Baseline Data Characterization Report
for
Copper Flat Mine
Sierra County, New Mexico

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New Mexico Copper Corporation

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Acronyms and Abbreviations

°C	degrees Celsius
°F	degrees Fahrenheit
µg/m^3	micrograms per cubic meter
µS/cm	microSiemen per centimeter
ABA	Acid Base Accounting
amsl	above mean sea level
ANPP	aboveground net primary production
ARD	acid rock drainage
ARDML	Acid Rock Drainage and Metal Leaching
BDR	Baseline Data Characterization Report
BLM	Bureau of Land Management
CAW	Class A weeds
CBW	Class B weeds
CCW	Class C listed weeds
CDG	Chihuahuan Desert Grassland
CDS	Chihuahuan Desert Shrubland
CFQM	Copper Flat Quartz Monzonite
CFR	Code of Federal Regulations
cfs	cubic feet per second
COC	contaminant of concern
CWA	Clean Water Act
DA/WR	Disturbed Area/Waste Rock
dbh	diameter at breast height
DEIS	draft environmental impact statement
DO	dissolved oxygen
EC	electrical conductivity
EMNRD	New Mexico Energy, Minerals and Natural Resources Department
EPA	United States Environmental Protection Agency
ESD	Ecological Site Description
ft	feet/foot
gpm	gallons per minute
GPS	Global Positioning System
H&O	Hink and Ohmart
HCT	humidity cell testing
HSU	hydrostratigraphic unit

km	kilometers
lpm	liters per minute
m	meters
Ma	million years ago
mg/L	milligrams per liter
mm	millimeters
MMD	New Mexico Mining and Minerals
m/s	meters per second
MSF	Middle Santa Fe Group hydrostratigraphic unit
Mst	million standard tons
MWMP	Meteoric Water Mobility Procedure
NAD	North American Datum
NAG	Net Acid Generation
NAIP	National Agricultural Improvement Program
NMAC	New Mexico Administrative Code
NMCC	New Mexico Copper Corporation
NMED	New Mexico Environment Department
NMOSE	New Mexico Office of the State Engineer
NMRPTC	New Mexico Rare Plant Technical Council
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NWI	National Wetlands Inventory
PFEIS	preliminary final environmental impact statement
PHC	probable hydrologic consequence
Project	Copper Flat Project
Quintana	Quintana Minerals Corporation
RH	relative humidity
ROW	right of way
SAG mill	semiautogenous mill
SAP	Sampling and Analysis Plan
SHB	Sergent, Hauskins, and Beckwith
SHPO	State Historic Preservation Officer
Site	Copper Flat Mine Permit Area
SoF	start of flow
SRK	SRK Consulting
SWQB	New Mexico Surface Water Quality Bureau
S-W Index	Shannon-Weiner Index
TD	Tailings Dam
TDS	total dissolved solids

THEMAC	THEMAC Resources Group Limited
TP	Tailings Pile
USACE	United States Army Corps of Engineers
USF	Upper Santa Fe Group hydrostratigraphic unit
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
watts/m^2	watts per square meter
WETLab	Western Environmental Testing Laboratory
WQCC	(New Mexico) Water Quality Control Commission

1 Introduction

The Copper Flat Project (Project) is the proposed re-establishment of a poly-metallic mine and processing facility near Hillsboro, New Mexico. The proposed Project would consist of an open pit mine, flotation mill, tailing impoundment, waste rock disposal areas, a low-grade ore stockpile, and ancillary facilities. The Project is owned and operated by the New Mexico Copper Corporation (NMCC), a wholly owned subsidiary of THEMAC Resources Group Limited (THEMAC).

The Project is located in Sierra County, New Mexico, approximately 30 miles southwest of Truth or Consequences and five miles northeast of Hillsboro (Figure 1-1). The Copper Flat Mine Permit Area can be reached by traveling south 15 miles from Truth or Consequences on Interstate Highway 25, then 12 miles west on New Mexico Highway 152. The Mine Permit Area lies two miles west-northwest from Highway 152 and is 2,190 acres in size.

Baseline data has been collected in the Mine Permit Area and in surrounding areas of interest since the late 1970s by various mining companies. Collected historic data provide a background and context for the data collected in 2010 and 2011 presented in this Baseline Data Report (BDR). This BDR is submitted to the New Mexico Energy, Minerals and Natural Resources Department (EMNRD) Mining and Minerals Division (MMD) by NMCC following the Sampling and Analysis Plan (SAP) (September 2010) per NMAC 19.10.6.602.D.(13). As required, data has been collected over a period of at least 12 months and in some cases, longer to allow for the evaluation of water quality and quantity, wildlife and wildlife habitat and vegetation in the Mine Permit Area and the vicinity. Baseline data were collected in the Copper Flat Mine Permit Area as well as surrounding areas deemed significant due to unique properties, proximity to the Mine Permit Area, and the real or perceived potential for sensitivity to mine operation and reclamation.

This report presents baseline data for these required categories governed by requirements, NMCC's 2010 SAP, field conditions, agency comments and accessibility:

- Climatological factors
- Topographic maps
- Vegetation
- Wildlife
- Topsoil
- Geology and ore body
- Surface water and groundwater
- Prior mining operations
- Cultural resources and known cemeteries and human burials
- Land use

Additional studies regarding potential impacts of mine operation and reclamation are planned and future reports will present findings for these investigations.

All baseline data collection was performed in compliance with the procedures defined in the NMCC 2010 SAP and the Quality Assurance Project Plan contained therein. Adjustments to the SAP necessary due to field conditions are noted herein. Additional information regarding the proposed Project is available in separate reports.

Figure

2 Climate

2.1 Regional Climate

The Copper Flat Mine Permit Area lies within the belt of mid-latitude westerlies where the prevailing wind direction is from the west. Winds at the Truth or Consequences, New Mexico, airport, located about 30 miles northeast of the Mine Permit Area, are generally from the northwest; however, the Black Range and foothills cause local variations in the winds. At Copper Flat, the wind direction is predominantly west to east, and secondarily north to south. Local wind speeds average about 10 to 15 miles per hour, although winds in excess of 50 miles per hour may occur at times. Temperature inversions are rare at Copper Flat, but are more common farther east along the Rio Grande valley, especially during the winter months. Vertical air dilution is generally good because of the area's high surface temperatures, creating strong daytime thermal mixing. Thermal mixing and moderate winds generally tend to suppress occasional nighttime inversions. The presence of higher winds and the lack of inversions contribute to a relatively clean atmosphere at the Mine Permit Area since any pollutants are readily mixed and dispersed (BLM, 1999).

Temperature data for the Mine Permit Area show a wide diurnal and seasonal variability, which is typical of dry climates. The warmest temperatures occur in June and July and the coldest temperatures usually occur in December and January. In spring and fall, daily maximum temperatures are moderate, typically averaging 65 to 85 degrees Fahrenheit (°F). Nights are cooler, with low temperatures averaging 32 to 50°F. Winter temperatures are frequently below freezing at night, but can be above 50°F during the day. During summer, temperatures can approach 100°F during the day. Daily temperature fluctuations of 30°F are common throughout the year (BLM, 1999).

Precipitation at the Mine Permit Area averages about 13 inches per year (ranging from nearly 3 inches in 1956 to over 20 inches in 1986). As much as half of the annual precipitation occurs in the form of intense thunderstorms during July, August, and September, when moist air enters the region from the Gulf of Mexico. Summer thunderstorms can result in heavy rainfall and flash floods. Average monthly precipitation in January through June is typically 0.50 inch or less. Snowfall is possible from October through April, but most likely (greater than 1 inch) between December through February (BLM, 1996).

Evaporation exceeds precipitation in southwestern New Mexico. Pan evaporation data, the most commonly collected data, are correlated with lake evaporation (i.e., free water surface evaporation) to predict evaporation from reservoirs and lakes. Lake evaporation at the Mine Permit Area is estimated to be approximately 58 to 65 inches per year, and pan evaporation is estimated to be approximately 80 to 90 inches per year (SRK, 1995).

2.2 Observed Meteorology at the Mine Permit Area

New Mexico Copper Corporation installed a 10-meter meteorological tower on August 2, 2010, with full data collection beginning September 1, 2010. Wind direction, wind speed, sigma theta of wind direction, and temperature data are collected at the 10-meter level. Temperature, relative humidity, and solar radiation are collected at the 2-meter level. Delta temperature is measured between the 10-meter temperature and the 2-meter temperature. At the ground level, precipitation is collected as well as evaporation. The tower is located in the vicinity of the proposed mill site and tailings near Hillsboro, New Mexico. Quarterly reports are included as Appendix 2-A.

The PM_{10} samplers are BGI PQ200 units with United States Environmental Protection Agency (EPA) reference method designation. Site 1 is located at the meteorological tower and Site 2 is located at the west property boundary west of the mine pit. Air quality quarterly monitoring reports are included as Appendix 2-B.

Site	Elevation (feet)	UTM (N)	UTM (E)
Tower I	5,402	3650419 m	0265721 m
PM_{10} Site 1	5,402	3650419 m	0265721 m
PM_{10} Site 2	5,596	3651000 m	0262618 m

Note: Coordinates were taken with a handheld Global Positioning System (GPS) in NAD83 Datum mode.

The remainder of Section 2.2 presents summary reports of the key meteorological parameters collected for the period October 1, 2010, through September 30, 2011. The project chose this time period to coincide with regular calendar quarters and to include the most recent data available for the months with the most complete data capture. All results are based on averages or totals (precipitation and evaporation).

2.2.1 Precipitation

The precipitation sensor is located at ground level and consists of a tipping bucket gauge representing 0.01 inches of rainfall per bucket tip.

Total precipitation for the year accumulated to 4.82 inches (Table 2-1). This total amount is significantly lower than the long-term average for the region, confirming the drought conditions observed for the fall, spring, and early of 2010 and 2011 (Figure 2-1).

Seventy-four (74) percent of the precipitation occurred during the summer season, represented by the months of June, July, and August. The total recorded precipitation during this period is 3.57 inches. The month with the greatest precipitation total is August at 3.12 inches (Figure 2-2). The driest three-month period corresponded to the spring months March, April, and May with 0.00 inches of recorded precipitation (Figure 2-2).

2.2.2 Temperature

Temperature sensors are located at the 10- and 2-meter levels (Tables 2-2 and 2-3). The probes are matched thermistors housed in fan-aspirated radiation shields. The matched thermistor set provides 10- and 2-meter temperature values as well as temperature flux over an 8-meter interval.

The mean annual 2-meter temperature is 19.5° C (67.1° F). The maximum annual 2-meter temperature of 37.7° C (99.9° F) occurred in the month of June (Figure 2-3). The minimum annual 2-meter temperature of -21.9° C (-7.4° F) occurred in the month of February. Hourly delta temperatures are shown in Figure 2-4.

2.2.3 Wind

Cup and vane wind speed and wind direction sensors are located at the 10-meter level. Data are in Table 2-4. All values reported here are based on one-hour averages. The starting threshold for the anemometer is 0.13 meters/second (m/s).

The mean annual wind speed is 5.3 m/s or 11.8 miles per hour. The maximum annual wind speed of 19.2 m/s occurred in the month of April. The minimum annual wind speed of 0.7 m/s first occurred in the month of December. April recorded the highest monthly average wind speed of 6.7 m/s. See Figure 2-5.

The prevailing wind direction for the year was from the west sector with a frequency of 14.1 percent (Figure 2-6). Winds from the west occurred 5.0 percent of the time in the >3.0 to 5.0 m/s range and 3.6 percent of the time in the >5.0 to 9.0 m/s range (Table 2-5).

The second most common wind direction occurred from the southwest with a frequency of 8.9 percent. The least common wind directions occurred from the northeast and east-northeast, each with a frequency of 2.3 percent.

2.2.4 Relative Humidity

Relative humidity is monitored at the 2-meter level. The probe is located in a gill plate naturally aspirated radiation shield.

The mean annual relative humidity is 26.6 percent (Table 2-6). The maximum annual relative humidity of 94.0 percent occurred in the month of September. The minimum annual relative humidity of 1.2 percent occurred in the months of May and June. August recorded the highest monthly average relative humidity of 40.9 percent. This value is consistent with August having the highest total monthly precipitation (Figure 2-7).

2.2.5 Net Radiation

Net radiation is monitored at the 2-meter level from a separate post located approximately 40 feet (ft) south of the tower (Table 2-7). The remote location avoids tower and guy wire shadows and reflections.

The mean annual net radiation value is 98 watts per square meter (watts/m^2). The maximum annual net radiation of 664 watts/m^2 occurred in the month of August. May and July recorded the highest monthly average, each with 126 watts/m^2. December recorded the lowest monthly average at 20 watts/m^2 (Figure 2-8).

2.2.6 Barometric Pressure

Barometric pressure is monitored at the 2-meter level. The sensor is located inside the datalogger enclosure and is vented to the atmosphere.

The mean annual barometric pressure is 844 mBars (Table 2-8). The maximum barometric pressure of 858 mBars occurred in the month of July. The minimum barometric pressure of 823 mBars occurred in the month of December (Figure 2-9).

2.2.7 Evaporation

Evaporation is monitored at ground level. The gauge outputs to the datalogger on a scale of 0 to 9 inches. The evaporation pan has an automatic fill device which re-fills the pan during night time hours on a pre-determined schedule. The pan was shut down for the winter months from November 10, 2010, through April 2, 2011.

The total measured annual evaporation is 62.53 inches (Table 2-9). Forty-eight (48) percent of the evaporation occurred during the summer season, represented by the months of June, July, and August. The total recorded evaporation during this period is 30.53 inches. The month with the greatest evaporation total is June at 14.25 inches (Figure 2-10).

2.2.8 Data Capture

The annual average percent data capture is 99.5 across all months and parameters (Table 2-10). Data capture rates for each parameter across all months exceeded 99 percent for the period with the exception of pan evaporation. All of this data loss is attributed to routine maintenance, field performance audits, and data missed in recovery.

Pan evaporation data capture ranged monthly from 89.8 percent (May 2011) to 97.4 percent (November 2010). Station percent data capture (Table 2-10 last column) assumed 100 percent data capture for the months of

December, January, February, and March, corresponding to the period of winter shut down for the evaporation pan. Likewise evaporation data capture for the partial months of November and April is based on days of actual attempted data collection prior to and following the winter shutdown.

2.3 Observed Air Quality at the Mine Permit Area

New Mexico Copper Corporation currently operates an ambient particulate monitoring program consisting of two low-volume PM_{10} particulate samplers at the Copper Flat surface copper mine (Figure 2-11).

Each sampler runs once every six days for a full 24-hour period from midnight to midnight. All samplers run simultaneously. The sample run schedule is based on the national sample day schedule published by the EPA.

During quarterly sampler flow checks, flow rate is adjusted to be within 4 percent of 16.67 liters per minute (lpm) under ambient conditions. Ambient temperature and pressure taken at the time of the flow checks/adjustments are used to calculate a correction factor. The correction factor is used to calculate actual flow rates (QACT).

