial scale irrigation on lands adjacent to the BNCC mining lease (Moore 2006), and this has resulted in a significant change in the hydrology of the Chinde Wash. What was once an ephemeral dry arroyo is now a perennial stream due to NAPI irrigation return flows and releases of excess irrigation water. This combination of events in the Chinde Area has resulted in the development of two wetlands along the Chinde Wash. One of the wetlands is located up-gradient of the mine lease and the second is located on the mine lease, up-gradient of the Big Fill. The historic Chinde diversion and the new natural channel regrade can be seen in Figure 22.

Table 8: Comparison of Pre-Mine and Post-Mine Peak Flows in the Chinde Wash Watershed (BNCC 2011)

Sedcad 4.0 Watershed Designation		**Pre-Mine**		**Post Mine**		**Difference From Pre-Mine**	
Pre	Post	Area	Peak Flow (cfs)	Area	Peak Flow (cfs)	Area	Peak Flow (cfs)
S24	S24	27,130	715	28,254	705	1,124	-10
S17 SW1	S17 SW1	1,100	34	824	40	-276	6
S15 SW1	S15 SW1	595	43	600	26	5	-17
S11	S27	446	172	1,726	332	1,280	160
S18 SW1	S18 SW1	146	10	120	10	-26	0

5.3.6.1.3 Chinde-Chaco River Watershed

Notable changes to the watershed from the pre-mining model to the post-mining model occurred along Hosteen Wash, Barber Wash, and South Barber Wash. The surface area within Hosteen Wash decreased by approximately 1300 acres from the pre-mining to the post-mining scenario due to diversion of surface water into the adjacent Chinde Watershed. Curve numbers for certain areas within Hosteen wash were significantly reduced to reflect the impact of mining impoundments and higher infiltration rates on the area. The total peak flow reduction from a pre-mining to a post-mining scenario along Hosteen Wash is about 850 cfs. Impacts along North and South Barber wash were also integrated into the assessment. South Barber Wash lost approximately 850 acres in its sub watershed. The area lost from South Barber was subsequently added to the North Barber sub watershed through a diversion. Detailed assessment and modeling of the individual drainages can be found in the PHC (BNCC 2011, Section 11.6). For purposes of this CHIA analysis and modeling was conducted on HUC 12 watersheds. Although peak flow to South Barber Wash is thought to be reduced by about 120 cfs after mining is completed, minimal effects to the entire HUC12 watershed occurred through the changes in the Barber and South Barber Washes. A summary of this information is presented in Table 9.

The peak flow resulting from a 10-yr 6-hr precipitation event at the watershed outlet is predicted to decrease from a pre-mining estimate of 2,096 cfs to a post-mining estimate 1,331 cfs. The total peak flow reduction for the entire HUC12 watershed, pre-mining to post-mining, is about 36.5%. For the purpose of this assessment, this decrease in flow represents a moderate impact.

Table 9: Comparison of Pre-Mine and Post-Mine Peak Flows in Chinde-Chaco River Watershed

Sedcad Watershed Designation	Pre-Mine		Post-Mine		Decrease in Peak Flow
	Total Contributing Area	Peak Discharge	Total Contributing Area	Peak Discharge	
	(ae)	(cfs)	(ac)	(cfs)	Percent
#2	2,010.00	680.13	1,650,000	81.38	88
#5	3,110.00	929.94	2,400,000	262.42	72
#1	1,210.00	298.3	850,000	32.21	89
#4	2,750.00	609.87	2,100.00	307.04	50
#8	6,840.00	1,408.08	5,480,000	575.42	59
#3	1,565.00	221.37	1,140,000	161.25	27
#7	3,215.00	444.33	2,365,000	326.8	26
#6	1,235.00	253.21	1,985,000	406.98	-61
#9 (Outlet)	14,220.00	2,096.39	12,760.00	1,331.61	36

The maximum percentage of the Chinde-Chaco River watershed managed by surface impoundments at any given time is about 8.2%. As seen in Figure 27, no permanent post-mine impoundments will affect this particular watershed. All impoundments are projected to be removed by 2025. For the purpose of this assessment, the impacts from surface water impoundment water-management on the Chinde-Chaco River watershed are negligible.

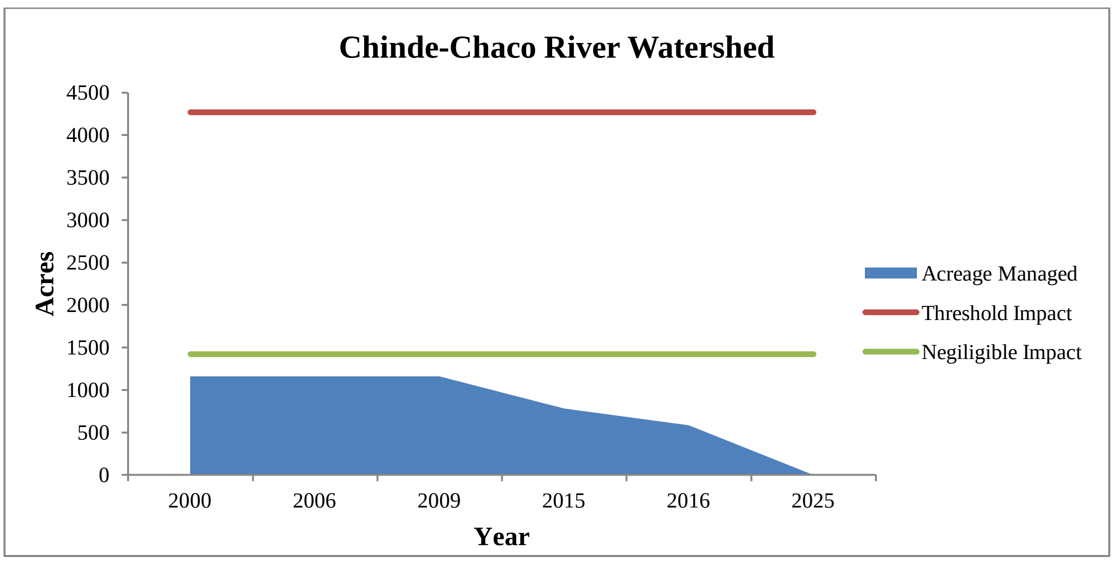


Figure 27: Percentage of the Chinde-Chaco River Watershed Managed by Impoundments

5.3.6.1.4 Coal Creek-Chaco River Watershed

The total peak flow reduction to the Coal Creek Watershed is much lower, as a percentage, than that of the Chinde-Chaco River Watershed. Although much of the runoff within the watershed area is generated in Lowe Arroyo due to the steeper slopes present in this area, the total impacts to the watershed are mitigated by the large geographical area of which it is comprised. Curve numbers were reduced significantly in order to model the post-mining changes along Lowe Arroyo. Detailed assessment and modeling of tindividual drainages can be found in the PHC (BNCC 2011, Section 11.6). For purposes of this CHIA analysis and modeling was conducted on HUC 12 watersheds.

The estimated pre-mining peak flow for the watershed, in response to the 10-year 6-hour rain event, is 1,719 cfs and the post-mining peak flow is 1335 cfs. The total peak flow reduction for the entire HUC12 watershed, pre-mining to post-mining, is about 22%. Results are presented in Table 10. For the purpose of this assessment, this decrease in flow represents a minor impact.

Table 10: Comparison of Pre-Mine and Post-Mine Peak Flows in Chinde-Chaco River Watershed

Sedcad Watershed Designation	Pre-Mine		Post-Mine		Decrease in Peak Flow
	Total Contributing Area	Peak Discharge	Total Contributing Area	Peak Discharge	
	(acres)	(cfs)	(acres)	(cfs)	Percent
#16	7300	467.26	7300	467.26	0
#15	3530	388.14	3530	388.14	0
#10	2860	370.9	2860	240.25	35
#11	6790	898.5	6790	500.47	44
#12	7730	933.82	7730	523.35	44
#17	23620	1827.86	23620	1471.57	19
#14	1280	261.33	1280	261.33	0
#13	1762	250.23	1762	250.23	0
#18	28252	1757.7	28252	1383.23	21
#19 (Outlet)	28252	1719.96	28252	1335.69	22

The maximum percentage of the Coal Creek-Chaco River watershed managed by surface impoundments at any given time is about 9.3%. As seen in Figure 28, permanent post-mine impoundments will affect 1,624 acres for this particular watershed under the current mine plan. For the purpose of this assessment, the impacts from surface water impoundment water-management on the Chinde-Chaco River watershed are negligible.