Actual flow rates are converted into standard flow rates (QSTD) at standard temperature (298 degrees Kelvin) and pressure (760 mm Hg). The filter weight gain is determined to be the difference between the unexposed filter weight and the exposed filter weight. Both QACT and QSTD together with net weight gain are used to determine the 24-hour particulate concentration in micrograms per cubic meter ($\mu g/m^3$).

2.3.1 Site 1 PM_{10} Results

The average of all 24-hour PM_{10} concentrations for this period is 18.5 $\mu g/m^3$ at Site 1. The maximum 24-hour PM_{10} concentration is 68 $\mu g/m^3$ recorded on September 30, 2011 (Table 2-11).

Site 1 collected 58 out of an attempted 61 samples during the period from October 1, 2010, through September 30, 2011. This correlates to 95 percent data capture.

2.3.2 Site 2 PM_{10} Results

The average of all 24-hour PM_{10} concentrations for this period is 16.4 $\mu g/m^3$ at Site 2. The maximum 24-hour PM_{10} concentration is 66 $\mu g/m^3$ recorded on September 30, 2011 (Table 2-12).

Site 2 collected 58 out of an attempted 61 samples during the period from October 1, 2010, through September 30, 2011. This correlates to 95 percent data capture (Table 2-13).

2.4 References

Bureau of Land Management (BLM), 1996, Draft environmental impact statement (DEIS), Copper Flat Project: Las Cruces, N. Mex., U.S. Department of the Interior. Prepared by ENSR, Fort Collins, Colo.

Bureau of Land Management (BLM), 1999, Preliminary final environmental impact statement: Copper Flat project: Las Cruces, N. Mex. U.S. Department of the Interior, 491 p.

Steffen Robertson and Kirsten (U.S.), Inc. (SRK), 1995, Copper Flat Mine hydrogeological studies. Copper Flat, New Mexico: Steffen Robertson and Kirsten, Inc.

Tables

Table 2-1

Copper Flat Met 1
Monthly Precipitation Totals
October 2010 through September 2011

Month	Precipitation (Inches)
October	0.37
November	0.02
December	0.16
January	0.00
February	0.02
March	0.00
April	0.00
May	0.00
June	0.02
July	0.43
August	3.12
September	0.68
Total Precipitation	***4.82***

Table 2-2

Copper Flat Met 1
Monthly Temperature Summaries
October 2010 through September 2011
10-Meter

Month	Maximum Temp (deg C)	Minimum Temp (deg C)	Mean Temp (deg C)
October	28.2	6.9	17.6
November	23.1	-4.1	9.9
December	19.6	-8.0	9.3
January	21.1	-10.0	5.6
February	20.9	-20.9	6.0
March	25.5	2.7	15.0
April	27.8	3.1	17.7
May	32.7	2.5	19.6
June	36.1	16.9	27.6
July	33.8	18.7	26.6
August	34.7	17.9	26.3
September	31.7	12.8	22.5
Annual	***36.2***	***-20.9***	***19.4***

Table 2-3

Copper Flat Met 1
Monthly Temperature Summaries
October 2010 through September 2011
2-Meter

Month	Maximum Temp (deg C)	Minimum Temp (deg C)	Mean Temp (deg C)
October	29.4	5.8	17.4
November	24.3	-5.1	9.6
December	19.8	-8.2	8.8
January	21.0	-10.9	5.0
February	22.4	-21.9	5.7
March	26.6	2.0	14.8
April	29.6	3.3	18.0
May	34.4	2.3	19.8
June	37.7	16.2	27.8
July	35.3	18.7	27.0
August	35.8	17.8	26.4
September	33.0	12.5	22.5
Annual	***37.7***	***-21.9***	***19.5***

Table 2-4

Copper Flat Met 1
Monthly Wind Speed Summaries
October 2010 through September 2011

Month	Maximum Wind Speed (m/s)	Minimum Wind Speed (m/s)	Mean Wind Speed (m/s)
October	14.0	0.8	4.2
November	15.7	1.1	5.2
December	19.0	0.7	3.9
January	12.5	0.9	3.8
February	16.3	0.7	5.5
March	17.5	0.8	5.4
April	19.2	1.1	6.7
May	16.6	0.9	6.2
June	16.2	0.9	5.8
July	13.3	0.9	4.6
August	12.9	0.9	4.5
September	11.6	0.9	4.4
Annual	***19.2***	***0.7***	***5.3***

Table 2-5

Copper Flat Met 1
Wind Summary Report
Wind Direction 10m versus Wind Speed 10m
October 2010 through September 2011

WS CLASS	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTALS
CALM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.5 TO 1.0	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0.001	0	0	0.0038
>1.0 TO 3.0	0.013	0.009	0.007	0.012	0.014	0.018	0.017	0.011	0.008	0.009	0.009	0.019	0.042	0.035	0.022	0.016	0.2602
>3.0 TO 5.0	0.019	0.013	0.011	0.01	0.009	0.015	0.029	0.035	0.013	0.017	0.02	0.016	0.05	0.02	0.019	0.031	0.3276
>5.0 TO 9.0	0.025	0.011	0.004	0.001	0.001	0.004	0.015	0.028	0.015	0.022	0.036	0.033	0.036	0.022	0.021	0.035	0.31
>9.0 TO 15.0	0.004	0.002	0	0	0	0	0.001	0.003	0.003	0.011	0.022	0.023	0.013	0.006	0.004	0.004	0.0944
>15.0 TO 20.0	0	0	0	0	0	0	0	0	0	0.001	0.001	0.001	0	0	0	0	0.0039
>20.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	***0.061***	***0.034***	***0.023***	***0.023***	***0.024***	***0.036***	***0.062***	***0.077***	***0.04***	***0.059***	***0.089***	***0.092***	***0.141***	***0.083***	***0.067***	***0.086***	

Table 2-6

Copper Flat Met 1
Monthly Relative Humidity Summaries
October 2010 through September 2011

Month	Maximum RH (%)	Minimum RH (%)	Mean RH (%)
October	88.1	8.6	37.9
November	72.9	8.1	28.3
December	93.9	7.2	37.1
January	68.5	9.8	33.5
February	82.5	3.1	31.8
March	61.3	2.4	18.8
April	54.5	2.4	16.5
May	62.2	1.2	16.5
June	54.7	1.3	12.5
July	85.7	12.0	35.7
August	90.9	8.2	40.9
September	94.0	10.7	37.7
Annual	***94.0***	***1.2***	***26.6***

Table 2-7
Copper Flat Met 1
Monthly Net Radiation Summaries
October 2010 through September 2011

Month	Maximum Net Radiation (watts/m^2)	Minimum Net Radiation (watts/m^2)	Mean Net Radiation (watts/m^2)
October	586	-153	60
November	419	-105	31
December	373	-105	20
January	432	-100	31
February	494	-106	53
March	559	-114	82
April	605	-118	110
May	628	-127	126
June	610	-195	118
July	656	-181	126
August	664	-176	111
September	610	-149	94
Annual	***664***	***-195***	***98***

Table 2-8

Copper Flat Met 1
Monthly Barometric Pressure Summaries
October 2010 through September 2011

Month	Maximum Barometric Pressure (mBar)	Minimum Barometric Pressure (mBar)	Mean Barometric Pressure (mBar)
October	857	831	845
November	855	830	844
December	852	823	843
January	853	833	844
February	854	830	842
March	853	830	843
April	853	833	842
May	855	832	843
June	853	838	847
July	858	846	851
August	857	832	842
September	850	836	842
Annual	***858***	***823***	***844***

Table 2-9

Copper Flat Met 1
Net Evaporation Summary
October 2010 through September 2011

Month	Monthly Net Evaporation (inches)	Cumulative Net Evaporation (inches)
October	3.959	3.959
November	1.152	5.111
December	***	***
January	***	***
February	***	***
March	***	***
April	9.562	14.673
May	11.146	25.819
June	14.249	40.069
July	10.339	50.407
August	5.938	56.345
September	6.181	62.526
Total		***62.526***

Note: Evaporation offline from 11/10/10 at 0900 through 04/02/2011 at 0700 for winter months.

Table 2-10

Copper Flat Met 1
Data Capture Summary
October 2010 through September 2011

Month	Wind Speed 10m	Wind Direction 10m	Sigma Theta 10m	Temp 10m	Temp 2m	Delta Temp	Relative Humidity	Net Radiation	Precip	Evaporation	Barometric Pressure	Station Pct
October	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	92.9	100.0	99.4
November	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	97.4	100.0	99.8
December	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7	0.0	99.7	99.7
January	99.7	99.7	99.7	99.7	99.7	99.7	100.0	100.0	100.0	0.0	100.0	99.9
February	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0
March	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0	100.0	100.0
April	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	91.7	100.0	99.2
May	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	89.8	100.0	99.1
June	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	92.2	100.0	99.3
July	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7	99.7	95.0	99.7	99.3
August	99.1	99.1	99.1	99.1	99.1	99.1	99.1	99.1	99.1	95.3	99.1	98.7
September	99.9	99.9	99.9	99.9	99.9	99.9	99.9	99.9	99.9	94.7	99.9	99.4
TOTALS	***99.8***	***99.8***	***99.8***	***99.8***	***99.8***	***99.8***	***99.9***	***99.9***	***99.9***	***95.7***	***99.9***	***99.5***

Note: Station percent data capture does not deduct for missing evaporation values during winter shut down. Evaporation data capture for November is based on attempted data collection from 11/1 through 11/10/10 prior to winter shutdown.

Table 2-11

Copper Flat PM_{10}
24-Hour Average PM_{10} Concentrations
October 2010 through September 2011
Site 1

Sample Run Date	PM_{10} Standard Concentration ($\mu g/m^3$)
10/5/2010	10
10/11/2010	11
10/17/2010	10
10/23/2010	(I)
10/29/2010	18
11/4/2010	17
11/11/2010	18
11/17/2010	10
11/22/2010	10
11/28/2010	31
12/4/2010	12
12/11/2010	7
12/16/2010	8
12/22/2010	9
12/28/2010	8
1/3/2011	8
1/9/2011	5
1/15/2011	6
1/21/2011	9
1/27/2011	7
2/2/2011	18
2/8/2011	13
2/14/2011	10
2/20/2011	18
2/26/2011	11
3/4/2011	12
3/10/2011	15
3/16/2011	12
3/22/2011	14
3/28/2011	13

Sample Run Date	PM_{10} Standard Concentration ($\mu g/m^3$)
4/3/2011	32
4/9/2011	59
4/15/2011	32
4/21/2011	13
4/27/2011	15
5/3/2011	16
5/9/2011	43
5/15/2011	19
5/21/2011	17
5/27/2011	17
6/2/2011	32
6/8/2011	37
6/14/2011	23
6/20/2011	35
6/26/2011	23
7/2/2011	41
7/8/2011	18
7/14/2011	16
7/20/2011	21
7/26/2011	15
8/1/2011	19
8/7/2011	17
8/13/2011	21
8/19/2011	(I)
8/25/2011	(I)
8/31/2011	16
9/6/2011	4
9/12/2011	20
9/18/2011	13
9/24/2011	19
9/30/2011	68

Table 2-12

Copper Flat PM_{10}
24-Hour Average Standard PM_{10} Concentrations
October 2010 through September 2011
Site 2

Sample Run Date	PM_{10} Standard Concentration (µg/m^3)
10/5/2010	9
10/11/2010	8
10/17/2010	9
10/23/2010	7
10/29/2010	52
11/4/2010	15
11/11/2010	3
11/17/2010	11
11/22/2010	7
11/28/2010	19
12/4/2010	12
12/11/2010	5
12/16/2010	10
12/22/2010	29
12/28/2010	(I)
1/3/2011	(I)
1/9/2011	6
1/15/2011	6
1/21/2011	10
1/27/2011	8
2/2/2011	11
2/8/2011	13
2/14/2011	11
2/20/2011	14
2/26/2011	10
3/4/2011	1
3/10/2011	15
3/16/2011	12
3/22/2011	13
3/28/2011	11

Sample Run Date	PM_{10} Standard Concentration (µg/m^3)
4/3/2011	23
4/9/2011	39
4/15/2011	44
4/21/2011	13
4/27/2011	14
5/3/2011	17
5/9/2011	42
5/15/2011	18
5/21/2011	13
5/27/2011	14
6/2/2011	36
6/8/2011	37
6/14/2011	21
6/20/2011	6
6/26/2011	23
7/2/2011	39
7/8/2011	3
7/14/2011	(I)
7/20/2011	9
7/26/2011	7
8/1/2011	9
8/7/2011	14
8/13/2011	9
8/19/2011	10
8/25/2011	13
8/31/2011	14
9/6/2011	18
9/12/2011	16
9/18/2011	12
9/24/2011	15
9/30/2011	66

Table 2-13

Copper Flat Met 1
Percent Data Capture by Quarter
October 2010 through September 2011

Quarter	Site 1	Site 2
4th Qtr 2010	93	93
1st Qtr 2011	100	93
2nd Qtr 2011	100	100
3rd Qtr 2011	88	94
Annual	***95***	***95***

Figures

Appendix 2-A

Meteorological Monitoring Quarterly Reports

Appendix 2-B

Air Quality PM_{10} Monitoring Quarterly Reports

3 Topography

The topography of the Copper Flat Mine Permit Area and the surrounding area is shown at a scale of 1:24,000 (where 1 inch equals 2,000 ft) in Figures 3-1 and 3-2. The topography shown in Figure 3-2 is from the USGS quadrangle maps, which pre-date the 1982 Quintana mine disturbance. The current topography based on a 2011 aerial survey is presented as Figure 3-3. In addition to topography, each figure shows the boundary of the Mine Permit Area and the Copper Flat Mine office/Core building, which is within ½ mile of the permit boundary.

Figure 3-1 presents the site boundary overlain on a May 2011 aerial photograph taken by Cooper Aerial of Tucson, Arizona for NMCC. Disturbances from previous mining and mineral development activities, including roads, pit, waste dumps, tailings, a diversion channel, scraped and developed plant facilities areas, and other disturbed lands, are captured in this image.

Figure 3-2 presents the mine boundary superimposed on the Skute Stone Arroyo and Hillsboro USGS 7.5 minute quadrangle maps. The topography shown on Figure 3-2 pre-dates the surface disturbance created by the Quintana Minerals mining operations in the late 1970s and early 1980s. It is shown because it is the most current USGS quadrangle map of the area.

Figure 3-3 shows the topography as it exists as of the May 2011 aerial survey completed by Cooper Aerial. Five-foot contour intervals are included to provide detailed and current information regarding the topography for the Mine Permit Area and surrounding area. To capture the detail of the 5-ft contour intervals, this figure is presented at a scale larger than 1:24,000. The scale represented on Figure 3-3 is 1-in = 1,200-ft or approximately 1:14,460.

Figure 3-4 presents the pipeline corridor that connects NMCC's production well field to the mine permit boundary. Due to the need to show the pipeline corridor, a scale larger than 1:24,000 is required as it is approximately 8 miles from the mine to production wells. The scale represented on Figure 3-4 is actually 1-in = 3,500-ft or approximately 1:42,170.