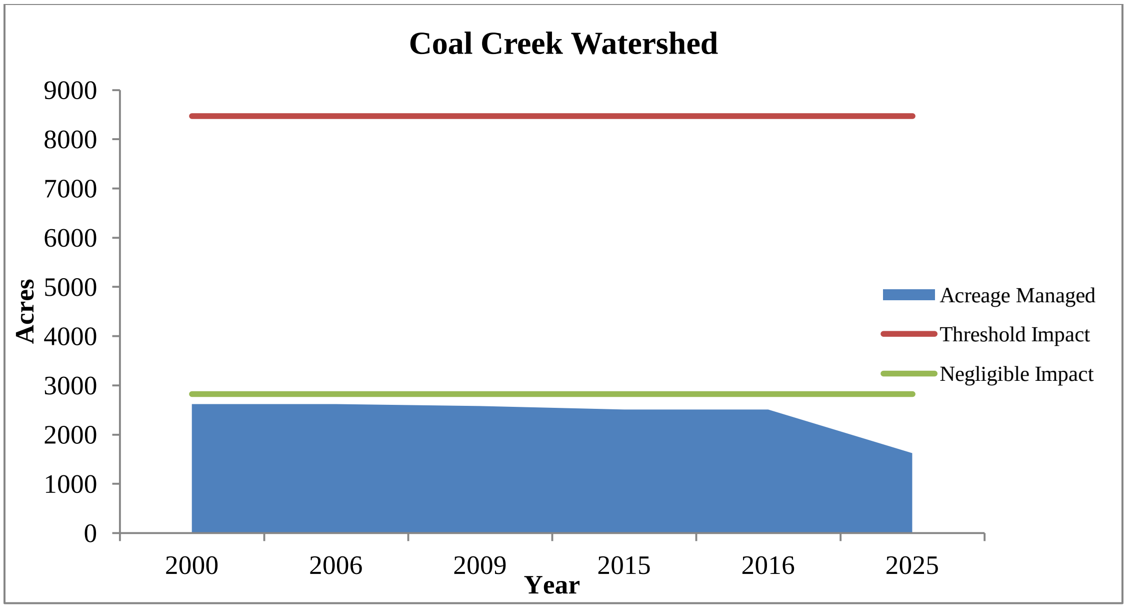


Figure 28: Percentage of the Coal Creek Watershed Managed by Impoundments

5.3.6.1.5 Cottonwood Arroyo Watershed

The primary hydrologic change to the Cottonwood Arroyo watershed is the disturbance of the North Fork of Cottonwood Arroyo. Approximately 10,662 feet of the North Fork will be permanently realigned from the pre-mine orientation due to reclamation (BNCC 2011). As noted in the discussion of Lowe Arroyo, the Cottonwood Arroyo watershed will slightly increase from the pre-mine scenario, but this increase will yield no appreciable hydrologic effects with respect to the evaluation method used in this CHIA.

Table 11 shows the comparison of peak flow for the 10-yr 6-hr precipitation event for the portions of Cottonwood tributaries that drain the proposed Area 4 North mine area. These results reflect disturbance conditions for the entire sub-watershed even though proposed mining affects only a portion of the sub-watershed. Yet the differences in peak flow are negligible between pre and post-mining at the lease line. The incrementally small change in peak flow reflects the small acreage of mining disturbance in the Cottonwood watershed as a whole.

The peak flow resulting from a 10-yr 6-hr precipitation event at the lease line is predicted to slightly increase from a pre-mining estimate of 2,879 cfs to a post-mining estimate 2,903 cfs. For the purpose of this assessment, this is considered a negligible impact.

Table 11: Comparison of Pre-mine and Post-Mine Peak Flows in the Cottonwood Arroyo Watershed (BNCC 2011)

SEDCAD 4.0 WATERSHED DESIGNATION		Pre-Mine		Post-Mine		Difference From Pre-Mine	
Pre	Post	Area (acres)	Peak Flow (cfs)	Area (acres)	Peak Flow (cfs)	Area (acres)	Peak Flow (cfs)
S21	S21	13,492	1,551	13,532	1,546	40	-5
S34	S34	18,191	674	18,279	665	88	-9
S36 (lease line)	S36	49,060	2,879	49,184	2,903	124	24
S37(Outlet)	S37	51,269	2,842	51,477	2,855	208	13

The maximum percentage of the Cottonwood Arroyo watershed managed by surface impoundments at any given time is about 6.6%. As seen in Figure 29, permanent post-mine impoundments will affect 561 acres for this particular watershed under the current mine plan. For the purpose of this assessment, the impacts from surface water impoundment water-management on the Cottonwood watershed are negligible.

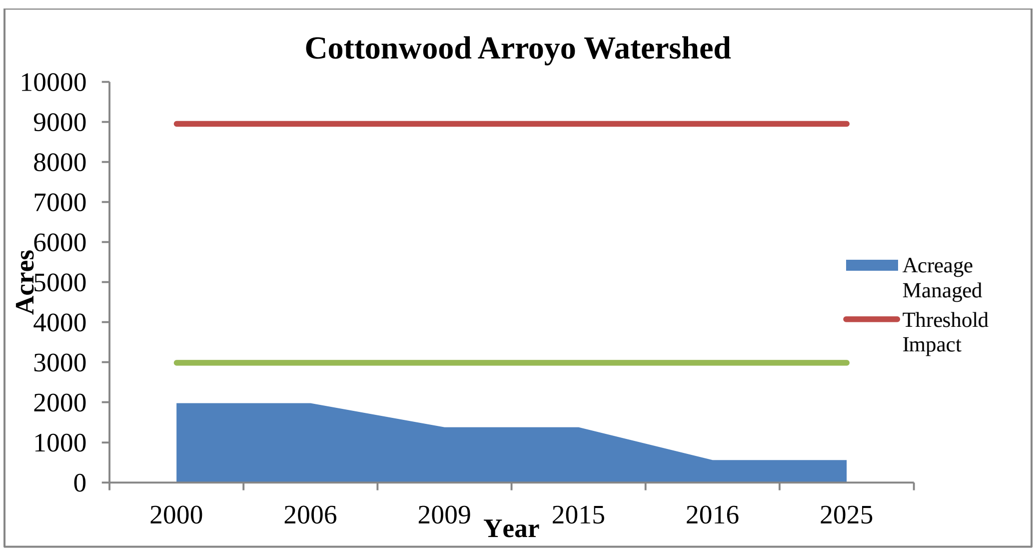


Figure 29: Percentage of the Cottonwood Arroyo Watershed Managed by Impoundments

5.3.6.2 **Surface Water Quality**

Several recharge mechanisms influence surface water quality within the permit and adjacent area. Precipitation and NAPI discharges generate runoff in the ephemeral washes, entraining sands, silts, and clays, inducing elevated concentrations of 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 NAPI has resulted in intermittent and perennial flows and rising of local groundwater tables increasing hydrologic communication between the Fruitland Formation and alluvial systems. The effect of runoff on spoil surface area influences the surface water quality. During mining and through bond release, surface water impoundments capture surface water runoff that was in contact with spoil material. The impounded surface water may discharge over the spillway during precipitation events exceeding the design capacity, or infiltrate through the bottom of the impoundments, entering the Fruitland Formation and alluvial and surface water systems.

Surface water quality impact assessment is conducted via comparison of upstream/pre-mining or baseline water quality to downstream or non-baseline water quality collected during and post-mining. This assessment is conducted on the primary drainages which traverse the BNCC permit area. As part of the ongoing BNCC surface water monitoring program, water quality has been assessed along the Chinde, Cottonwood, Pinabete, and No Name drainages at the location shown in Figure 17. The only drainage for which non-baseline surface water quality data exists is Chinde Wash.

Surface water quality impact assessment is also conducted via comparison to applicable water quality standards as outlined in Table 3, as well as the SMCRA dissolved iron standard of 10mg/L. The NNEPA water quality program is an integral component in the protection of the hydrologic balance and surface water quality. As such, OSMRE will work in partnership with the NNEPA if concentrations of chemical parameters have potential to change the present or potential use outside the lease area. The hydrologic balance is protected by the material damage definition, additionally; discharges to the surface water are reported to USEPA under point source permit No. NN0028193. 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. 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.

5.3.6.2.1 Chinde Wash

Surface water quality data is available on the Chinde Wash at four BNCC monitoring stations which bracket the lease area; CD-2 and CD-2A downstream of the mine and CD-1 and CD-1A upstream of the mine (Figure 17). Water quality data was collected at CD-1 and CD-2 from 1986 to 1997 and at CD-1A and CD-2A from 1996 to present. There is no pre-mining data on Chinde Wash, however, CD-1 and CD-1A were considered as baseline as they are upstream of the mine. It is important to note that while upstream of mining, CD-1 and CD-1A are both downstream of NAPI activities, and there is no pre-NAPI data on Chinde Wash, which is subject to both direct and indirect NAPI influences. Direct discharge events for the streams are highly variable, occur quickly, and can last up to 12 hours causing significant erosion and sediment transport in the channel. The indirect NAPI related discharges are a result of return flows to the wash caused by the infiltrating irrigation water, and most likely result in the continuous baseflow within Chinde Wash (BNCC 2011, Section 11.6). Data from CD-2 and CS-2A will be used for the downstream analysis on Chinde Wash.

Downstream data was found to have slightly higher variability relative to baseline data where the median percent relative standard deviation for all constituents was 100 percent as compared to 85 percent. The NNEPA fish consumption criterion was not exceeded for any samples. NNEPA acute aquatic and wildlife habitat criteria were exceeded for cadmium, chromium, selenium, silver and zinc for 4, 100, 1, 2 and 60 percent of all samples respectively. NNEPA chronic aquatic and wildlife habitat criteria were exceeded for aluminum, cadmium, chromium, lead, selenium, and zinc for 46, 100, 3, 57, 70, and 60 percent of all samples respectively. Lead exceeded the NNEPA secondary human contact standard for 4 percent of all samples. Livestock criteria for boron, chloride, selenium, sulfate and TDS were exceeded for 0.5, 5, 23, 0.5 and 6 percent of all samples. The median cadmium, lead, selenium and zinc concentrations were 6, 2, 1.25 and 1.3 times greater than NNEPA chronic aquatic and wildlife habitat standards. The median chromium and zinc concentrations were 16 and 1.3 times greater than NNEPA acute aquatic and wildlife habitat standards. All other median values are below all criteria indicating that the criteria exceedances are generally more characteristic of the high variability in the data set as compared to the general water quality. Therefore surface water quality within the Chinde Wash as compared to NNEPA and other relevant criteria is appropriate for the designated post-mining land use of livestock grazing. However, elevated levels of selenium were found relative to chronic aquatic and wildlife habitat NNEPA criteria. One sample or approximately 6 percent of all samples exceeded the SMCRA dissolved iron standard; however, the median dissolved iron concentration of 0.1 mg/L is 100 times smaller than the criterion.

The comparison to baseline median plus 2 MAD from the upstream stations CD-1 and CD-1A showed the following; minor impacts for boron, selenium, sulfate, TDS, conductivity, and manganese where 15, 24, 21, 22, 22, and 10 percent of all samples exceeded baseline respectively; moderate impacts for aluminum, arsenic, chloride, nitrate, TSS, and total iron where 50, 50, 39, 35, 32, and 32 percent of all samples exceeded baseline respectively. Of these the median concentrations of aluminum and arsenic exceeded the baseline median plus 2 MAD. The median concentrations for all of these criteria except selenium, however, were below the relevant use criteria. Impacts for all other constituents were determined to be negligible. No major impacts have occurred within Chinde Wash and water quality is generally appropriate for the designated post-mining land use of livestock grazing. Potential concerns do, however, exist regarding selenium concentrations relative to aquatic and wildlife habitat use.

5.3.7 **Groundwater**

OSMRE will evaluate groundwater quantity and quality related to the overall hydrologic balance and potential impact of BNCC on groundwater uses, specifically livestock watering as this is the primary use of groundwater within the CIA, and considering livestock water quality criteria. OSMRE must also evaluate that the operation has been appropriately designed to provide the groundwater quantity and quality information necessary to assess potential impacts per 30 CFR 780.21(g). Minimization of impacts to the hydrologic balance relative to groundwater is focused on reducing the disturbance footprint to the extent practical via contemporaneous reclamation. Additionally, local areas of acid forming material are managed through proper blending and mixing of overburden materials. BNCC also minimizes potential effects to the alluvial groundwater quantity by instituting stream buffer zones to limit disturbances in channel reaches unaffected by mining.

5.3.7.1 **Alluvium**

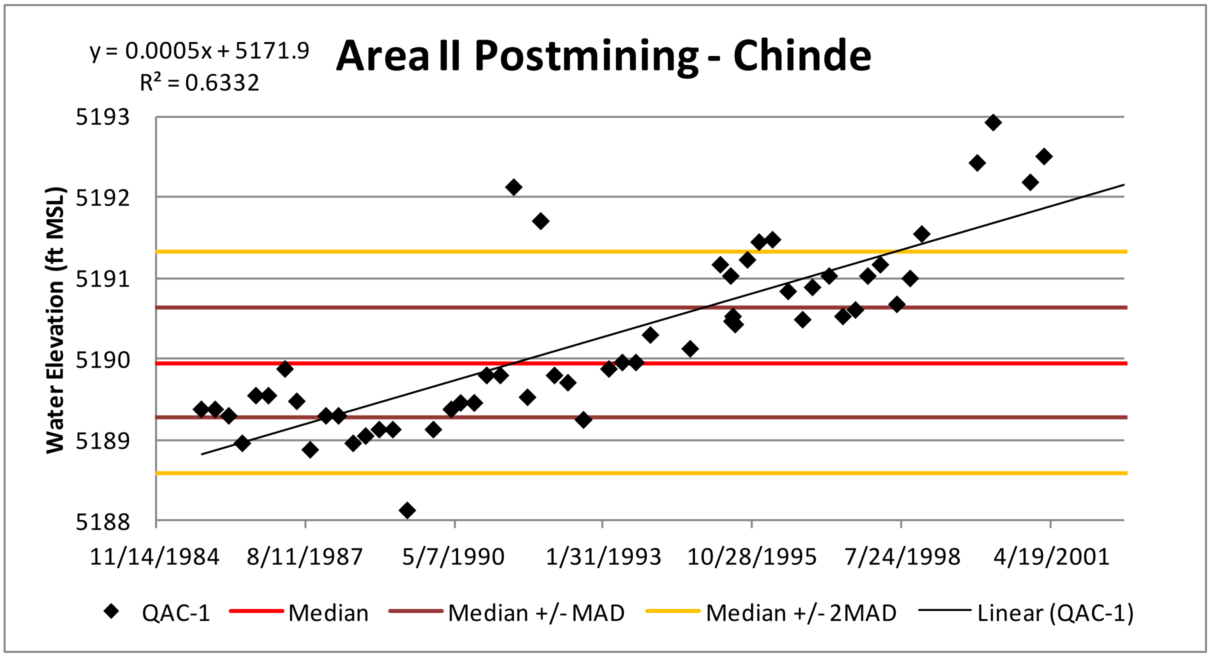
Alluvium is the most used groundwater resource within the CIA, and is primarily used for livestock watering. OSMRE will evaluate the potential impact of BNCC to the existing and foreseeable uses outside the permit area related to alluvial water quantity and quality. Non-baseline, i.e. downstream and/or postmining, alluvial wells exist within Areas I and II of the BNCC permit. Along Chinde Wash alluvial data was collected from 1979 to 1980 at GM-9 within the BNCC lease, from 1985 to present at QAC-1 at the western mine lease boundary, and from 1975 to 1982 at GM-10 just downstream of QAC-1. One alluvial well, Bighan-1, exists along drainages that are tributary to Morgan Lake within the permit area; data was collected from 1995 to 2001 at this location along the eastern lease boundary just south of the permit boundary. The location of Bighan-1 along the eastern mine permit boundary suggests that the well would be representative of baseline; however, it was installed after mining impact in the area and is therefore discussed below and not in baseline assessment. Monitoring well locations can be seen in Figure 19.

5.3.7.1.1 Alluvial Quantity

There are no current uses of the alluvium in Area I or II of the BNCC lease, however, there have been historic uses of the alluvium for livestock watering (BNCC 2011, Section 11.6). The wells along Chinde Wash and Morgan Lake tributaries were not monitored prior to mining impacts in the area, and can therefore not be used for baseline characterization. Therefore, the alluvial quantity assessment at these locations cannot rely upon a comparison of pre mining alluvial groundwater quantity to post mining conditions. The potential for impacts to alluvial groundwater quantity was assessed using two metrics: the percent of all sampling events which were dry and the water elevation in feet above Mean Sea Level

(MSL). Water elevation was not collected for all samples; however, inference of water presence was based on the presence of water quality data. Therefore the total number of samples used to calculate the percent of dry sampling events is often higher than the number of samples used for the water elevation comparisons.

Alluvial groundwater monitoring data suggests the Chinde Wash alluvium is mostly saturated across the length of the lease area, where water was found for all sampling events at GM-9, GM-10 and QAC-1. Alluvium at Custer-1 and Custer-4 was found to be dry for 75% of all sampling events, whereas Bighan-1 had water for all sampling events. Water elevation data was, available at QAC-1 along Chinde Wash, and at Custer-1, Custer-4 and Bighan-1. Variability as characterized by the percent relative standard deviation (%RSD) for water elevation data showed that the Custer wells had the highest variability, where the median %RSD was 14 times greater than that of Bighan-1; and 11 times greater than that QAC-1 on Chinde Wash. The lower variability of water elevation levels in Chinde Wash may in part be due to perennial nature of the drainage as a result of NAPI agricultural irrigation discharges. Water levels at all four wells have been increasing over time (Figure 30), most likely as a result of infiltration of NAPI runoff and agricultural irrigation discharges. As water levels are steadily increasing in the alluvium of Area I and II it is reasonable to assume that groundwater levels are not below baseline fluctuations, and therefore the impact is negligible. More detailed alluvial quantity data can be found in Appendix F.