Figures

4 Vegetation Survey Results

4.1 Introduction and Background

Parametrix, Inc. was contracted by New Mexico Copper Corporation to assess vegetation conditions within the Copper Flat Mine Permit Area, as well as surrounding riparian habitats along Las Animas Creek and Percha Creek. This chapter summarizes the approach and results for characterizing or quantifying vegetation attributes throughout the study sites. The study approach implemented for this report was based on the vegetation section from the Copper Flat SAP (Parametrix, 2010a). Comments received from the state and federal agency reviewers were used to adjust and expand the methodology proposed in the SAP into the actual sampling approach that was implemented. Fieldwork in support of this document was completed by Parametrix botanists during several field sessions through the 2010 and 2011 growing seasons.

4.2 Study Areas

Several areas of interest outside of the Copper Flat Mine Permit Area (sometimes referred to as “Permit Area” in this chapter) were identified by regulatory and management agencies in the SAP comments. Specific study locations outside of the Permit Area were Las Animas Creek and its riparian zone; Percha Creek, including Percha Box and riparian habitats therein; Warm Springs Canyon; and nearby cold- and warm-water springs and seeps. Unfortunately, the botanists were not granted access permission by private landowners for all of the areas of interest outside of the Permit Area. It was not possible to access Warm Springs Canyon, many of the springs and seeps surrounding the Permit Area, and Las Animas Creek on the Ladder Ranch during vegetation field work.

The study sites were located in the western half of Sierra County, New Mexico. The sampling method, intensity, and objective varied by location. For the purposes of clarifying the specific study approach and study results in particular areas, content throughout this chapter is organized according to sampling location. Areas surveyed in support of this report include (Figure 4-1):

Copper Flat Mine Permit Area;
Pipeline Corridor;
Riparian Habitats along Las Animas Creek; and
Riparian Habitats along Percha Creek, including Percha Box.

4.2.1 Copper Flat Mine Permit Area

Under this report, the Copper Flat Mine Permit Area includes approximately 2,200 acres of Chihuahuan desert hills, much of which was previously disturbed during previous mining ventures. Mining activities and infrastructure constructed by the Copper Flat Partnership, ca. 1982, combined with previous mining-related activities, have contributed to the disturbance of approximately 690 acres within the Copper Flat Mine Permit Area (BLM, 1999); 358 acres is on public lands and 331 acres is estimated on private lands (according to disturbance acreages listed in BLM [1999]). New calculations by Parametrix (Parametrix, 2010a) designated a total disturbed area of 965 acres for the Permit Area, based on digitizing high-resolution 2009 aerial photography. The Permit Area was reclaimed in 1986, although it appears that active revegetation was inconsistent, patchy, and yielded variable results.

The history of repeated disturbance in the Permit Area has dramatically affected vegetation communities. Current vegetation community distribution in the mined areas is perhaps more strongly correlated with previous land use than with the biotic or abiotic factors that typically render the distribution of vegetation types or vegetation potential. The “baseline” vegetation condition for portions of the Permit Area include: a tailing dam, barren areas, various roads, a diversion channel, pit and pit lake, waste rock piles, prospector mining disturbance, grazing, and other disturbed areas. However, relatively intact vegetation communities are also still present within the Permit Area.

The proposed sampling and analysis approach was intended to capture the current vegetation attributes and conditions throughout the Permit Area. The study goals included

1. Delineate a current vegetation map stratified according to disturbance history and dominant vegetation type.
2. Describe specific vegetation attributes for plant communities delineated within the Permit Area through quantitative measurements of:
    - Basal vegetation cover by species and ground cover,
    - Aerial vegetation cover by species,
    - Woody plant density,
    - Annual productivity, and
    - Plant species richness and diversity.
3. Complete a plant species inventory.
4. Perform a threatened or endangered species survey.
5. Conduct a noxious weed survey.
6. Complete a wetlands survey.

4.2.2 Pipeline Corridor

New Mexico Copper Corporation is in the process of exploring the feasibility of using an existing subsurface pipeline to fulfill the mine's operational water needs. The pipeline runs from a well field approximately 8 miles off-site to the east into the Permit Area. A 100-foot-wide corridor (50 ft on either side of the underground pipe) was included in the vegetation survey. The pipeline corridor survey area was approximately 10 miles long. The corridor crosses through state, private, and Bureau of Land Management (BLM) property.

4.2.3 Las Animas Creek

Las Animas Creek, located in the Caballo Lake watershed, lies approximately 4 miles north of the Permit Area and contains variable stream flow. The creek has ephemeral, intermittent, and perennial reaches along approximately 40 total river miles. The Las Animas Creek study area fell entirely on private land. Ladder Ranch did not grant access permission for this study; as a result, the study area for Las Animas Creek includes the riparian habitats along approximately 7 river miles of the creek from the eastern Ladder Ranch boundary to Interstate Highway 25.

4.2.4 Percha Creek

Percha Creek lies approximately 2 miles south of the Permit Area, and like Las Animas Creek, it has ephemeral, intermittent, and perennial sections. Percha Creek lies in the Caballo Lake watershed and enters Caballo Lake on the south end of the reservoir. The reach surveyed for this report also includes Percha Box, a steep-walled canyon with perennial flows. The Percha Creek study area includes the riparian habitats along approximately 15 river miles from Hillsboro, New Mexico to just above Interstate Highway 25. Most of the study area was on private land with the exception of the Percha Box reach and a small section of State Trust land. Percha Box is carved through a portion of BLM property.

4.3 Methodology

Sampling objectives in each of the individual study areas were selected based on the specific habitat(s) that occur, projected type and level of disturbance or impact, and recommendations from the SAP agency comments. Information collected in each study area is intended to capture baseline conditions for the particular area. The methods implemented under this report included variable levels of quantitative and semi-quantitative studies as well as visual presence/absence surveys.

4.3.1 Copper Flat Mine Permit Area

Information collected in the Copper Flat Mine Permit Area was intended to document baseline vegetation characteristics before mining operations continue. Some of the vegetation assessment transects lie outside of the disturbance footprint in current mine engineering drawings. Parametrix intended for these locations to be suitable for long-term monitoring. These data may be useful in the future for gauging reclamation success or monitoring climatic, natural, or other (non-mining) disturbance-driven changes to vegetation in the Permit Area.

In 1996, SRK conducted a vegetation survey in the Permit Area (SRK, 1997). Their study was implemented in support of Alta Gold Company’s proposal to re-open the Copper Flat Project. The 1996 survey employed a modified Parker Three-Step method to characterize vegetation composition, density, and biomass production of native perennial plants. The Parker Three-Step method uses a cluster of three transects in a stratum to characterize the desired vegetation attributes. Unfortunately, the original datasheets or data summaries by cluster are no longer available. A recent effort to relocate metal stakes marking the 1996 transects was unsuccessful. Consequently, the previous SRK data cannot be incorporated into the current vegetation assessment for trend analysis or other purposes.

During late-summer 2010 and June 2011, Parametrix botanists completed a quantitative vegetation survey of the Permit Area in support of the current permit application. The survey period was timed to accurately capture annual biomass production and cover. The growing season for warm season (C4 photosynthetic pathway) grass species is typically April through August in New Mexico. Because biomass production rates typically increase with precipitation, quantitative data collection was performed during the late summer following monsoons to accurately capture annual production. This time period is also representative of peak vegetation cover during most years and is considered a favorable period to identify many plant species. Plant cover (especially by annuals) can be greatly reduced after the first frost. A total of 96 stratified random transects were measured in the Baseline Study Area.

The Permit Area lies within the transition zone between Chihuahuan Desert Scrub and the Desert Grassland Ecotone according to Dick-Peddie (1999). Though the entire permit boundary technically lies within the Chihuahuan Desert Scrub type, the delineation line between these two types is only about 200 meters (m) west of the permit boundary. Two Natural Resources Conservation Service (NRCS) Major Land Resources Areas converge within the Permit Area. Much of the western half is considered Mogollon Transitions (Interior Chaparral – Woodlands/Grassland subclass), while the eastern half is predominantly characterized as Southern Desertic Basins, Plains, and Mountains (Chihuahuan Desert Shrubs subclass) (NRCS, 2007).

Prior to fieldwork, the Permit Area was stratified according to existing disturbance, proposed disturbance, and NRCS Ecological Site Description (ESD) (NRCS, 2010). This stratification served as an initial vegetation map and also facilitated a stratified random-sampling design for field data collection. Two NRCS ESDs were delineated by the NRCS in the Permit Area—Gravelly (R042XB010NM) and Hills (R038XB102NM). ESD delineations formed the basis for stratifying currently undisturbed portions of the Permit Area and also coincided with distinctly different vegetation types. Following quantitative data collection and analysis, the Parametrix botanists reclassified the Gravelly portions of the Permit Area as Chihuahuan Desert Shrubland. Areas that the NRCS had defined as the

Hills ESD were reclassified as Chihuahuan Desert Grassland. As described in the results section of this chapter, these two general vegetation types had distinctly different lifeform cover and species composition.

As already mentioned, previous mining activities have significantly affected vegetation in portions of Copper Flat. Statistical analyses of the data collected during a 2010 preliminary assessment by Parametrix found significant differences in shrub density, grass cover, and species diversity among the tailing dam, waste rock piles, and control areas. In consideration, the disturbed areas were stratified according to whether the area is a waste rock pile, pit, or tailing dam. Some areas (previous mining pits) were nearly void of vegetation altogether but reflect the pre-mining vegetation condition in these areas under the current permit application. Consequently, this stratum was included in the sampling.

The proposed mine permit boundary occupies approximately 2,200 acres (Table 4-1). Figure 4-2 shows the location of each transect and the distribution of different strata. A sample size of 93 transects was recommended within the permit boundary in the SAP. Two additional vegetation measurement transects were established in the arroyo bottom and another transect was recorded in the diversion channel (Table 4-1). These three transects were installed in response to SAP agency comments. The three additional transects were measured in June 2011, yielding a total of 96 transects. Table 4-2 includes the Universal Transverse Mercator (UTM) coordinate locations for each of the 96 transects.

Before fieldwork, transect locations were randomly selected using the random point generation function within Hawth's Analysis Tools ArcGIS plug-in. During this process, the required number of random transects was placed in each stratum. A 40-m buffer was enforced at transition lines between strata and also between individual transects to reduce cross sampling. The resulting geographic coordinates were transferred to a GPS receiver for field navigation to the target locations. After arriving at the sample point, personnel captured a digital photograph in the transect location, and then stretched a 50-m transect tape to record quantitative information specific to characterizing cover, production, density, and diversity at each individual stratum.

Unknown plant species were collected from the field and a species determination was made, if possible, using regional floras. Some unknown species were also verified at the University of New Mexico herbarium. In cases where a species could not be determined because critical floral structures or fruit were not obtained, the individual was determined to at least the genus level. If no regional species of concern shared the genus, no further examination was completed. Each field datasheet was checked for data quality and completeness before moving onto the next transect location. After fieldwork was completed, data were entered into MS Excel. A thorough quality control review was completed to check for omissions, outliers, and inaccuracies in electronic data tables prior to data summary. Corrections were completed by reviewing the original datasheets, meeting with field personnel, or reviewing collected plant samples.

4.3.1.1 Cover

At the beginning point of each transect, a 50-m tape was stretched along the ground in a random direction determined by spinning the compass dial without looking. Cover was measured with a laser device at stations along the transect using the point-intercept method. The laser device consisted of two green-light laser pointers fixed to a piece of angled aluminum beam and mounted on a camera tripod. Each laser produced a point of light 1 to 2 millimeters (mm) in diameter. Intercepts were recorded to the right and left of the tape 1 m apart along the entire 50-m tape, resulting in a total of 100 point measurements along each transect.

Both aerial vegetation cover and ground cover were recorded at each sample point. Cover was recorded by species if a plant was intercepted; in situations where multiple species were intersected by the laser, both species were recorded. A single species was not recorded more than once at the same point. Ground cover was also determined at each sample point according to whether basal vegetation, litter, bare soil, downed wood, or various rock categories (i.e., cobble, gravel, rock, bedrock, etc., differentiated by size) were intersected at the ground surface.

For this report, absolute plant species covers recorded by the laser point intercept method were converted to relative covers by lifeform (grass, forb, shrub, annual), by perennials, and as all live vegetation (perennials and annuals). In this manner, the relative perennial cover contributions were compared. Cover summaries in this study were calculated as "first hit" analysis.

4.3.1.2 Annual Biomass Production

Production was assessed by clipping all herbaceous vegetation within 1-m^2 quadrats placed at 25-m intervals along the transect. Vegetation from the current growing season was clipped and stored in paper bags labeled by species and transect. Care was taken to remove and discard vegetation from the previous growing season (which is usually gray and sometimes partially blackened). When a large shrub covered more than 75 percent of the quadrat area, these shrubs were clipped within a 0.25-m^2 quadrat nested inside the 1-m^2 quadrat.

Biomass collections were then air-dried at room temperature for 6 to 10 weeks. Samples were weighed regularly during the drying process to monitor when weight loss stopped (i.e., the samples were air dry). Following drying, sample bags were weighed on an Ohaus Scout II electronic balance to the nearest 0.1 gram.

4.3.1.3 Woody Plant Density

Woody plant density was determined on belt transects 2 m wide by 50 m long (100 m^2) nested along the sample transect with 1 m on each side of the tape. Field personnel tallied all woody plants rooted within the belt by species. Individual plants were tallied at ground level. Multi-stemmed shrubs were considered one individual plant if they appeared to emerge from a single root crown. Woody plants were also tallied according to whether they were considered "large" or "small." Shrubs were considered "large" if they were ≥1 m in height or diameter (breadth); or "small" if they were <1 m in height. Trees were considered "small" if their height was <2 m or "large" if they exceeded this height.

4.3.1.4 Diversity

Species diversity in the Permit Area was evaluated using two different approaches. A plant species inventory was completed over the course of three field visits. A more quantitative measure of diversity was also employed to assess species richness, species evenness, and community complexity from the transect data.

There are a variety of quantitative statistical measures that assess plant species diversity. Measures can be used to describe species richness, species evenness, and/or the structural complexity of a community. Species richness is simply the total number of species that occur within a transect, stratum, or the entire site. Species evenness expresses how evenly or unevenly species are distributed within the plant community. Evenness can be expressed as the proportion or percentage that each species represents of the whole (sum of all species).

The Shannon-Weiner (S-W) Index is one commonly used measure of species diversity (Krebs, 1989; Shannon, 1948). Both species richness and species evenness are factors in this index. The greater the number of species, the higher the index value becomes. In addition, the more evenly matched species are with each other with respect to quantities (whether the quantity is cover, production, or other parameter), the higher the index value. In other words, if certain species are too dominant, the index value decreases. If the species have relatively similar dominances, the index value will go up. Statistically, the index monitors the probability of whether the next sample will contain the same species as the previous sample or whether the next sample will be a new species (Krebs, 1989; Shannon, 1948). The S-W equation is given below (Krebs, 1989; Shannon, 1948).

$$H' = -\sum_{i=1}^{S}(p_i \ln p_i)$$

Where:

H	is the diversity index
Σ	means to sum the values for each species
i	refers to the i^{th} species
s	refers to the total number of species
p_i	is the proportion of individuals of the total sample (in this case, cover) belonging to the i^{th} species
ln	is the same as the natural log

Cover was the only parameter used in the S-W Index calculations published in this report.