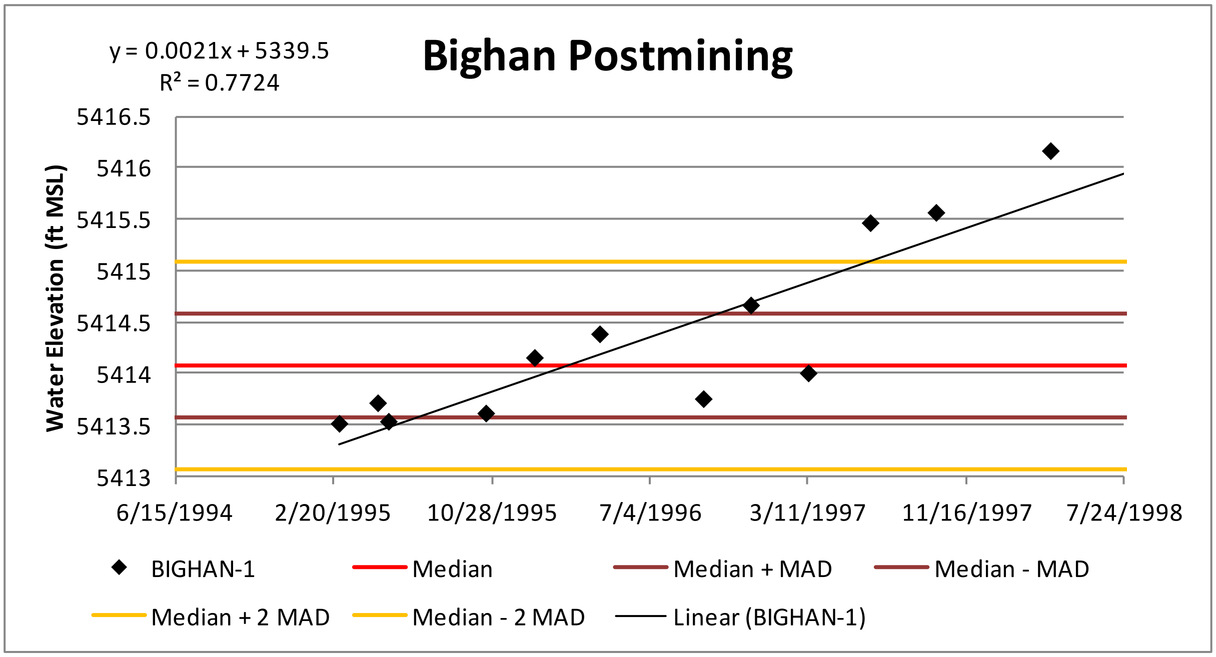


Figure 30: Chinde and Bighan Alluvial Water Elevations

While alluvial groundwater downstream of the Area IV North permit boundary has been monitored at QACW-2 since 2005 after mining began in the North Fork of the Cottonwood Arroyo, the well has been dry for all monitoring events. Dry periods of this length are not outside of the variability observed in the baseline quantity data at this well, therefore the dry period can be characterized as a negligible impact. Groundwater modeling of Area IV North conducted as part of the PHC assessment was used to help assess the approximate magnitude of changes in groundwater flow in the Cottonwood alluvium that might occur as a result of mining in Area IV North. The groundwater model predicted a steady-state post-reclamation alluvial groundwater flow at the mouth of Cottonwood Arroyo of about 4.6 gallons per minute (gpm) compared to the pre-mine alluvial groundwater flow estimate of 4.3 gpm (BNCC 2011, Section 11.6). However, baseline groundwater flows in the Cottonwood alluvium are never at steady state and vary considerably seasonally and from year to year and will continue to vary throughout mining and after reclamation. The model-predicted 0.3 gpm increase in groundwater flow in the Cottonwood alluvium. This prediction is quite low relative to the baseline variability in the Cottonwood alluvial groundwater. Thus, mining and reclamation within Area IV North is not expected to result in a long-term measurable change to the alluvial groundwater quantities or potential well yield from the alluvium. Groundwater quantities in the Cottonwood alluvium have historically been insufficient to sustain a reliable water supply at two of the three wells that were monitored for baseline conditions. This is not expected to change even with the modeled flow increase of 0.3 gpm. Impacts to the Cottonwood alluvial quantity are considered to be negligible because they are similar to fluctuations caused by natural processes (Ecosphere Associates Inc. 2011).

5.3.7.1.2 Alluvial Quality

Water quality data is available at all three wells (GM-9, GM-10 and QAC-1) along Chinde Wash, and at Bighan-1 along Morgan Lake tributaries. The wells along Chinde Wash and Morgan Lake tributaries were not monitored prior to mining impacts in the area and can therefore not be used for baseline characterization. Instead, baseline data collected along Cottonwood Arroyo was used as a surrogate for the area. Cottonwood Arroyo data was selected as representative of the alluvial systems in Areas I and II since it is also subject to NAPI influences. However, this is an imperfect representation as Cottonwood

Arroyo is only subject to NAPI direct discharges and not NAPI irrigation return flows, which leach water soluble constituents from the unconfined surface formations. This difference in source water type suggests that Cottonwood Arroyo baseline alluvial water quality dissolved concentrations would most likely be lower than the baseline concentrations along Chinde Wash and in Area I. Therefore impacts assessed by this method may be overestimated.

5.3.7.1.2.1 Bighan Alluvium

The location of Bighan-1 along the eastern mine permit boundary suggests that the well would be representative of baseline; however, it was installed after mining impact in the area and is therefore discussed below and not in baseline assessment. It is important to note that there is ambiguity surrounding this well specifically as to whether it is truly representative of potential mining impact or of baseline conditions.

The variability of Bighan-1 data is relatively low where the median %RSD is 31, significantly lower than that of the Cottonwood baseline which has a median %RSD of 121. At Bighan-1 arsenic, selenium, chloride, sulfate, TDS and fluoride exceeded livestock criteria for 4, 4, 4, 13, 6 and 100 percent of all samples. Of these Median fluoride concentrations exceed livestock criteria where the median fluoride concentration was 5 times larger than criteria.

A comparison to the Cottonwood baseline Median + 2MAD showed the following; moderate impacts for total iron where 50 percent of all samples exceeded baseline respectively; major impacts for arsenic, fluoride, selenium, and nitrate where 95, 100, 100, and 100 percent of all samples exceeded baseline respectively. Impacts for all other constituents were found to be negligible. Of these the median concentrations of arsenic, boron, selenium, fluoride, and nitrate exceeded the Cottonwood baseline Median + 2MAD where they were 5, 6, 3, 4, and 21 times larger respectively. The median concentrations for all of these criteria except fluoride, however, were below the relevant livestock use criteria. Therefore, while the impact designation can be considerable for certain constituents it does not appear to transfer to a significant impairment of use. Alluvial water quality at Bighan-1 is generally appropriate for the designated post-mining land use of livestock grazing, although there are possible concerns over fluoride concentrations. The fluoride exceedance may indicate impacts to the alluvial system or may also be indicative of general alluvial quality in the area, as Cottonwood is not a perfect surrogate baseline since it is only impacted by NAPI direct discharges. In contrast, the Bighan area is impacted by indirect NAPI irrigation return flows which leach the unconfined surface formations and may have significant quality impacts. Additionally, based on spoil leachate data and observations in spoil wells located in the historic mining area north of the BNCC permit, fluoride is lower in spoil water leachate than in the coal water and is attenuated in flow through mine spoil. There are no apparent trends over time in the Bighan-1 fluoride concentrations.