4.3.1.5 Sample Adequacy

Sample adequacy is a statistical calculation or determination, estimating the minimum number of transects (i.e., samples) needed to meet a defined confidence level (e.g., 90 percent). Another approach towards assessing sample adequacy is stabilization of the mean (Clark, 2001). Some vegetation parameters may not be normally distributed, particularly under conditions where quadrat or sample area size does not appropriately match plant dispersion in the field (e.g., sparse vs. clumped plant distributions). Evaluating numerous data sets in New Mexico, Clark (2001) has shown that mean cover frequently stabilizes after 15 to 20 samples, while other parameters appear to stabilize between 30 and 40 transects. The stabilization of the mean calculation was employed for calculating sample adequacy in this report. The calculation uses the overall (or total) sample size mean and then sets limits of ± 10 percent of the mean (similar to a 90 percent confidence interval) as the statistical target to achieve. A running mean of successive samples (or transects) was then calculated from the results.

Information collected during an April 2010 preliminary vegetation pilot study (Parametrix, 2010b) defined the minimum sampling intensity for each stratum. During the preliminary assessment, eighteen 25-m-long vegetation transects (six each in the control, tailing dam, and waste rock piles) were completed. These data were then used to statistically predict the adequate number of samples to meet statistical sample adequacy for perennial plant cover. The total number of transects per stratum was determined by reviewing these results and also weighting the sample size according to total acreage of the stratum. According to the preliminary assessment (Parametrix, 2010b), the minimum transect number per stratum needed to be increased to a minimum of six transects and the transect length extended to 50 m. Both of these recommendations were implemented during sampling. A minimum of 10 transects were installed in each stratum besides the arroyo.

Our sampling objective was to meet statistical sampling adequacy (± 10 percent of the mean) for perennial plant species cover in each stratum besides the arroyo. Sample adequacy was calculated and reported for multiple variables. Results of sample adequacy analyses were included in detailed vegetation summary tables produced for the permit area results section.

4.3.1.6 Plant Species Inventory

Plant species inventories were completed in the Permit Area during three field efforts: April 2010, late-summer 2010, and May/June 2011. The intent behind staggering these surveys was to capture a relatively complete plant species list in the Baseline Study Area, including fall or spring annuals and species that can be difficult to definitively identify outside of their flowering and/or fruiting period. Inventories paid particular attention to the presence or absence of agency-, state-, or federally regulated rare, threatened, or endangered species. Field botanists researched documented nearby locations and habitat requirements of species of concern before completing the inventory. If a species of concern was encountered, a GPS file would have been recorded. Species closely resembling a species of concern were photographed and/or collected following the discretion of the field botanist and appropriate regulations. When state- or federally listed noxious weeds were encountered, the specific location and extent of infestation was also to be documented with a GPS receiver.

4.3.1.7 Detailed Riparian Vegetation and Wetlands Mapping

In accordance with the New Mexico Department of Game and Fish's suggestion (in their SAP comments), a detailed riparian map was delineated for Greyback Arroyo through the Permit Area. The map also included vegetation along the diversion channel. Vegetation map units were characterized for areas dominated by typical riparian species (such as cottonwood [*Populus* sp.] and willow) (*Salix* sp.), as well as communities characteristic of arroyo riparian habitats in this portion of the state, such as habitats dominated by seepwillow (*Baccharis* sp.) or burro bush (*Hymenoclea monogyra*). If terraces were dominated by similar vegetation species in the surrounding uplands, then the particular area was not mapped. The intent was to characterize communities most directly affected by arroyo functional processes.

Vegetation types were assigned according to the Hink and Ohmart (H&O) mapping convention. The H&O system was developed in support of the Middle Rio Grande Biological Survey (Hink and Ohmart, 1984) and is now widely used to characterize riparian vegetation types in New Mexico. Their vegetation classification system defined a community type as a "distinctive, local assemblage of species, the designation of which is based on the dominant or co-dominant species in canopy and shrub vegetation layers" (Hink and Ohmart, 1984). In this system, structure types corresponded to sub-association level in the Brown-Lowe-Pase system (Brown et al., 1979 as cited in Hink and Ohmart, 1984). The H&O system has also been useful for characterizing habitat potential for various songbirds and other wildlife species.

Two canopy layers (overstory and understory) are distinguished in the H&O system. The overstory (tree) canopy layer is defined as trees with foliage cover concentrated above 20 ft. The understory (shrub and young tree) canopy layer consists of perennial, woody vegetation with foliage cover concentrated below 15 ft. Six structure types are recognized (1–6) according to vertical distribution of foliage (i.e., foliage density along a vertical gradient) within the two canopy layers (Table 4-3).

Species composition in the woody structure types is characterized using predetermined species acronyms. Many of the species encountered through Parametrix's detailed mapping of the study areas did not have pre-assigned species acronyms; therefore, acronyms were assigned for these species (Table 4-4). By H&O convention, a slash (/) distinguishes species composition of the overstory from the understory, with dominant overstory species listed on the left side of the slash and dominant understory species listed to the right. When more than one species dominates a single canopy layer (i.e., "co-dominant" species), a hyphen (-) is placed between the species acronyms. Each species classified as a dominant or co-dominant in the H&O type composes at least 25 percent of the relative foliage cover in that canopy layer; thus, up to four species may be considered co-dominants in each canopy layer. Species acronyms are listed in descending order of dominance for each canopy layer.

During field data collection, a Parametrix botanist marked transitions between vegetation communities with a GPS unit and assigned the appropriate H&O type. Percent total cover of overstory and understory canopy layers and percent relative species cover for each layer were recorded using ocular estimates. Most of the individual vegetation units were also photographed. GPS data were transferred to a laptop computer and overlaid on 2009 National Agricultural Improvement Program (NAIP) aerial photography. Unique vegetation polygons were digitized at 1:5,000 map scale in ESRI ArcGIS 10. Additional field notes containing other tree or shrub species observed in the polygon, but not considered a co-co-dominant under the H&O convention, were also attributed in the shapefile's database table.

This mapping effort was also intended to capture wetlands and jurisdictional waters of the United States. Waters of the United States are defined by 33 CFR Part 328.3 (b) and are protected by Section 404 of the Clean Water Act (CWA) (33 USC 1344), which is administered and enforced by the U.S. Army Corps of Engineers (USACE). The Baseline Study Area was assessed for the presence of waters of the United States using U.S. Geological Survey (USGS) topography maps and county soil survey maps, followed by field verification during riparian vegetation mapping.

4.3.2 Pipeline Corridor

In accordance with state and federal natural resources protection laws, a field survey of the pipeline corridor was conducted to evaluate potential impacts on threatened or endangered species, wetlands/waterways, noxious weeds, and other sensitive plant species. The proposed corridor was surveyed by Parametrix field botanists in April 2010, and May, June, and August 2011. A visual survey of the adjacent environment was also conducted to evaluate the potential for and presence of habitat suitable for state- and federally listed, and sensitive species. An assessment of waters of the United States that could be affected by the proposed project was performed using USGS quadrangles, National Wetlands Inventory (NWI) maps, aerial photography, and county soil survey maps in-house, and then verified during the field visits.

Federal and state lists for protected species in Sierra County were examined for this report. In addition, lists were obtained from the New Mexico Rare Plant Technical Council (NMRPTC, 2011) and the BLM. The habitat requirements of listed species were compared to the habitat at the proposed project location to identify potentially affected species or “target species.” Species considered unlikely to occur due to their known distribution in a county, or for which suitable habitat does not exist within the proposed Baseline Study Area, were removed from further consideration. It was determined that direct and short-term impacts on vegetation resulting from proposed project-related ground disturbance activities would be minimal, so a more quantitative study was not considered necessary.

4.3.3 Arizona Sycamores at Las Animas Creek

The New Mexico Department of Game and Fish requested (in their SAP comments) that NMCC characterize riparian communities along Las Animas Creek in this report. Arizona sycamore (*Platanus wrightii*) stands extend from approximately 3 miles west of the confluence of Las Animas Creek and Caballo Reservoir through the Ladder Ranch property. Las Animas Creek contains the eastern-most naturally occurring Arizona sycamore populations in New Mexico (Plant Maps, 2011). Arizona sycamore is a relatively unique resource in this portion of New Mexico; therefore, this species was a particular focus in the Las Animas Creek study area.

The Arizona sycamore is a deciduous, pioneer, obligate riparian tree of the Southwest United States and northern Mexico. Previous dendrological studies have shown that Arizona sycamores can have a lifespan of more than 200 years (Stromberg, 2001a). Arizona sycamore provides habitat for many different bird species (Stromberg, 2001a). Hydrologic and geomorphic conditions that favor recruitment and survival of other obligate riparian trees such as cottonwoods and willows are better understood than biohydrology in Arizona sycamore. To bridge this gap, Dr. Juliet Stromberg, associate professor at Arizona State University, has published several research papers over the last 10 years to document the influence of environmental conditions such as stream flow regimes, temperature, and depth to groundwater on Arizona sycamore.

Arizona sycamore reproduces both sexually (shoots referred to as gamets) and vegetatively (ramets). The sexual reproduction strategy and requirements in Arizona sycamore are similar to other riparian obligates in this region such as cottonwoods and willows (Stromberg, 2001a; Stromberg, 2001b; Stromberg, 2002). Arizona sycamore trees produce an abundance of small seeds on achenes fastened in clusters of round balls (heads) that are green in flower and become brown in fruit (Carter, 1997). Heads remain on the tree throughout the winter (Carter, 1997), gradually detach in the winter/spring, and then release seeds coated with tufted hairs (Stromberg, 2002). Seed viability lasts approximately 6 months (Zimmerman, 1969; Bock and Bock, 1989). With favorable conditions, seeds germinate in the spring.

Studies have indicated that germination events are episodic and sometimes sporadic, with frequent germination and establishment coinciding with winter and early spring flooding and wet springs (Stromberg, 2002). Winter flooding creates desirable geomorphic conditions and fresh alluvium while spring moisture (flooding or precipitation) moistens seeds and provides adequate water for seedling sustenance (Stromberg, 2002). Seedling growth is also more rapid in sites with perennial stream flow and shallower groundwater than at sites with ephemeral stream flow and groundwater deeper below the surface (Stromberg, 2001a). Summer flooding via monsoonal events may be suitable for germination, but this was not observed in Stromberg (2002).

Typically, ramet production is more abundant and frequent than gamet production (Stromberg, 2002). Ramet production periods do not appear to necessarily coincide with favorable or unfavorable years of seedling establishment (Stromberg, 2002). Earlier research (Glinski, 1977) found no correlation between sprout densities and percent of canopy dieback, soil texture, or distance from channel (as cited in Stromberg, 2002). However, Stromberg (2002) suggests that vegetative reproduction may be triggered by disturbance, changes in resource availability, and/or disease.

Growth rates of Arizona sycamore are influenced by growing season flows (Stromberg, 2001b). Winter flooding recharges groundwater while summer flooding recharges nutrients and replenishes soil water. Summer flood frequency significantly increases growth rates on both perennial and intermittent reaches (Stromberg, 2001b). Growth is more frequently limited by moisture availability in non-perennial reaches, and high temperature and drought result in very low growth rate (Stromberg, 2001b). Growth in older trees is more strongly correlated with total annual flow than summer flow (Stromberg, 2001b). However, growth rates in younger trees show a high correlation with both summer and annual flow (Stromberg, 2001b). Older trees are also more tolerant of deeper groundwater than younger cohorts (Stromberg, 2001b; Stromberg, 2001a).

Arizona sycamore is most productive when groundwater averages less than 2 m below the tree during the growing season, and less than 0.5 m below the stream thalweg, and where groundwater fluctuates less than 1 m annually (Stromberg, 2001a). Forests measured under these conditions also have the highest compositional diversity (Stromberg, 2001a). When groundwater depth ranges between 3 and 5 m (low, seasonally fluctuating stem water potentials), low growth rates and moisture stress are observed (Stromberg, 2001a).

Because the perennial reaches of Las Animas Creek were excluded from our survey, the study area occurs where conditions are more likely to show indications of moisture stress, with reduced probability of natural regeneration for Arizona sycamore. The general intent of this study was to develop a basic understanding of the current distribution and extent of this species in general, as well as the distribution and extent of important biotic integrity indicators such as stress, disease, and natural recruitment.

The specific objectives of the current Arizona sycamore study at Las Animas Creek included:

- Map the current distribution and extent of Arizona sycamores throughout the study area;
- Map the distribution of other (non-sycamore) riparian vegetation types;
- Understand with which riparian tree and shrub species the Arizona sycamore most frequently coexists;

- Complete a preliminary assessment of the size classes and health conditions of Arizona sycamore trees;
- Map the distribution and extent of current regeneration of sycamore trees;
- Identify favorable and limiting reaches for natural sycamore sustenance and recruitment;
- Map the distribution and extent of trees showing increased signs of canopy dieback or stem dieoff; and
- Establish 25 reference trees for long-term monitoring that capture the current variation of age/size classes and health conditions currently present along the creek.

4.3.3.1 Detailed Riparian Vegetation Mapping

Riparian vegetation mapping at the Las Animas Creek study site was completed during an initial field assessment in September 2011. The H&O mapping convention was used to characterize vegetation communities along the creek for portions in which access was permitted. A botanist visited each unique polygon and delineated the vegetation type following similar methods as described under Section 4.3.1.7 (Detailed Riparian Vegetation and Wetlands Mapping) above. Contrary to the other riparian study areas in this report, mapping was only completed for zones meeting typical riparian habitat criteria (areas dominated by riparian indicator tree and shrub species). Arroyo vegetation mapping (areas dominated by Baccharis, burro brush, or mesquite) was not completed along Las Animas Creek. It was also not possible to enter some of the fenced private properties during the field survey; thus, a vegetation type was not determined for inaccessible portions. Isolated properties also contained small patches of cultivated trees, even sometimes planted Arizona sycamores, and the maps in this report do not accurately characterize some of these cultivated tree clusters.

4.3.3.2 Arizona Sycamore Study

In addition to completing the general H&O survey protocol and delineating a riparian vegetation map, the team of botanists focused on characterizing the general distribution and extent of Arizona sycamore age/size classes and condition classes. Percent canopy dieback for Arizona sycamore trees and observations of sexual recruitment were recorded at each polygon.

A second field trip was completed in November 2011 to document Arizona sycamore recruitment zones and characterize current constraints for natural Arizona sycamore sustenance and recruitment along sub-reaches through the study area. An ecologist walked the entire creek bottom through the study area during this second visit and searched for younger individuals in the channel bottom, on the channel banks, and in the adjacent floodplain if conditions appeared to be favorable for regeneration. When stands of younger trees (seedlings, saplings, or poles) were encountered, the botanist recorded a GPS point and a digital photograph. Seedlings were defined as trees less than approximately 2 inch diameter at breast height (dbh). Saplings (approximately two to four dbh), or clusters of saplings; and poles (approximately four to ten dbh), or clusters of poles, were distinguished by dbh and then documented. After returning from the field, GPS locations of seedlings, saplings, and poles were plotted in ArcGIS 10 and used to digitize zones where recruitment was still favorable. If younger stems arose from the base of a parent tree or emerged in rings around a larger tree, they were considered ramets. Otherwise, younger trees were considered gamets. Each ramet observed was not documented during the survey since they are not necessarily indicators of sycamore population viability and they're relatively common throughout the study area.