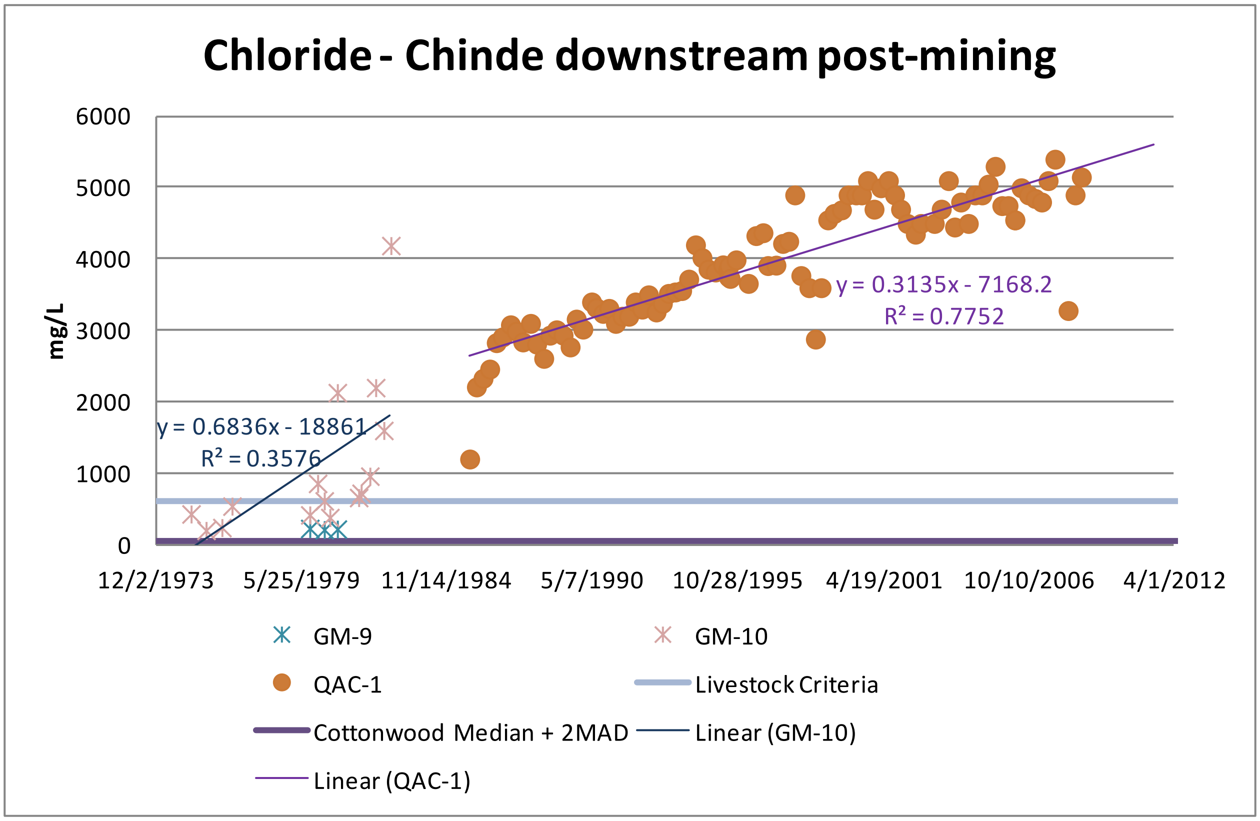
5.3.7.1.2.2 Chinde Wash Alluvium

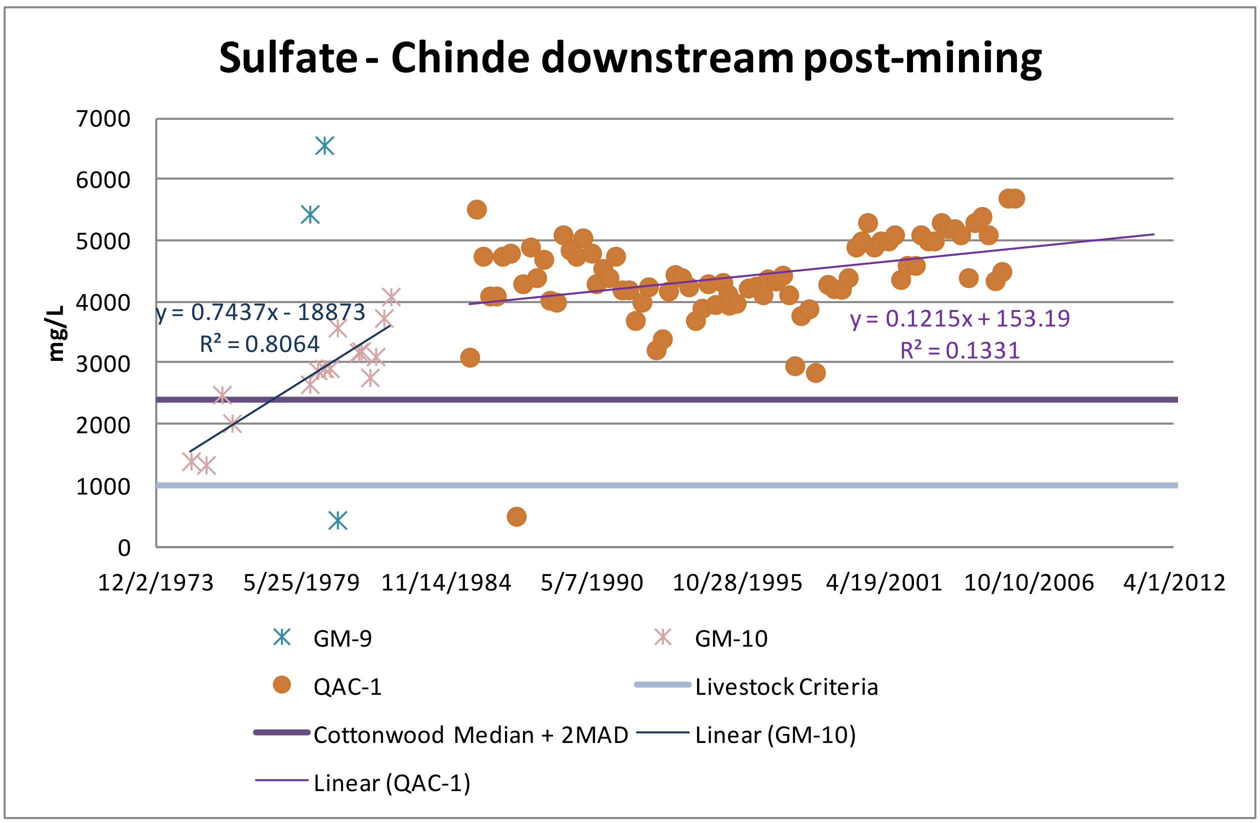
The variability of Chinde Wash alluvium water quality is greater than that of the Bighan-1 where the median %RSDs were 114 and 31 respectively, and both show lower variability than Cottonwood Wash baseline alluvium water quality which had a median %RSD of 121. Additionally, Chinde Wash alluvium water quality is more variable than Chinde surface water quality which had a median %RSD of 100.

Along Chinde Wash the pH was below the NNEPA standard range for one sample where the pH was 6.45. Arsenic, cadmium, lead, selenium, chloride, fluoride, nitrate, sulfate and TDS exceeded livestock criteria for 1, 1, 8, 7, 92, 11, 3, 98 and 98 percent of all samples respectively. The median concentrations for chloride, sulfate, and TDS exceeded livestock criteria and concentrations were 6, 4, and 4 times larger than the applicable criteria respectively.

A comparison to the Cottonwood baseline Median + 2MAD showed the following; moderate impacts for total iron where 50 percent of all samples exceeded baseline respectively; minor impacts for pH, cadmium, copper, selenium, fluoride and nitrate where 24, 16, 19, 25, 11 and 18 percent of all samples exceeded baseline respectively; moderate impacts for arsenic, chromium, lead and radium where 43, 51, 52 and 47 percent of all samples exceeded baseline respectively; major impacts for conductivity, boron, total iron, manganese, chloride, sulfate and TDS where 94, 98, 74, 88, 100, 95 and 97 percent of all samples exceeded baseline respectively. Impacts for all other constituents were found to be negligible. Of these the median concentrations of conductivity, boron, chromium, total iron, lead, manganese, chloride, sulfate, and TDS exceeded the Cottonwood baseline Median + 2MAD where they were 4, 6, 2, 2, 2, 15, 22, 2 and 3 times larger respectively. The median concentrations for all of these criteria except chloride, sulfate, and TDS, however, were below the relevant livestock use criteria. Therefore, while the impact designation can be considerable for certain constituents it does not appear to transfer to a significant impairment of use. Alluvial water quality along Chinde is generally appropriate for the designated post-mining land use of livestock grazing, except for concerns over chloride, sulfate and TDS concentrations.

These exceedances relative to baseline may indicate mining related impacts to the alluvial system or may be indicative of general alluvial quality in the area, as Cottonwood is not a perfect surrogate baseline. Cottonwood is only impacted by NAPI direct discharges, whereas Chinde Wash is impacted by both NAPI direct discharges and indirect NAPI irrigation return flows which leach water soluble constituents from the unconfined surface formations and may have significant water quality impacts. However, elevated sulfate and TDS concentrations at BNCC are associated with water quality from backfilled spoil and CCB disposal areas as characterized in section 5.2.2.1 below. Additionally, the concentrations of chloride, sulfate, and TDS have been steadily increasing within the Chinde Wash alluvium over time, as illustrated in Figure 31. More detailed alluvial quality data can be found in Appendix F.


Chloride - Chinde downstream post-mining
mg/L
6000
5000
4000
3000
2000
1000
0
12/2/1973
5/25/1979
11/14/1984
5/7/1990
10/28/1995
4/19/2001
10/10/2006
4/1/2012
y = 0.6836x - 18861
R² = 0.3576
y = 0.3135x - 7168.2
R² = 0.7752
GM-9
GM-10
QAC-1
Livestock Criteria
Cottonwood Median + 2MAD
Linear (GM-10)
Linear (QAC-1)


Sulfate - Chinde downstream post-mining
mg/L
7000
6000
5000
4000
3000
2000
1000
0
12/2/1973
5/25/1979
11/14/1984
5/7/1990
10/28/1995
4/19/2001
10/10/2006
4/1/2012
y = 0.7437x - 18873
R² = 0.8064
y = 0.1215x + 153.19
R² = 0.1331
GM-9
GM-10
QAC-1
Livestock Criteria
Cottonwood Median + 2MAD
Linear (GM-10)
Linear (QAC-1)

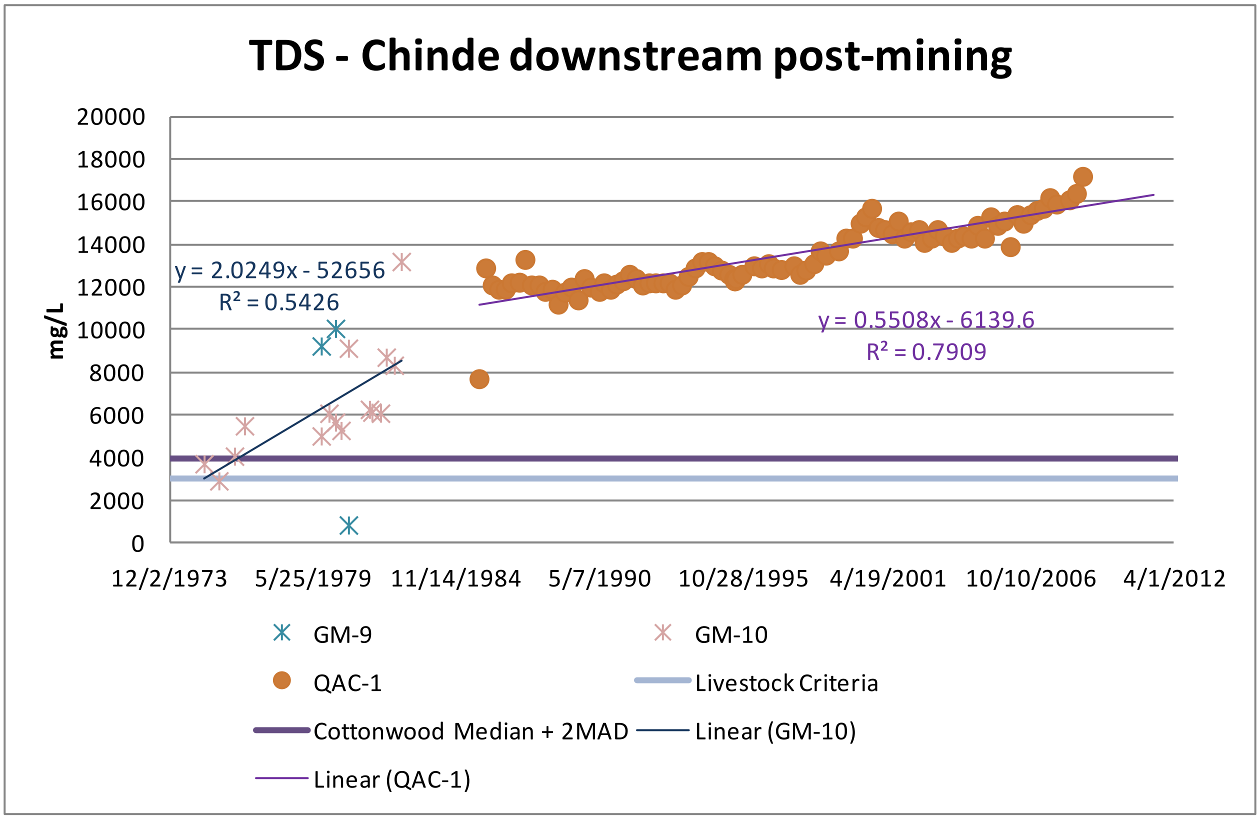


Figure 31: Chinde Alluvium Concentrations over Time

5.3.7.1.2.3 Cottonwood Arroyo Alluvium

While QACW-2 has been monitored since 2005 after mining began in the North Fork of the Cottonwood Arroyo, it has been dry for all monitoring events; therefore no water quality data has been collected for comparison to baseline. Impacts to alluvium in Area IV North are not expected to be significant as there is a stream buffer zone around the main stem of the Cottonwood Arroyo including the alluvial deposit.

Long-term (500 years) TDS transport modeling simulations within Area IV North were performed using a lower bound source TDS concentration of 3,550 mg/l and an upper bound TDS concentration of 11,850 mg/l (BNCC 2011, Section 11.6). Based on these results, the long-term post-reclamation TDS concentrations in the groundwater in the Cottonwood alluvium may be expected to increase down gradient of the Area IV North mine area. The results indicate a delayed long-term increase in the TDS concentrations in the Cottonwood alluvium that may be within a magnitude of 0 to 22 percent near the mouth of Cottonwood after more than 500 years. A 22 percent increase would result in a predicted TDS concentration of 3687 mg/L. TDS concentrations between 3000 and 5000 mg/L may not cause adverse effects to adult livestock, however, growing/young livestock could be affected by looseness or poor feed conversion (Lardy, Stoltenow and Johnson 2008).

The natural variability in the baseline TDS concentrations in the Cottonwood alluvium is comparable to or greater than the magnitude of the model-predicted changes in TDS concentrations. For example, the median plus one median absolute deviation of the TDS concentrations measured in baseline samples at Cottonwood alluvial wells QACW-2 and QACW-2B are 22 percent and 10 percent higher than the median respectively, indicating large natural variation in TDS concentrations in the alluvium water quality. Cottonwood Arroyo alluvial monitoring at QACW-1 had insufficient water for sampling so it is not possible to assess the variability in TDS concentrations at this location. The median plus one median absolute deviation of the TDS concentrations measured in baseline samples at alluvial well GM-17 on the North Fork of Cottonwood was 3 percent higher than the median. However, the median TDS concentration in baseline samples from this well was 15,210 mg/l, making the alluvial groundwater at this location on the North Fork of Cottonwood unsuitable for use. In summary, the baseline median plus one median absolute deviation ranges from 3 to 22 percent higher relative to the medians (Ecosphere Associates Inc. 2011).

While the predicted TDS change of 0 to 22 percent could result in TDS concentrations above livestock criteria, the predicted change is within the variability of 3 to 22 percent observed in baseline fluctuations. Thus, the impact of the model predicted changes in TDS concentrations in the Cottonwood alluvium are considered to be negligible as the predicted long-term changes in water quality are within the variability observed in the baseline fluctuations. Additionally, changes unrelated to mining could result in a greater magnitude of change in TDS concentrations in the Cottonwood Arroyo alluvium, within the 500 year modeled timeframe. Any changes in alluvial groundwater quality are not expected to affect surface water quality or potential ecological receptors, as alluvial groundwater is not a source of base flow and generally does not discharge to the surface (Ecosphere Associates Inc. 2011).

5.3.7.2 **Fruitland Formation Quantity**

Based on mining experience at the Navajo Mine, the coals, the overburden, and the interburden in the Fruitland Formation are not expected to yield much water during mining in Area IV North. The mine pits have remained dry throughout the lease area except on rare occasions when surface flows are captured. Groundwater seeps are rarely observed along the highwall as any groundwater in the Fruitland overburden and coal is consumed by evaporation along the highwall (BNCC 2011). The few seeps that have been observed during mining were at locations within Area I where the highwall was near NAPI irrigation plots. Groundwater flow rates through the Fruitland coals within Area III are believed to be extremely low because of the low hydraulic conductivities of the coal and the relatively flat hydraulic gradients. For a long period following mining within Area III gradients will be toward the mine backfill. As the mine spoils begin to saturate over the long-term, the buildup of heads in the mine spoil will increase, reversing the gradients with respect to the mine spoils. Based on model estimates of Area IV North it could take as long as 80 years for gradient reversal to occur (BNCC 2011). Transport directions for mine spoil water at that time would be laterally down dip in the Fruitland Formation, toward the outcrop areas to the south and west of Area III, and vertically into the PCS. Lateral flow from the mine spoils through the Fruitland Formation and vertically into the PCS will be very low due to the low hydraulic conductivity of these units and due to the relatively flat gradients that can be expected based on pre-mine conditions. Most discharge to the PCS and Fruitland Formation outcrops to the south and west of Area III is expected to be removed by evapotranspiration, although a portion of this groundwater discharge could reach the Cottonwood Arroyo alluvium.