A total of 25 Arizona sycamore trees were also documented as reference trees for potential long-term monitoring. This activity was completed during the September 2011 field visit. Each reference tree was photographed and marked with a tree tag. The dbh, height, and percent canopy dieback was measured for each tree. Percent canopy dieback was determined using an ocular estimate of cover. Tree height was estimated according to the tangent method, with a measuring tape and clinometer. The dbh was recorded with a standard dbh tape. If multiple stems arose from the tree, a dbh was recorded for each stem individually. Initially, the botanists had also intended to use boring instruments to age-reference trees; however, some private landowners objected to penetrating trees on their property. As a result, no increment cores were collected.

4.3.4 Percha Creek

Vegetation mapping along Percha Creek characterized the extent and distribution of riparian and wetland communities through the study area, including Percha Box. The botanists also included arroyo riparian habitats to provide a complete, current data set to detect potential long-term change in the future. For consistency, the H&O mapping convention was used to characterize vegetation types along Percha Creek. A botanist visited each unique polygon and characterized the vegetation type following the same methods as described under Section 4.3.1.7 (Detailed Riparian Vegetation and Wetlands Mapping) above. A GPS point was also collected in the field to document reaches where stream flow was encountered during fieldwork. Field work was completed during October 2011.

4.4 Baseline Data Results

4.4.1 Copper Flat Mine Permit Area

Several levels of data collection occurred during the 2010 and 2011 field seasons in the Permit Area. Presence/absence surveys were conducted for noxious weeds, plant species of concern, and wetlands. Semi-quantitative cover estimates were used to delineate and map riparian and arroyo riparian vegetation communities through Greyback Arroyo, while quantitative methods were employed to measure cover, shrub density, species richness, and annual biomass production.

Quantitative data summaries for cover, species richness, and production were not adjusted for annual precipitation in this report, as is common in range science. It should be noted, however, that the 2010 growing season was wetter than average, which may have inflated the cover, production, and diversity (of annuals) results published in this report. All but three (the arroyo transects) of the vegetation transects were measured during August and September 2010. Based on precipitation records obtained from the Western Regional Climate Center (http://www.wrcc.dri.edu/index.html), precipitation from January through August 2010 was nearly 60 percent above the mean (Figure 4-3). The April through August growing season, which represents the typical growing season for warm season grasses, was 47 percent above the mean. Precipitation during November and December 2009 was also above average.

Most of the quantitative vegetation data were collected during a single season; therefore, the results cannot be considered representative of typical conditions at the site. However, previous research has shown that aboveground net primary production (ANPP) is highly correlated with annual precipitation (Webb et al., 1978). This is particularly the case across North American grasslands where variation in precipitation explains more than 90 percent of variation in ANPP (Sala et al., 1982). Hadley and Szarek (1981) measured strong year-to-year variation in ANPP in response to rainfall, specifically in the northern Chihuahuan Desert grasslands.

Muldavin et al. (2008) showed a similar positive correlation between annual precipitation and ANPP in shrublands and grasslands of the northern Chihuahuan Desert. Much of the yearly variation in ANPP in C4 grassland was attributed to precipitation (Muldavin et al., 2008). Variations in ANPP in the grassland were nearly 500 lbs/acre annually. The three most productive years also coincided with an early onset (July) monsoon, analogous to weather records for Hillsboro in 2010.

Annual precipitation can also influence plant cover in the Chihuahuan Desert ecosystem. Ernest et al. (2000) indicated that inter-annual differences in plant cover were most strongly correlated with precipitation during the same growing season. Plant cover at long-term monitoring plots varied by 30 percent over the 9-year monitoring period in response to annual rainfall variations of nearly 8 inches over the same period (Ernest et al., 2000).

4.4.1.1 Cover

(Please note that cover is represented as "first hit" analysis. Since "first hit" analysis was used in report summaries, the combined cover between vegetation canopy and ground cover sums to 100 percent. However, ground in itself does not add to 100 percent in "first hit" analysis. Aerial cover and canopy cover are used interchangeably throughout this section. Also, "cover" refers to mean aerial vegetation cover unless "ground cover" is specified. Stated cover values are means for species or lifeforms across transects within a stratum unless otherwise specified).

Tables in Appendix 4-A include detailed cover summaries for individual transects by stratum. Total aerial vegetation cover (64 percent) and perennial vegetation cover (55 percent) was higher in the Chihuahuan Desert Grassland (CDG) than any other stratum (Table 4-5). CDG also had the highest perennial grass aerial cover (38 percent) and the greatest canopy cover by annual species (9 percent). The pit stratum contained the lowest aerial vegetation cover values. Total vegetation canopy cover was 4 percent in the pit stratum. No annual plant species were encountered along cover transects in the pit site.

The Chihuahuan Desert Shrubland (CDS) stratum had the second highest total vegetation cover (42 percent) and aerial perennial plant cover (37 percent). The CDS had the highest shrub cover (20 percent) and perennial forb cover (8 percent) measured across strata in the permit area. The disturbed area/waste rock pile stratum, tailing dam, and the arroyo stratum had total vegetation cover values of 39, 34, and 25 percent, respectively. However, mean perennial plant cover was slightly higher on the tailing dam stratum (34 percent) than the disturbed area/waste rock pile (31 percent). Detailed summaries for measured cover are discussed by stratum in the following sub-sections.

4.4.1.1.1 Chihuahuan Desert Grassland

The CDG stratum included Animas Peak, the primary natural landform in the permit area. Dense patches of Wheeler sotol (*Dasylirion wheeleri*) grew on the slopes of Animas Peak; however, on this landform and throughout the CDG, the stratum was dominated by warm season grasses. Typical shrubs characteristic of the northern Chihuahuan Desert were also common. This stratum occupied 933 acres of the Permit Area. Creosote bush (*Larrea tridentata*), a species that is sometimes considered an indicator for ecosystem degradation in this system, was encountered infrequently. Small oak or netleaf hackberry (*Celtis laevigata*) woodlands were present in isolated drainages on the northern and western portions of the Permit Area. One-seed juniper (*Juniperus monosperma*) was most common on hill slopes with a north-facing aspect on the western half of the site.

Representative photographs of the CDG stratum are included as Figure 4-4. Perennial grasses composed 68.1 percent of the relative perennial plant cover as well as 58.7 percent of the relative total plant cover in the CDG. Two grass species, black grama (*Bouteloua eriopoda*) and side oats grama (*Bouteloua curtipendula*) were relatively abundant. Side oats grama aerial cover was 13.1 percent while mean aerial black grama cover was 11.2 percent. Tobosa grass (*Pleuraphis mutica*) had the third highest mean aerial cover (3.90 percent) for graminoid species. Other perennial grass species with greater than 1 percent mean aerial cover included Harvard's three-awn grass (*Aristida harvardii*), cane bluestem (*Bothriochloa barbinodis*), blue grama (*Bouteloua gracilis*), hairy grama (*Bouteloua hirsuta*), and fluff grass (*Dasyochloa pulchella*).

Perennial plant cover ranged from 36 to 74 percent in the CDG. Perennial forb cover composed 7.4 percent of the relative perennial plant cover and 6.4 percent of the relative live vegetation cover. Total perennial forb cover was 4.1 percent. Spreading buckwheat (*Eriogonum effusum*) had 2 percent cover or 48.7 percent of the relative cover for perennial forbs. Other perennial forb species occurred with lower cover on average. Total shrub cover was 13.6 percent in the CDG stratum. Shrubs composed 24.5 percent of the relative perennial vegetation cover and 21.1 percent of the relative total plant cover. Four shrub species had more than 1 percent cover. They included broom snakeweed (*Gutierrezia sarothrae*), cat-claw mimosa (*Mimosa aculeaticarpa*), honey mesquite (*Prosopis glandulosa*), and spiny dogweed (*Thymophylla acerosa*). Threadstem chinchweed (*Pectis filipes*) composed 73 percent of the relative cover from annual species. The cover of annual species was 8.9 percent. Rock, litter, and cobble were evenly distributed across the ground surface when plant species were not intercepted. Gravel and bedrock were present in cover results but with very low values (<3 percent). Bare soil cover in the CDG was fairly low (7.1 percent).

4.4.1.1.2 Chihuahuan Desert Shrubland

A 261-acre section lying in the southeast corner of the Permit Area was classified as the CDS stratum. The CDS type was composed primarily of shrub species indicative of the Chihuahuan Desert. Representative photographs of the CDS type are included as Figure 4-5 in this report. Grasses and perennial forbs were both fairly well represented. Terrain in this type was generally more even than in the CDG. Previous disturbance was relatively limited with the exception of grazing and isolated pockets of prospector mining. Based on results of quantitative data measured in support of this report, shrubs compose 53.0 percent of the relative perennial plant cover and 46.3 percent of the relative live plant cover.

Tables in Appendix 4-A include a detailed cover summary from data collected at each transect in the CDS. Total shrub cover was 19.5 percent. Honey mesquite had more cover than any other individual species recorded (6.4 percent). Tarbush (*Flourensia cernua*) with 5.7 percent cover and broom snakeweed (2.89 percent), both shrubs, were the next most prominent species. The only other shrub species with more than 1 percent cover was creosote bush. Total grass cover was 9.5 percent. Grass species composition was relatively even. Black grama grass (1.16 percent), side oats grama (1.8 percent), fluff grass (1.8 percent), bush muhly grass (*Muhlenbergia porteri*, 1.3 percent cover), and tobosa grass (*Pleuraphis mutica,* 1.4 percent cover) were the most abundant grass species.

Total perennial forb cover was 7.8 percent. Rattlesnake weed (*Chamaesyce albomarginata*) was the only perennial forb with cover (2.6 percent) in excess of 1 percent. This species composed 33.6 percent of the relative perennial forb cover.

Annual plant cover was 5.3 percent. Six-weeks grama (*Bouteloua barbata*), an annual grass, and woolly honeysweet (*Tidestromia lanuginosa*), an annual forb, both had cover values >1 percent. Woolly honeysweet and six-weeks grama cover were 1.1 and 1.7 percent, respectively.

As mentioned earlier, cover data are represented as “first hit” analysis. As a result, ground cover values by themselves do not add up to 100 percent, as is true if ground cover is characterized as a separate cover layer. Cobble ground cover was 22.9 percent in the CDS, which greatly exceeded other ground cover categories. Gravel (5.7 percent) and litter (4.4 percent) were the next most common ground cover classes. Bedrock (2.4 percent) and rock (2.7 percent) were also encountered in the CDS stratum. Bare soil cover in the CDS was 20.8 percent.

4.4.1.1.3 Disturbed Areas/Waste Rock Piles

Based on the botanists’ observations, the disturbed area/waste rock pile stratum was the most variable and difficult to characterize due to previous mining activities and associated reclamation efforts. Scraped areas, mining waste dumps, waste rock piles, and/or placer mining overburden are scattered throughout this 866-acre stratum. Vegetation potential changes drastically over very short distances in the disturbed areas/waste rock piles. Soil substrate, terrain, and plant distribution were heterogeneous. According to vegetation cover data recorded at the waste rock pile stratum, total perennial plant cover was 31.2 percent and grasses were the most abundant lifeform (18.7 percent cover). Graminoids composed 59.8 percent of the relative perennial cover and perennial grasses composed 49.5 percent of the relative live vegetation cover. Side oats grama was the most dominant grass species with 5.6 percent cover. Cane bluestem (3.7 percent), black grama (1.68 percent), and fluff grass (2.2 percent) were also prominent. Representative photographs of the waste rock pile stratum are displayed in Figure 4-6.

Total shrub cover was 8.8 percent in the disturbed area/waste rock pile stratum. Total perennial plant cover was composed of 28.3 percent shrub cover. Shrubs also composed 22.9 percent of the total vegetation cover. Honey mesquite, broom snakeweed, and feather dalea (*Dalea formosa*) each had greater than 1 percent cover. Honey mesquite, with 2.8 percent cover, was the most abundant shrub.

Total cover for perennial forbs was 3.7 percent. Spreading buckwheat was the most dominant perennial forb (1.20 percent cover).

Annual species cover was 7.3 percent. Six-weeks grama, threadstem chinchweed, and tansy aster (*Machaeranthera tanacetifolia*) each had a mean cover greater than 1 percent. Tansy aster was the most dominant annual. Cobble ground cover was 23.6 percent. Bare soil cover in the disturbed area/waste rock pile stratum was 21.8 percent. Litter and gravel each had mean cover values of 5.5 percent. Rock (4.6 percent cover) and bedrock (0.4 percent cover) were also intercepted as ground cover.

4.4.1.1.4 Tailing Dam

The tailing dam stratum consisted of an approximately 4,600-foot-long by 200-foot-wide earthen tailing dam engineered during previous mining at the site. The total area of the tailing dam stratum was 17 acres. The botanists were not able to confirm whether or not this structure was revegetated during previous reclamation efforts; however, based on the current vegetation distribution and diversity it is likely that this area was seeded. Representative transect photographs from the tailing dam stratum are shown in Figure 4-7.

Total cover of perennial plants was 34.1 percent (Table 4-5). Silver bluestem (*Bothriochloa laguroides*) occurred at each transect sampled in the stratum. Perennial grass cover was 20.6 percent, perennial forb cover was 1.1 percent, and shrub/tree cover was 12.4 percent. Annual species cover was present in trace quantities (0.3 percent). Grasses, forbs, and shrubs composed 60.4, 3.2, and 36.4 percent, respectively, of the relative perennial plant cover.

Silver bluestem cover was 17.30 percent, which composed 84.0 percent of the relative perennial grass cover. Side oats grama (1.30 percent) was the only other grass species with greater than 1 percent cover. None of the perennial forbs encountered in the stratum had more than 1 percent cover. Honey mesquite (6.6 percent), broom snakeweed (1.20 percent), and feather dalea (2.6 percent) were the three most abundant shrubs.

Gravel (31.5 percent cover) was the most prominent ground cover in the tailing dam stratum. Cobble had 20.7 percent cover. Rock (6.9 percent cover) and litter (5.7 percent) had relatively similar cover values. Bare soil cover in the tailing dam stratum was very low (2.3 percent). No bedrock was encountered at the 10 transects in the tailing dam stratum.

4.4.1.1.5 Pit

The pit stratum occurred in previous mining pits covering 21 acres of the Permit Area. Representative transect photographs of the pit stratum are shown in Figure 4-8. Most of the ground surface was composed of crushed, cobble-sized rock. Plant cover was very low in the stratum. Seven of the 10 transects measured in the stratum were void of vegetation altogether. Bare soil was the most abundant cover type (62.6 percent). Total live vegetation cover was 4.4 percent. No annual plant species were encountered at transects in the stratum.

Perennial grasses were intercepted at two of the transects in the pit stratum. Mean grass cover was 1.6 percent. Most of the grass cover recorded in the stratum, however, was contributed by one outlier transect. Grass cover at this transect was 15.0 percent. The only other transect with any measured grass cover had 1.0 percent cover. Three grass species were intercepted in the stratum—Harvard's three-awn (*Aristida harvardii*), silver bluestem, and side oats grama. Silver bluestem (1.2 percent cover) was the only species with more than 1 percent cover.

Three perennial forb species and three shrub species were also recorded in the pit stratum. Forbs were only recorded at one transect location. Shrubs were intercepted at two transects. California brickelbush (*Brickellia californica*, 1.9 percent) was the only shrub species with more than 1 percent cover. Most of the ground cover was composed of cobble (65.8 percent). No bedrock was intercepted in the stratum. Gravel, litter, and rock cover was 11.2, 5.6, and 5.6 percent, respectively.

4.4.1.1.6 Arroyo

Two vegetation transects were placed in the arroyo and another transect was recorded at the bottom of the diversion channel. These three transects were installed in response to SAP agency comments, which requested that two additional transects be installed in the arroyo. The most detailed characterization of arroyo habitat was a detailed riparian/arroyo vegetation map developed with semi-quantitative methods, as described later in Section 4.4.1.8 (Riparian Vegetation Types). The three vegetation monitoring transects in this stratum were completed during June 2011. Given the very small sample size in the stratum, these data do not accurately characterize the entire 50-acre habitat; however, they do provide a snapshot of the current conditions.

Total vegetation cover in the arroyo stratum was 25.0 percent. Shrubs were the most abundant lifeform. Total shrub cover was 19.0 percent, which composed 76.0 percent of the relative live plant cover. No annual plant species or perennial forbs were encountered at the three transects in the stratum. This was likely attributed to the timing of the survey and the small sample size. Total grass cover was 6.0 percent, or 24.0 percent of the relative live vegetation cover. Vine mesquite (*Panicum obtusum*) contributed most of the grass species cover. Mean cover for vine mesquite was 6.0 percent.

Emory's baccharis (*Baccharis emoryi*) was the most abundant shrub species in the arroyo stratum. Note that this species is now considered seepwillow (*B. salicifolia)* by some sources (FNA, 2011). Baccharis cover was 13.0 percent but likely would have been much higher if transects had been recorded later in the season. Baccharis plants appeared to be moisture stressed during the monitoring period. Many of the individuals in the arroyo bottom had died back down to the base and were in the early stages of resprouting when the transects were recorded. Baccharis also appeared to be heavily browsed by cattle, which also reduced its cover. Burro bush was also abundant in the arroyo stratum (5.0 percent cover or 20.0 percent of the relative live plant cover).

Litter cover was 45.7 percent in the arroyo stratum. The high litter cover was mostly attributed to baccharis leaves along the soil surface. Bare soil cover was 21.7 percent. Gravel, cobble, and rock cover was 6.0, 1.0, and 0.7 percent, respectively. No bedrock was recorded in the stratum.

4.4.1.2 Annual Production

Net annual production was extremely variable across strata. Tables in Appendix 4-B include detailed summaries of production by species data captured along each transect in a stratum. Mean annual production by lifeform is also summarized in Table 4-6. The CDG stratum was the most productive. Mean production was 1,433.4 lbs/acre. Perennial graminoids were the most productive lifeform (952.7 lbs/acre) and contributed 66 percent of biomass composition. Perennial forbs produced 112.1 lbs/acre (8 percent composition), shrubs and trees produced 200.7 lbs/acre (14 percent composition), and annuals produced 167.9 lbs/acre (12 percent composition). Perennial plant composition comprised 88 percent of the net annual production, or 1,265 lbs/acre in the CDG stratum. Black grama and side oats grama were by far the most productive graminoids in the CDG. Mean black grama grass production was 276.1 lbs/acre while mean side oats grama production was 403.0 lbs/acre. These two species combined made up 71 percent of the graminoid composition in the CDG. Shrub/tree, perennial forb, and annual species were more variable in the CDG because production values were more evenly distributed across several species in these lifeforms.

Graminoid production was much lower in the CDS stratum. Black or side oats grama grass production did not achieve the mean values recorded for these species in the CDG stratum. Mean annual perennial graminoid production in the CDS was 260.3 lbs/acre (or 20 percent composition) and highly variable across transects. The standard deviation for perennial graminoid production was 377.7 lbs/acre. Shrubs produced an average of 654.0 lbs/acre (51 percent composition) in the CDS. Three shrub species, tarbush, broom snakeweed, and honey mesquite, each produced an average of more than 100 lbs/acre in the CDS. Creosote bush was encountered at production plots at four of the 19 transects, and creosote was also the fourth most productive shrub species in the CDS. Total annual production in the CDS was 1,274 lbs/acre, with perennial species contributing 1,086 lbs/acre (85 percent of the composition).

Mean annual production for all species totaled 917.6 lbs/acre in the waste rock pile stratum. Of this, 90 percent of the composition (826.2 lbs/acre) was perennial plants with perennial grasses contributing 417.9 lbs/acre (46 percent composition), forbs contributing 98.1 lbs/acre (11 percent composition), and shrubs/trees contributing 310.2 lbs/acre (34 percent composition). Silver bluestem was the most productive perennial graminoid in the waste rock pile stratum. This species alone produced a mean total of 178.5 lbs/acre, which composed 43 percent of the perennial grass production. Side oats grama was also relatively productive in the disturbed area/waste rock pile stratum. Side oats grama had a mean annual production of 85.5 lbs/acre in the disturbed area/waste rock pile stratum. Production at two transects (TP-12 and TP-16) was more representative of the CDG stratum. Both transects fell in a transition zone between strata, where previous disturbance was less evident.

Silver bluestem was also the most prominent graminoid in the tailing dam stratum. This species composed nearly 98 percent (360.8 lbs/acre) of the perennial grass production in this stratum. Only four other grass species were encountered at production quadrangles in this stratum. Honey mesquite was by far the most productive shrub species on the tailing dam, with a mean production of 273.6 lbs/acre. This species comprised 67 percent of the shrub production. These two species combined (honey mesquite and silver bluestem) produced 78 percent of the annual perennial plant production in the tailing dam. Total annual production in the tailing dam stratum was 822.0 lbs/acre. Perennial grasses produced 396.9 lbs/acre (48 percent composition), perennial forbs contributed 3.6 lbs/acre (<1 percent composition), shrubs/trees produced 406.9 lbs/acre (50 percent composition), and annual plants produced 14.6 lbs/acre (2 percent composition) in the tailing dam stratum.

The pit was the least productive stratum. Production quads only encountered live plants at one of the ten transects (PI-5). Silver bluestem, side oats grama, and California brickelbush were beginning to recolonize the transition zone between a previous mining pit and the waste rock piles at this location. Mean production would have been 0 lbs/acre in this stratum without this transect. Including this outlier transect, mean annual production was 248.1 lbs/acre.

Production quantities were not recorded in the arroyo stratum because these three transects were tallied in June. Warm season grasses encountered along these transects contained very little green growth; thus, net annual production would not have been accurately represented from data collected during this time period.

4.4.1.3 Woody Plant Density

The arroyo stratum had the highest woody plant density followed by the CDS, disturbed area/waste rock pile, CDG, tailing dam, and pit stratum, in that order (Table 4-7). Tables in Appendix 4-C include detailed summaries of individuals recorded by species for each stratum. Broom snakeweed had the highest species density at four of the six strata.

Mean woody plant density in the CDS was 3,249 plants/acre. Broom snakeweed had the highest species density measured in the CDS stratum (1,308 plants/acre). This species was followed in descending order of density by tarbush (594.5 plants/acre), burro bush (298.3 plants/acre), mariola (*Parthenium incanum*, 291.9 plants/acre), and creosote bush (240.8 plants/acre). Individuals from eight species, four-wing saltbush (*Atriplex canescens*), yerba-de-pasmo (*Baccharis pteronioides*), desert willow (*Chilopsis linearis*), tarbush, burro bush, creosote bush, Torrey wolfberry (*Lycium torreyi*), and honey mesquite, exceeded 1 m in height. A total of 17 woody species were recorded at the density belt transects in the CDS.

In the CDG, mean woody plant density was 2,381 plants/acre. Four species in the CDG had densities greater than 200 plants/acre. These species include broom snakeweed, cat-claw mimosa (*Mimosa aculeaticarpa*), mariola, and honey mesquite. A total of 11 species in this stratum had stem heights greater than 1 m. High mass (*Aloysia wrightii*), netleaf hackberry, tarbush, one-seed juniper, creosote bush, cat-claw mimosa, honey mesquite, scrub-live oak (*Quercus turbinella*), little-leaf sumac (*Rhus microphylla*), and three-leaf sumac (*Rhus trilobata*) each had stems taller than 1 m in the CDG. The CDG stratum had the highest woody species richness according to density data. A total of 27 woody species were encountered within belt transects in this stratum.

Mean woody plant density in the disturbed area/waste rock pile stratum was 2,779 plants/acre. Twenty woody species were recorded at belt transects in the disturbed area/waste rock pile stratum. Feather dalea had a much higher density (519.8 plants/acre) here than in both of the control sites (CDS and CDG). Stems taller than 1 m were encountered on nine species including, yerba-de-pasmo, California brickelbush, Apache plume (*Fallugia paradoxa*), tarbush, creosote bush, Torrey's wolfberry, cat-claw mimosa, honey mesquite, and little-leaf sumac.

The tailing dam had a mean woody plant density of 1,951 plants/acre. Like the disturbed area/waste rock pile stratum, feather dalea had a relatively high density (785.4 plants/acre) in the tailing dam stratum. Stems taller than 1 m were observed on five species—yerba-de-pasmo, California brickelbush, Apache plume, honey mesquite, and little-leaf sumac. Only seven woody species were encountered along density belt transects at this stratum.

Woody species were encountered along five of the 10 belt transects in the pit stratum. Mean woody plant density across transects was 291.5 plants/acre. Only two species, saltcedar (*Tamarix chinensis*) and California brickelbush, had stems taller than 1 m. In addition to these two species, Wright's buckwheat (*Eriogonum wrightii*), Apache plume, broom snakeweed, and honey mesquite were recorded at density transects in the pit stratum.

Mean woody plant density in the arroyo stratum was 6,005 plants/acre. Nine woody species occurred in density transects in this stratum. Burro bush and Emory's baccharis each had a mean density in excess of 1,800 plants/acre. These two species were also the only species with stem heights greater than 1 m according to the field-collected data; however, this is somewhat misleading. Trees such as Plain's cottonwood (*Populus fremontii*), Goodding's willow (*Salix gooddingii*), netleaf hackberry, soapberry (*Sapundus saponaria*), little walnut (*Juglans microcarpa*), and Emory oak (*Quercus emoryi*) were present in other portions of the arroyo. Several additional shrub species that occurred in the arroyo stratum would have also contributed more stems greater than 1-m tall if the sampling intensity had been higher.

4.4.1.4 Diversity

Table 4-8 lists all the plant species observed during species inventories and quantitative data collection in the Permit Area along with native status, lifeform, and duration (or life history). A total of 175 species were encountered during the various surveys. Ten tree species, 32 shrub species, 93 forb species, and 40 grass species were observed in the Permit Area. Tree species contributed 5 percent of all the species observed at the site while shrubs, forbs, and grasses contributed 18, 53, and 23 percent, respectively. Only 27 species observed at the site during inventories were not captured in quantitative transect data.

In previous projects, Parametrix botanists observed inconsistencies among authors, databases, and other regional or nationwide sources in descriptions of the longevity or life history (annual, perennial, biennial) of plant species, as well as the native status (native or introduced). As a result of variable precipitation and temperature throughout a growing season, including habitat, a plant species may complete its lifecycle from germination to seed production in a single year or multiple years. This factor sometimes led to other professionals assigning multiple durations for a single plant species, as is also common in the USDA PLANTS database (plants.usda.gov). After reviewing multiple sources, and with consideration of field observations at the project site, a Parametrix botanist assigned the most appropriate class for each species.

Perennial plant species or species coded as perennial/biennial contributed 125 plant species, or 71 percent of the total number of species observed at the site. Annuals, biennials, or combinations therein (annual/biennial, annual/biennial/perennial, etc.) contributed 29 percent towards the total number of plant species observed, or 50 species. A total of 160 native plant species and 15 non-native plant species were recorded at the site.

Results of the S-W Index analyses yielded somewhat surprising results. Perennial plant and total plant cover index scores were highest in the disturbed area/waste rock pile stratum followed by the CDS, CDG, tailing dam, pit, and arroyo, in that order (Table 4-9). High index scores in the disturbed areas/waste rock piles might be attributed to their early successional nature and overall variable conditions, which perhaps contributed to a higher than expected diversity. Some portions of this stratum contain piles of waste rock nearly void of vegetation and other portions have been reclaimed. Species evenness was also relatively high in the disturbed area/waste rock pile stratum, which contributed to the high score. This may be a result of previous reseeding efforts. Results of this index are promising for future reclamation potential at this site.

S-W Index scores were relatively high in each of the control sites. The CDG and CDS strata had perennial plant cover index scores of 2.89 and 3.01, respectively. Both communities contained high diversity and evenness. The difference in index scores between perennial plant cover and total plant was higher in the CDS community than the CDG community. This is attributed to higher annual plant diversity in the CDS community. A total of 21 annuals were encountered in the CDS stratum while 14 were recorded at transects in the CDG stratum. Note that cover results tables in Appendix 4-A also contain detailed S-W Index results.

A total of 84 species were intercepted with cover hits in the CDG stratum, which had a higher species richness than any of the other strata sampled (Table 4-10). Twenty-three perennial grass species, 24 perennial forbs, 23 shrub/tree species, and 14 annuals were encountered at cover transects in this stratum. The CDS had the second highest total number of species captured along cover transects, with 69. This stratum also had the highest number of annuals (21). A total of 15 grass species, 17 perennial forb, and 16 shrub/tree species were recorded in the CDS cover data. Cover transects at the disturbed area/waste rock pile stratum intercepted 65 total species. Perennial grasses, perennial forbs, shrubs/trees, and annuals contributed 19, 16, 13, and 17 species, respectively. Cover transects captured a much lower diversity at the tailing dam (23 total species), pit (10), and arroyo (8) strata than the other types. Low diversity in the arroyo type could partially be attributed to the small sample size and the timing of the survey (early June).

4.4.1.5 Sample Adequacy

A total of 96 vegetation monitoring transects were sampled in the Permit Area. Sampling intensity within each stratum was based on a small pilot study at the site (Parametrix, 2010b). While obtaining statistical sampling adequacy for each variable measured under this study would have been unrealistic, sometimes requiring several thousand transects per stratum, the goal was to meet statistical sampling adequacy for perennial plant species cover in each stratum with the exception of the arroyo. This goal was achieved at two of the five remaining strata (Table 4-11). Cover summary tables in Appendix 4-A also contain detailed sampling adequacy results at the lifeform level. Because of the history of disturbance at the site, variable soil depths, unnaturally variable soil substrate from previous mining, variable water collection patterns in crevices or at the base of waste rock, and patchy earlier reclamation efforts, anomalous vegetated microsites are frequently found throughout the site. Vegetation communities with this distribution create variability both within a transect and across transects in a stratum. This distribution creates extreme challenges to obtaining sample adequacy. The botanists also hesitated to move transects into other strata to achieve lower standard deviation values because this could have led to underestimating the amount of heterogeneity within a stratum.