Potentiometric gradients in the other coal seams within Areas III, IV, and V of the BNCC coal lease are expected to be generally toward the northeast, similar to the gradients for No. 3 coal seam. However, the upper coal seams (No. 6, No. 7, and No. 8) outcrop to a greater extent within the valleys of Pinabete Arroyo, No Name Wash, and Cottonwood Arroyo within the BNCC coal lease. The groundwater gadients within these upper coal seams are influenced by outcrop discharge along the arroyos. The baseline hydrogeologic model generated to support the PHC assessment simulated local potentiometric gradients toward the Pinabete Arroyo, No Name Wash, and Cottonwood Arroyo in all of the Fruitland coal units. The local influence of topography on potentiometric gradients was greatest for the shallowest coal, the No. 8 seam (Norwest Corporation 2011). Field observations of salt deposits and enhanced vegetation production also indicate that local discharge may occur from the No. 8 coal at the coal outcrop along Pinabete Arroyo. Baseline groundwater model simulations and potentiometric elevations at wells

KF-2007- 01, KF84-22A, and KF83-10A were used to prepare the potentiometric surface of the No. 8 coal seam provided in Figure 21.

The open mine pit acts as a drain for drawdown of any groundwater in the overburden/interburden, in the coal seams. Model simulations of the advance of proposed open pit mining in Area IV North have been performed to provide estimates of drawdown and recovery in the Fruitland coals during mining and reclamation. It is estimated that mining in Area IV North will cause around 5 feet of drawdown by the time of completion of mining in both the No.3 and the No. 8 coal seams (BNCC 2011). The groundwater model developed for the PHC was also applied to simulate the rate of recovery of water levels in mine backfill and in the Fruitland coals adjacent to the mining block. Maximum drawdown is less than 17 feet, occurring approximately 30 years following the start of mining (BNCC 2011). Upward gradients of groundwater movement from the PCS to the mine backfill do not occur until about 85 years after the start of mining. After that time, the recovery of the potentiometric surface in the backfill is complete and gradients are vertically downward from the backfill to the PCS.

These results together with the estimated 5-foot drawdown contour maps at the end of mining show that the hydrogeologic effects of proposed mining within Area IV North are localized and occur over a long time period. The long-term change resulting from the removal of the interbedded coal, shales, mudstones, and sandstone strata and replacement with a relatively homogeneous and isotropic mine backfill will be an increase in the rate of vertical flow into the PCS from the mine backfill compared with the vertical flow into the PCS from the Fruitland formation prior to mining.

Cumulative effects of drawdown are determined to be negligible because there are no wells completed in the Fruitland Formation and the PCS that could be impacted and these units are not capable of providing a sustainable water supply (BNCC 2011a).

The projected and observed impacts to the water quantity within the Fruitland Formation resulting from coal mining at the Navajo Mine have been minimal to date. Since there are no current uses for the Fruitland formation in or adjacent to the Navajo Mine and no foreseeable uses other than oil and gas extraction, impacts to the Fruitland formation are not expected to preclude current or foreseeable uses. Additionally, the predicted and observed impacts to the Fruitland Formation do not extend outside of the immediate areas surrounding the mine pits and reclaimed areas; and the Fruitland Formation is generally not capable of providing a sustainable water supply (BNCC 2011, Section 11.6). Therefore for the purpose of this assessment, the impacts to the groundwater quantity of the Fruitland Formation are considered to be negligible.

5.3.7.3 **Fruitland Formation Quality**

Spoil leaching tests were performed in support of the PHC assessment for the Navajo Mine SMCRA permit revision. The spoil leaching test results show a considerable range in the concentrations of TDS and sulfate, which are the primary constituents of concern with respect to spoil leachate. Spoil leaching test results found an increase in TDS concentrations in spoil water leachate ranging from 400 to 2,700 mg/l and an increase in sulfate concentrations in spoil water leachate ranging from 630 to 2,580 mg/l (BNCC 2011, Appendix 11-VV). The leaching test results are fairly consistent with the results for the Bitsui #5 spoil well completed in the mine spoils in the Bitsui Pit, located at the north end of the BNCC Navajo Mine. The Bitsui Pit was backfilled in the 1980s and is the only pit at Navajo Mine where saturation of mine spoils has been observed. Arsenic and selenium were below detection in most of the leaching test results and in the Bitsui 5 spoil well. Fluoride is also lower in the spoil water leachate than in the coal water and is attenuated in flow through mine spoil. Boron and manganese concentrations are also elevated in mine spoil water (BNCC 2011, Section 11.6).

During active mining, hydraulic gradients and groundwater flow directions in the Fruitland Formation are towards the mine pits and backfill areas. Thus, it is expected that there would be little change in the quality of groundwater beyond the limits of the mine pit and mine backfill during mining and reclamation operations. These results show that in addition to increases in concentrations of TDS and sulfate, concentrations of boron and manganese may also increase relative to the baseline coal water (BNCC 2011, Section 11.6).

A comparison of baseline water quality to livestock criteria found that water in the Fruitland Formation is a very poor source of supply for livestock watering use, specifically because of elevated chloride and TDS concentrations, which are well above livestock criteria. There are no livestock watering wells completed in the Fruitland Formation that could be impacted and the aquifer is generally not capable of providing a sustainable water supply for this use. The only documented current and historic use of the Fruitland Formation in the area is for oil and gas extraction, which does not have protective use criteria designations since water quality is not particularly significant for this use. Therefore, analysis of post mining groundwater quality in the Fruitland Formation including adjacent Fruitland Formation coal aquifers, CCB disposal areas and the backfilled spoil will be evaluated against baseline Fruitland Formation groundwater quality as well as livestock use criteria. A complete comparison to livestock use criteria can however be found in Appendix F. An analysis of constituents generally associated with backfill spoil and CCB leachate including pH, conductivity, boron, total iron, manganese, selenium, chloride, fluoride, sulfate and TDS is presented below.

The variability of groundwater quality data from backfill spoil, and non-baseline Fruitland Formation coal aquifers is similar to that of the corresponding baseline groundwater quality data within the coal lease where the median %RSDs are 68 and 67 respectively. A comparison of spoil wells to the Median + 2MAD for baseline Fruitland coals within the BNCC lease area showed the following; negligible impacts for conductivity, chloride, and fluoride; minor impact for total iron where 27 percent of all samples exceeded baseline; moderate impact for selenium where 33 percent of all samples exceeded baseline; major impacts for pH, boron, manganese, sulfate and TDS where 64, 98, 64, 100 and 93 percent of all samples exceeded baseline respectively. Of these the median concentrations for boron, manganese, sulfate, and TDS exceeded the baseline Median + 2MAD where they were 2, 10, 187 and 1.3 times larger respectively. No pH values were outside of the livestock criteria range. There is no livestock criterion for manganese, and median boron concentrations were below the livestock criterion; however, median concentrations for sulfate and TDS exceeded livestock criteria where they were 8 and 5 times larger respectively. Therefore, within spoil wells sulfate and TDS are all considered to be of concern relative to baseline and livestock criteria. It is important to note that impact to boron and fluoride concentrations is lower in spoil wells relative to CCB wells.

A comparison of non-baseline Fruitland Formation coal aquifer wells to the Median + 2MAD for baseline Fruitland Formation coal aquifer wells within the BNCC lease showed the following; negligible impacts for pH, conductivity, total iron, manganese, chloride, and TDS; minor impacts for selenium and fluoride where 20 and 13 percent of all samples exceeded baseline respectively; major impacts for boron and sulfate where 92 and 64 percent of all samples exceeded baseline respectively. The median concentrations for boron and sulfate exceeded the baseline Median + 2MAD and concentrations were 1.3 and 6 times larger respectively. When compared against livestock water quality criteria, median boron and sulfate concentrations were below the livestock criteria. Therefore, within non-baseline Fruitland coal wells no constituents are considered to be of concern relative to baseline and livestock criteria, although boron and sulfate have major impacts relative to baseline. It is important to note that impact to non-baseline Fruitland coal wells within the BNCC lease is significantly reduced relative to impacts in CCB and spoil wells.

Since there are no current uses for the Fruitland formation in or adjacent to the Navajo Mine and no foreseeable uses other than oil and gas extraction, impacts to the Fruitland formation are not expected to preclude water uses. Additionally, the predicted and observed impacts to the Fruitland Formation do not extend outside of the immediate areas surrounding the mine pits and reclaimed areas and the aquifer is generally not capable of providing a sustainable water supply (BNCC 2011, Section 11.6). Therefore for the purpose of this assessment, the impacts to the Fruitland Formation groundwater quantity are considered to be negligible.