Vegetation on the tailing dam was more evenly distributed than in the disturbed area/waste rock pile stratum. Based on the cover data, 9.7 transects were adequate for meeting statistical sampling adequacy in the tailing dam stratum; therefore, the ten transects selected for study were sufficient. These ten transects were also adequate for capturing total vegetation cover and total cover. Vegetation species distribution was relatively even in the disturbed area/waste rock pile stratum as illustrated by the relatively high S-W Index. Perennial cover, however, was extremely variable between transects. Statistical sample adequacy for perennial cover in the disturbed area/waste rock pile stratum required 104 transects. A total of 25 transects were read in this stratum.

Any vegetation encountered in the pit stratum resulted in extremely high standard deviation values. Standard deviation values exceeded the mean cover for each lifeform in this stratum. Based on sample adequacy calculations, 3,032 transects were required in this very small stratum.

Sample adequacy was achieved in the CDG stratum for perennial plant cover, total vegetation cover, and total cover. This stratum included the majority of the projected mine footprint. In fact, according to sample adequacy calculations, this stratum was oversampled. A total of 8.9 transects were adequate whereas 29 were measured in the CDG. Total cover sample adequacy was obtained in the CDS stratum but 49 transects would have been required to adequately capture total vegetation cover. A total of 39 transects would have met statistical sample adequacy in the CDS stratum; however, only 19 were measured.

4.4.1.6 Noxious Weeds

The State of New Mexico, under the administration of the Department of Agriculture, lists certain weed species as noxious weeds. “Noxious” in this context means plants not native to New Mexico that are targeted for management and control and that have a negative impact on the economy or environment. Class C listed weeds (CCW) are common, widespread species that are fairly well established within the state. Class B weeds (CBW) are considered fairly common, but not yet widespread within certain regions of the state. Class A weeds (CAW) have limited distributions within the state.

Only one noxious weed species was observed in the Permit Area. Saltcedar patches were encountered along the pit lake and sporadically along Greyback Arroyo. Detailed riparian vegetation maps (Appendix 4-D) show locations where saltcedar is most prominent in the Permit Area. Polygons with “SC” noted as a co-co-dominant species contained saltcedar with at least 25 percent of the relative overstory or understory cover, depending on which side of the slash ("/") SC is listed. For more information on the total acres dominated by saltcedar in the Permit Area, see Section 4.4.1.8 (Riparian Vegetation Types) below.

4.4.1.7 Rare, Threatened, or Endangered Species

No rare, threatened, or endangered species, or plant species of concern were encountered in the Permit Area. Table 4-12 lists plant species of concern known to occur in Sierra County, agency status, and habitat notes. General habitat requirements were present in the Permit Area for two New Mexico species of concern: Sandberg pincushion cactus (*Escobaria sandbergii*) and Wright's campion (*Silene wrightii*). Habitat criteria for the U.S. Fish and Wildlife Service (USFWS) species of concern and state-listed endangered Duncan's pincushion cactus (*Escobaria duncanii*) was marginally present in the Permit Area, although the only known New Mexico population is northeast of the Permit Area at the base of Mud Mountain near Black Chute Mine (SEINet, 2011). Mud Mountain lies approximately 4 miles west of Truth or Consequences.

4.4.1.8 Riparian Vegetation Types

A detailed riparian and arroyo vegetation map was delineated for arroyo habitats along Greyback Arroyo, the pit lake fringe, and the diversion channel. As described in Section 4.3 (Methodology), the H&O vegetation classification was used to assign appropriate types based on ocular estimates of species cover in the overstory and understory canopy layers. Some species, baccharis in particular, appeared moisture stressed. It was commonly observed that baccharis plants had senesced leaves down to the base and resprouted new leaves from below ground rather than on existing aboveground stems. The Parametrix botanists did not commonly observe this habit in sites with higher soil moisture where baccharis is common, such as riverside sandbars in southern reaches of the Rio Grande. They were not able to determine from reviewing previous research from scientific journals, or other sources, if this is a typical response to moisture stress or other environmental conditions for this species. During ocular estimates of baccharis cover, the field botanist used best professional judgment to decide if baccharis or total shrub cover (as a result of likely increased baccharis cover) would exceed 25 percent later in the growing season—the minimum threshold for a woody structure type or co-dominant species designation in the H&O system. The probable late-season height for baccharis was also used to determine the appropriate structure type. Based on dead baccharis stems from the previous growing season, most of the baccharis was taller than 5 ft in 2010.

Figures in Appendix 4-D map the distribution of individual H&O types delineated throughout the Permit Area. Table 4-3 explains how structure types are differentiated in the H&O system. In order to meet co-dominant species criteria in the H&O system, a species must comprise at least 25 percent of the relative cover in the canopy layer. A total of 49.8 acres of riparian/arroyo habitat was delineated in the Permit Area (Table 4-13). Structure type 5 (shrubs taller than 5 ft with >25 percent total shrub cover) was the most common structure type observed. A total of 34.0 acres (or 68 percent of the arroyo/riparian habitat) was classified as structure type 5.

Structure types 3 and 4 were relatively similar in area. Areas characterized as structure type 3 included two canopy layers—an overstory structure that is between 20 and 40 ft tall growing above a shrub understory. Structure type 4 is a woodland with similar overstory structure as a type 3, minus the understory layer. A total of 7.4 acres were mapped as structure type 3 while 5.9 acres were mapped as structure type 4.

Structure type 6 was also encountered in the arroyo habitat. Structure type 6 is composed of shorter (generally <5 ft tall) shrubs with >25 percent cover. Many of the surrounding CDS portions of the Permit Area may meet structure type 6 criteria. However, this type was only included in the arroyo/riparian vegetation mapping if typical arroyo indicator species were present. Arroyo vegetation mapping stopped as the vegetation community became more similar to surrounding uplands. A total of 2.4 acres were mapped as structure type 6.

A small (0.1 acre) cattail (*Typha latifolia*) community was observed along the fringe of the pit lake. Cattail marshes were assigned a "MH" type (for "Marsh Habitat") according to the H&O convention. This type occurred in a small depression along the outside edge of the pit perimeter. No open water was present in the cattail community during the time of the survey although the location had relatively high soil moisture.

With the exception of the pit lake, open water was only observed in one location in the Permit Area. This occurred in the arroyo bottom immediately downstream of a large culvert (see maps in Appendix 4-D). The riparian vegetation surrounding the small (approximately 10 ft x 20 ft during the time of the survey) open water feature was dominated by Goodding's willow, referred to as "TW" (for "Tree Willow") in H&O vegetation maps, and Emory's baccharis, referred to as "B" (for "Baccharis") in the H&O convention.

Note that since multiple species can be assigned as co-dominants in both the overstory and understory canopy layers in the H&O system, the sum of acres for co-dominant species is not equal to the sum of the total acres mapped. In other words, a 5-acre area can contain both baccharis and cottonwood as co-dominant species; therefore, 5 acres would be reported for both species in the following paragraphs.

Baccharis was the most prominent species in the arroyo/riparian habitats in the Permit Area based on the vegetation delineations (Table 4-14) conducted by Parametrix. This species was included as a co-dominant species in 22.2 acres. Burro bush (15.5 acres) was the next most abundant co-dominant species after baccharis. Baccharis and burro bush were frequently found together in the same polygon in Greyback Arroyo although baccharis appeared to prefer slightly more moist conditions than burro bush. Baccharis was common on microsites within the arroyo bottom or the immediate fringe. Burro bush appeared to be more frequent from the arroyo fringe to lower terraces. Figure 4-9 includes photographs of typical burro bush and baccharis habitats in the Permit Area.

More typical southwestern riparian indicators such as cottonwood and Goodding's willow were encountered in relatively small areas of the Permit Area. Cottonwood ("C" in the H&O designations) was classified as a co-dominant species in 5 acres. Goodding's willow-dominated communities totaled 1.8 acres. Cottonwood (*Populus fremontii*) was more widely distributed than Goodding's willow. Willow trees were restricted to a single location within the Permit Area. Figure 4-10 contains representative photographs of cottonwood and willow habitat at the site.

Netleaf hackberry ("NLH" in the H&O designations) woodlands composed 2.5 acres of the Permit Area. This species appeared to favor higher terraces along the arroyo or the transition zone between the arroyo and surrounding hills. Emory's oak ("Qu" in the H&O designations) was found in isolated drainages in the Permit Area. Because Greyback Arroyo and the diversion channel were the primary areas of interest for this mapping effort, small oak woodlands that occurred in drainages outside of Greyback Arroyo were likely under-represented in the detailed mapping.

Honey mesquite ("HM" in the H&O designations) was included as a co-dominant species in arroyo habitat types across 13.8 acres of the Permit Area. Honey mesquite communities were only included in the detailed mapping if they either were found as a tree growth form or they coexisted with more typical arroyo habitat species.

Saltcedar ("SC" in the H&O designations) was mapped as a co-dominant species in 7.6 acres of the Permit Area. Patches were concentrated along the fringe of the pit lake and the bottom of Greyback Arroyo near the main entrance to the mine. Figure 4-11 includes representative photographs of saltcedar communities at both locations.

Apache plume was a co-dominant species in 10 acres of the arroyo habitat. Apache plume (see "AP" in the H&O designations) occurred on relatively high terrace surfaces along Greyback Arroyo. Rubber rabbitbrush (*Ericameria nauseosus*) and velvet ash (*Fraxinus velutina*) were also considered co-dominant species in portions of the arroyo habitat. Rabbitbrush ("RB" in the H&O designations) dominated a small, 0.4-acre section of the diversion channel while velvet ash ("VA" in the H&O designations) was mapped in 0.7 acres. Isolated single soapberry (*Sapundus saponaria*) and little walnut (*Juglans microcarpa*) trees were observed along the arroyo but never with sufficient cover quantities to warrant inclusion in a map unit.

4.4.1.9 Wetlands and Jurisdictional Waters of the U.S.

Jurisdictional wetlands, those protected from unauthorized dredge and fill activities under CWA Section 404 (33 USC 1344), have three essential characteristics: (1) dominance by hydrophytic vegetation, (2) hydric soils, and (3) wetland hydrology. To be jurisdictional, a wetland must have a significant connection to a known jurisdictional, navigable waterway. Executive Order 11990 (Protection of Wetlands) requires the avoidance, to the greatest extent possible, of both long- and short-term impacts associated with the destruction, modification, or other disturbance of wetland habitats.

Two locations within the Permit Area appeared to meet vegetation, soil, and hydrologic conditions defined by the CWA, although formal wetland delineations were not completed. The first location was a small cattail wetland adjacent to the pit lake (see vegetation maps in Appendix 4-D). Based on preliminary discussions with the USACE, this wetland was not considered jurisdictional because there was no significant connection to a jurisdictional, navigable waterway.

The second location that met general wetland criteria was the Goodding's willow forest (Figure 4-12) near the main mine entrance (visible on maps in Appendix 4-D). For vegetation mapping purposes, the patch size was determined to be 1.5 acres. However, Goodding's willow trees extended beyond the smaller area that would likely meet hydric soils and hydrologic criteria. It is likely that the portion of the polygon that met all three wetland criteria was <0.5 acre.

4.4.2 Pipeline Corridor

Much of the proposed Baseline Study Area consists of existing roads (paved and unpaved), associated rights-of-way, a power utility corridor, and areas previously cleared around well sites. In addition, heavy cattle grazing has affected vegetation over large portions of the proposed project corridor. During the 2010 and 2011 field surveys, 67 species of plants were observed within the proposed pipeline corridor (Table 4-15). The dominant plant species observed within the site consisted of low woollygrass (*Dasyochloa pulchella*), weeping lovegrass (*Eragrostis curvula*), spreading buckwheat, tarbush, broom snakeweed, creosote bush, tobosa grass (*Pleuraphis mutica*), and honey mesquite. These species were observed fairly uniformly throughout the proposed pipeline corridor.

No state-listed noxious weeds were observed within the pipeline corridor during the 2010 and 2011 botanical surveys. Based on NWI data and field verification, wetlands are not present within the proposed pipeline corridor. Suitable habitat for state- or federally listed threatened, endangered, or sensitive plant species, or species of concern observed during the field surveys was marginal due to previous and current disturbance. No species listed as threatened or endangered were observed during the surveys.

4.4.3 Arizona Sycamores at Las Animas Creek

Arizona sycamore was the primary species of interest at Las Animas Creek. While this species was relatively widespread through the study area, recent sycamore recruitment was restricted to a 0.5 mile long segment of

Las Animas Creek where isolated seedlings or saplings and sometimes patches of saplings or poles were observed (Figure 4-13). This portion of the study area, referred to as the “recruitment zone”, is delineated in maps under Appendix 4-E. The 12.5 acre recruitment zone was relatively unique compared to the rest of the site in that: (1) young Arizona sycamores were present, (2) the upstream portion of the recruitment zone had a floodplain surface that appeared to be regularly flooded during peak runoff or monsoonal flash floods, (3) surface water was present through most of this stream segment, and (4) recent alluvial deposition was sometimes encountered.

As previous research from other river systems (see Section 4.3.3) has described, Arizona sycamore recruitment also appeared to be episodic and sporadic along Las Animas Creek. Most of the individuals classified as pole, sapling, or seedling cohorts appeared to be similar age, and may have established during identical recruitment episodes. Recruitment did not appear to be an annual occurrence, even in the recruitment zone, and we suspect that none of the individuals observed germinated during the past year. Many of the new recruits were also in the channel bottom and vulnerable to uprooting during high flow events.

Favorable conditions for gamet reproduction were rarely observed in the Baseline Study Area. The entire study reach was privately owned and homes and other structures have been constructed immediately along the banks of the creek, especially in the eastern half of the study area. Previous and on-going channel construction projects have straightened the active channel, removed vegetation, bermed the banks, and confined the creek to a deep, narrow channel to varying degrees (Figure 4-14). While canalization of the active channel was critically important to protecting structures, these efforts have greatly reduced the potential for Arizona sycamore recruitment thereby reducing the biotic integrity of the population. It’s also likely that these activities have lowered alluvial groundwater in the study area, which according to previous research (summarized in Section 4.3.3), results in reduced growth rates and vigor in Arizona sycamore.

To date, however, the Arizona sycamore population through the study area has displayed relatively little canopy dieback or mortality. While stressed individuals were observed, their distribution was inconsistent. Map notations in Appendix 4-E identify a location where pronounced canopy dieback was consistently observed. Middle aged trees appeared to most commonly display indications of stress. According to a local resident of the Animas valley, bark sloughing has become more pronounced in recent years (Chatfield, 2011). Increased bark sloughing has not been identified as a response to moisture stress or disease in existing research to our knowledge.

Previous mining ventures distributed potted Arizona sycamore trees to property owners in the Animas valley (Chatfield, 2011). Cultivated sycamore trees appeared to have been most extensively planted along the eastern half of the Baseline Study Area. Under the current conditions through most of the study area, this may be the most viable option for establishing a new generation of Arizona sycamore.