5.3.7.4 **Pictured Cliffs Sandstone Quantity**

The PCS is a marginal water resource due to low permeability, poor water quality, gas production, and low yields. The PCS is also a natural gas reservoir in the San Juan Watershed. Stone et al. (1983) state that the PCS cannot be considered a major aquifer and it is important only because it is the water-bearing horizon immediately underlying the coals in the Fruitland Formation.

Lateral flow through the PCS within Area II is expected to be generally toward the northeast as indicated by the potentiometric surface provided in Figure 15. There could also be a component of flow west toward the PCS outcrop located east of the Chaco River. Groundwater flow rates through the PCS will be very low due to the very low hydraulic conductivity of the PCS. Any discharge along the PCS outcrop to the west of Area II will likely be removed by evapotranspiration. Based on pre-mine observations along the PCS outcrop adjacent to Areas III and IV North, flow rates in the PCS are expected to be insufficient to sustain flow at seeps and into the alluvial aquifer.

It is estimated that a 5 foot drawdown will be present in the PCS at the completion of proposed mining in Area IV North. The layer of shale separating the bottom of the lowest coal seam and the PCS serves to restrict groundwater inflow from the PCS during mining. The thickness of shale layer between the No. 2 coal and the PCS averages about 8.7 feet over the Area IV North mine block but is absent in some places. This variation in the shale thickness has been accounted for in the estimates of drawdown within the PCS. Artesian pressures in the PCS occur in the eastern portion of the Area IV North mine block where the shale thickness separating the coal from the PCS is greater. Accordingly, any drawdown in the PCS is dampened, particularly in these locations where the shale thickness is greater.

The model simulated steady-state post mining potentiometric surface in the PCS is provided in Figure 32. This surface is similar to the pre-mining PCS potentiometric surface in Figure 15, except for the localized increase in the heads in the PCS below the mine backfill within Area IV North. The higher head in the PCS below the mine backfill is due to the higher heads at the base of the mine backfill. Very little change in heads is predicted at locations away from mine backfill, including at the former PCS wells GM-19 and GM-28, located within the lease area at distances of about 3,500 and 3,000 feet from the Area IV North mine pit. This localized increase in heads in the PCS results in an increase in gradients toward the northwest and toward the northeast.

There is one identified livestock watering well completed in the PCS located along the western side of the Chaco River west of Area V which may be influenced by alluvial waters of the Chaco River and it is not known if the well is actively being used. The unit is known to have very low yields in the vicinity of BNCC and is generally not capable of providing a sustainable water supply for this use. The primary documented current and historic use of the PCS in the area is for oil and gas extraction, which is not particularly sensitive to water quantity loses within the extraction zones. Therefore impacts to the PCS are not expected to disturb water users. Additionally, the predicted and observed impacts to the PCS do not extend outside of the immediate areas surrounding the mine pits and subsequent reclaimed areas. Therefore for the purpose of this assessment, the impacts to the PCS groundwater quantity are considered to be negligible.

5.3.7.5 **Pictured Cliffs Sandstone Quality**

Comparison of baseline water quality to livestock criteria found that water in the PCS is a very poor source of supply for livestock watering use, specifically because of elevated chloride, sulfate, and TDS concentrations, which are well above livestock criteria. However, there is one identified livestock watering well completed in the PCS located along the western side of the Chaco River west of Area V which may be influenced by alluvial waters of the Chaco River. It is not known if the well is actively being used. The unit is known to have very low yields in the vicinity of BNCC and is generally not capable of providing a sustainable water supply for this use. The primary documented current and historic use of the PCS in the area is for oil and gas extraction, which does not have protective use criteria designations, as water quality is not particularly significant for this use. Therefore, impacts to the PCS are not expected to disturb water users. The only non-baseline PCS monitoring well KP-84 did not have sufficient water for sampling during the historic monitoring period from 1990 to 1998. Therefore there will be no comparison of non-baseline PCS quality to baseline conditions.

Direct intermediate-term impacts to the groundwater quality beyond the active mine area are not expected to occur during mining and reclamation operations. During active mining, hydraulic gradients and groundwater flow directions in the PCS would be toward the mine pits and backfill areas. Thus, it is expected that there would be little change in the quality of groundwater beyond the limits of the mine pit and mine backfill during mining and reclamation operations. However, over the long term as these gradients reverse post-reclamation increase in TDS and sulfate concentrations in mine spoil backfill may result in increased TDS and sulfate concentrations in the PCS adjacent to mining (Ecosphere Associates Inc. 2011). Additionally, the predicted and observed impacts to the PCS do not extend outside of the immediate areas surrounding the mine pits and subsequent reclaimed areas and are not expected to disturb water users. Therefore for the purpose of this assessment, the impacts to the PCS groundwater quantity are considered to be negligible.

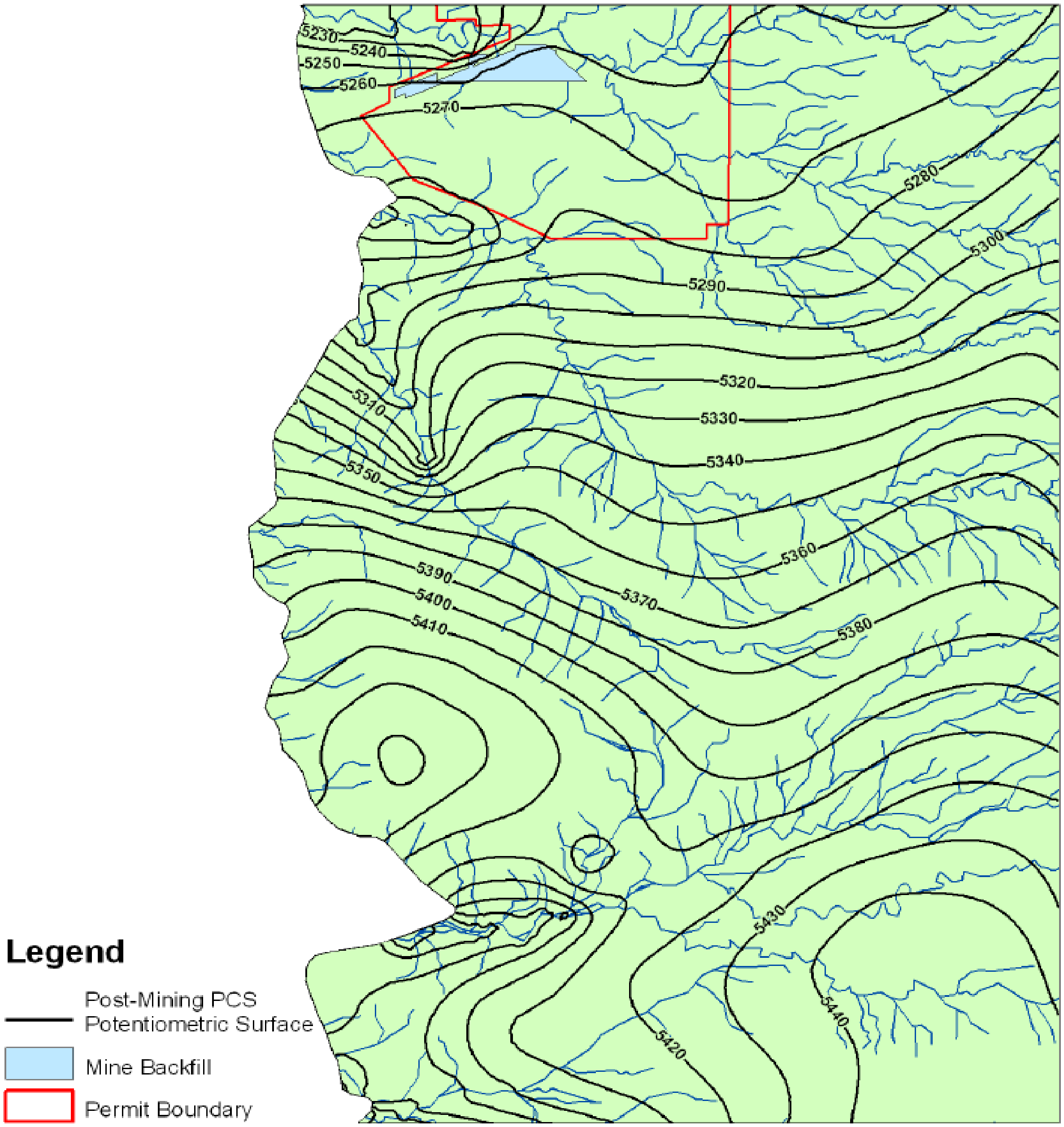


Figure 32: Post-Mining Potentiometric Surface in the PCS Aquifer (BNCC 2011)