4.4.3.1 Riparian Vegetation Types

The riparian mapping along Las Animas Creek characterized 463 acres of riparian forest and woodland habitats. H&O structure type 1 was the most abundant structure type in the study area. A total of 231 acres (or 50 percent) of the riparian area was considered structure type 1 (Table 4-16). Much of this area, however, was very similar in canopy structure to a structure type 2 community. Understory layers were sometimes broken and scattered. About 118 acres, or 26 percent of the study area was classified as structure type 4. Structure type 4 was the second most widespread structure type. Structure types 4 and 3 composed 59 and 48 acres, respectively. Type 3 communities were most common in the floodplains adjacent to reaches with surface water observed during our field visits while open woodland communities (structure type 4) were most common in the upstream portion of the study area. Riparian shrublands (structure types 5 and 6) were not encountered and arroyo shrubland habitats were not mapped in this study area, though they were commonly observed in the western-most and eastern-most reaches. Isolated patches of cultivated pecan, fruit, and pistachio trees were also digitized but not assigned a riparian structure type. These cultivated patches occupied 7 acres.

Arizona sycamore (“AS” in H&O mapping) was the most abundant co-dominant species (Table 4-17). Arizona sycamore was included as a co-dominant species in 262 acres, or 57 percent of the riparian habitat along Las Animas Creek. Sycamore gallery forests were more common in the eastern-half of the study area. Most of the Arizona sycamore co- dominated communities were considered mature forests (structure type 1 or 2). Cottonwood gallery forests were delineated throughout the study area, but more consistently in the western half. A total of 213 acres (46 percent) of the riparian area contained cottonwood (“C” in H&O maps) as a co-dominant. Cottonwood was considered a co-dominant in structure type 1, 2, 3, and 4 habitats.

A total of 226 acres (49 percent) of the riparian habitat was co- dominated by netleaf hackberry (“NLH” in H&O designations). Netleaf hackberry was associated with several species through the study area. This species was even a common understory component beneath Arizona sycamore and cottonwood gallery forests. Very few monotypic netleaf hackberry woodlands were observed in the Las Animas Creek study area compared to the Percha Creek site.

Velvet ash was the fourth most abundant co-dominant species. This species (“VA”) was a significant component in riparian types across 38 percent (176 acres) of the study area. Velvet ash and little walnut frequently displayed canopy dieback throughout the study area. Stress indicators were most evident with these species in the western-most and southern portions of the study area. Little walnut was a co-dominant component in 23 acres.

Tree willow (53 acres) and coyote willow (26 acres) co- dominated stands were restricted to areas with surface water. Areas with surface water in the channel had an increased compositional diversity compared with surrounding, drier sites. Young tree willow (“TW”) and cottonwood seedlings were commonly observed along the channel bottom through this portion of the study area, though they’ll easily wash away during a flash flood. Tree willow was also observed but not considered a co-dominant in the upstream portion while coyote willow (“CW” in H&O) distribution was more restricted to polygons where it was considered a co-dominant. Coyote willow individuals, though not widespread, were extremely tall and robust compared to the species’ typical growth habit.

Approximately 85 acres of the riparian habitat contained a burro bush understory. Burro bush (“BB”) communities were underrepresented since arroyo shrublands were not included in map delineations for the Las Animas Creek study area. Baccharis (“B”) communities were also not entirely delineated. Baccharis and burro bush were abundant components of the arroyo habitats in the upstream- and downstream-most reaches. Desert willow was also sometimes associated with these two species along with honey mesquite.

Honey mesquite was also a component in riparian forests and woodlands across 72 acres (15 percent) of the study area. Honey mesquite was frequently associated with velvet ash in open woodlands or as an understory component beneath Arizona sycamore and/or cottonwood gallery forests. This species (“HM”) was typically observed in its tree growth form under these conditions. Soap berry (“SB”) and grey oak (“GO”) were mapped as co-dominants across approximately 3 acres.

Several invasive exotic species were also observed in the Las Animas Creek study area. Siberian elm (2 acres), mulberry (<1 acre), and saltcedar (<1 acre) were considered co-dominants across a relatively small area. A very small linear band of tree of heaven was observed along a property fence in the eastern half of the study area but not captured in riparian mapping. Each of these species have been challenging to manage in the Rio Grande valley.

4.4.3.2 Reference Tree Characteristics

Tagged and measured Arizona sycamore trees significantly varied in size and health condition. Reference tree height estimated ranged from just over 5 ft to 116 ft (Table 4-18). The dbh was also highly variable, as intended. A young seedling-sized individual growing on the bank of Las Animas Creek had a measured dbh of 0.2 inches. The largest dbh recorded was 88.5 inches. Several trees had multiple stems and a dbh of each stem was recorded when multiple stems were encountered. This sometimes occurred on large trees, taller than 100 ft, such as tree tag 993.

Stress indicators such as canopy dieback and dead branches were also highly variable (Figure 4-15). Two of the reference trees (tags 897 and 995) had >25 percent canopy dieback. Both trees were approximately 25 ft tall. Based on general observations in the study area, trees in this size class displayed stress indicators most frequently. Another tree (tree tab 885) had an estimated canopy dieback of 10 percent. This individual was much larger (76.8 dbh) than the other two reference trees with significant canopy dieback. Each of these three reference trees also contained dead branches.

The majority of the reference trees measured, however, appeared healthy -- showing little to no indication of moisture stress or disease. We recommend re-visiting each of the 25 reference trees on a regular, semi-annual basis, to re-photograph and re-measure.

4.4.4 Percha Creek

Riparian and arroyo-riparian vegetation communities were documented along a 15-mile segment of Percha Creek in support of this report. The survey area included the Percha Box reach. Detailed riparian vegetation mapping was integrated into this study in response to agency comments on the SAP (Parametrix, 2010a). Vegetation types were delineated for approximately 950 acres (Table 4-19). Similar to the other detailed riparian vegetation maps in this report, stand classification followed the H&O convention with minor adaptations to include additional (non-Rio Grande bosque) species in the system. The botanists mapped arroyo habitat types in addition to more typical riparian types to allow potential future researchers to measure net gains or losses for either general type. Stream flow was observed during the October 2011 fieldwork along a 4-mile-long section of the stream through Percha Box (see maps in Appendix 4-F). The perennial reach of Percha Creek contained more riparian indicator species than areas downstream or upstream of Percha Box. Based on general observations in Percha Box, disturbances important for maintaining ideal biohydrology for riparian species, such as regular flooding, are still relatively intact. Recent flood debris deposits were observed as high as approximately 20 ft above the active channel in portions of the narrow slot canyon. Flood disturbance appears to be so frequent in one short, particularly narrow section of the canyon, that riparian tree species are short-lived and absent.

The detailed vegetation maps for the areas along Percha Creek are provided in Appendix 4-F. The most prominent H&O structure type delineated was type 5 (shrubs). See Table 4-3 for a general description of H&O structure types. A total of 654.6 acres (or 69 percent of the Percha Creek study area) were considered structure type 5 (Table 4-19). Dense multistoried riparian communities (structure types 1 and 3) were also documented during the assessment. Structure type 3 communities composed 17 percent of the riparian/arroyo area, or 156.9 acres. Communities designated as structure type 1 totaled 11.3 acres or 1 percent of the Baseline Study Area. Woodland types (structure types 2 and 4) were also well represented in the Percha Creek study area. A total of 91.3 acres of structure type 4 communities were delineated. Structure type 4 communities consisted of 10 percent of the detailed mapping area. Structure type 2 communities composed 4 percent of the riparian/arroyo mapping area, or 34.7 acres. No structure type 6 or non-woody structure types (such as cattail marshes) were recorded in the site although two very small (20 by 50 ft^2) streamside patches of cattail were observed in Percha Box. It should be noted, however, that many of the baccharis and burro bush-dominated communities in the study area could arguably be better represented as type 6 structure types.

Burro bush (“BB” in the H&O designations) was the most widespread co-dominant species (Table 4-20). Burro bush was considered a co-dominant species in 636.0 acres of the Percha Creek study site. This species was common on side terraces upstream and downstream of Percha Box. Relatively little burro bush was found in the perennial reach. Burro bush-dominated terraces also typically contained upland shrub species and Apache plume. Baccharis (“B” in the H&O designations) was also abundant throughout the study area. A total of 419.4 acres were composed of baccharis as a co-dominant. Baccharis was common within the arroyo bottom and along the active channel margins in most of the site. Figure 4-16 includes representative photographs of the baccharis communities along Percha Creek. This species also sometimes inhabited lower terraces and side bars. Baccharis shrubs appeared moisture stressed in the non-perennial reaches. Relatively large areas were observed with dieback and resprouting. Seepwillow flourished in the perennial reach. Vibrant stems and generally taller individuals were observed in Percha Box.

Cottonwood, Gooding’s willow, or a combination of both species was observed at 307 acres of the Percha Creek site (32 percent of the mapped area). Goodding’s willow and cottonwood were mapped as co-dominant species in 50.5 acres and 156.4 acres, respectively. Figure 4-17 includes representative photographs of the Goodding’s willow communities observed along Percha Creek. This species was particularly abundant throughout Percha Box. Recent recruitment of Goodding’s willow was observed regularly in the Percha Box reach. Seedling and sapling-sized willow trees were frequently encountered. Goodding’s willow-dominated stands were almost exclusively restricted to portions of Percha Creek with perennial water.

A broad range of cottonwood age/size cohorts were observed in the Percha Creek study area, although seedling recruitment was encountered less frequently than for Goodding’s willow. Extremely large cottonwood trees were present on historic floodplain surfaces as the canyon widened in the downstream portions of Percha Box, while narrower portions of Percha Box had an abundance of cottonwood poles. Cottonwood was more widely distributed throughout the Percha Creek study area than Goodding’s willow. The current health of cottonwood trees was variable throughout the Percha Creek study site. Isolated trees in the arroyo bottom or on low floodplain terraces upstream of Percha Box had dead upper branches. Cottonwood trees in the perennial reaches, however, showed no signs of stress. Figure 4-18 contains photographs of cottonwood-dominated stands along Percha Creek.

Coyote willow (*Salix exigua*) was less common than cottonwood or Goodding’s willow. This species (“CW” in the H&O designations) was considered a co-dominant species in 13.4 acres of the Percha Creek study area. Coyote willow was encountered in an isolated depression upstream of Percha Box and also (but infrequently) within Percha Box. Figure 4-19 shows representative photographs of coyote willow-dominated communities in the Percha Creek study area.

Netleaf hackberry (“NLH” in the H&O designations) was observed throughout the study area at Percha Creek. This species frequently occurred on higher geomorphic surfaces than the other riparian tree species. Hackberry woodlands (type 4 communities) were common at the base of surrounding upland hill slopes. Netleaf hackberry-dominated types were delineated in 152 acres.

Little walnut (“LW” in the H&O designations) was mapped as a co-dominant species in 45.2 acres. Woodlands and forests, composed at least partially of little walnut, were primarily restricted to downstream of Percha Box. Little walnut frequently displayed indications of stress. Most of the trees observed in the study area had senesced leaves from their upper branches (Figure 4-20).

Velvet ash (“VA” in the H&O designations) was fairly well distributed in the riparian portions of Percha Creek. Ash was mapped as a co-dominant species across 43.2 acres. Stands co- dominated by this species were observed both upstream and downstream of Percha Box. This species displayed signs of moisture stress in the non-perennial reaches less frequently than little walnut.

Two state-listed noxious weed species were classified as co-dominants in the Percha Creek study area. Tree of heaven (*Ailanthus altissima*) and Siberian elm (*Ulmus pumila*) were each encountered. Tree of heaven ("TH" in the H&O designations) was a co-dominant in 4.5 acres of the site. Tree of heaven was restricted to areas just downstream of the bridge crossing in Hillsboro (Figure 4-21). Siberian elm was more widely distributed, as individuals were observed upstream and downstream of Percha Box. Elm was a co-dominant in 22.3 acres.

Desert willow was a co-dominant species in 34.2 acres. Most of the acreage from this species was attributed to a fairly large, isolated patch well downstream of Percha Box. Desert willow and burro bush composed most of this particular stand.

Honey mesquite and burro bush terraces dominated the downstream portions of the Percha Creek study area. Honey mesquite-dominated communities were mapped across 319.7 acres. These terraces typically also contained Apache plume and a diverse suite of upland shrubs such as cat-claw acacia (*Acacia greggii*), whitethorn acacia (*Acacia constricta*), and cat-claw mimosa. Three-leaf sumac and little-leaf sumac were also associated with this type. In some cases, shrub species distribution was so variable that it was difficult to assign an appropriate H&O type; as a result, the botanists assigned the honey mesquite-burro bush complex for consistency.

Planted ponderosa pine (*Pinus ponderosa*) trees and cedar cultivars were mapped around houses in Hillsboro. These trees occurred on the north side of the Creek.

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Tables

Table 4-1

Total Acreage and Measurement Transects of Sampling Strata in Copper Flat Mine Permit Area

Stratum	Acres	Number of Transects
Access Road	36.5	0
Chihuahuan Desert Grassland (CDG)	932.9	29
Chihuahuan Desert Shrubland (CDS)	260.9	19
Pit	21.4	10
Pit Lake	5.0	0
Arroyo/Riparian	50.5	3
Tailing Dam (TD)	16.6	10
Disturbed Area/Waste Rock Pile	865.7	25
Grand Total:	**2,189.5**	**96**

Table 4-2

Copper Flat Mine Permit Area Vegetation Transect Location

Plot ID	Easting	Northing	ESD Name	General Current Condition	Sample Stratum
BD-1	263209	3651245	Hills	Relatively Undisturbed	Chihuahuan Desert Grassland
BD-10	265001	3650562	Hills	Relatively Undisturbed	Chihuahuan Desert Grassland
BD-11	265363	3651055	Hills	Relatively Undisturbed	Chihuahuan Desert Grassland
BD-12	265508	3650873	Hills	Relatively Undisturbed	Chihuahuan Desert Grassland
BD-13	266167	3650510	Gravelly	Relatively Undisturbed	Chihuahuan Desert Shrubland
BD-14	266515	3650374	Gravelly	Relatively Undisturbed	Chihuahuan Desert Shrubland
BD-15	266518	3650239	Gravelly	Relatively Undisturbed	Chihuahuan Desert Shrubland
BD-16	266573	3648908	Gravelly	Relatively Undisturbed	Chihuahuan Desert Shrubland
BD-17	266596	3650026	Gravelly	Relatively Undisturbed	Chihuahuan Desert Shrubland
BD-18	266631	3649237	Gravelly	Relatively Undisturbed	Chihuahuan Desert Shrubland
BD-19	266630	3649489	Gravelly	Relatively Undisturbed	Chihuahuan Desert Shrubland
BD-2	263531	3651087	Hills	Relatively Undisturbed	Chihuahuan Desert Grassland
BD-20	266653	3649388	Gravelly	Relatively Undisturbed	Chihuahuan Desert Shrubland
BD-21	266707	3649813	Gravelly	Relatively Undisturbed	Chihuahuan Desert Shrubland
BD-22	266761	3649749	Gravelly	Relatively Undisturbed	Chihuahuan Desert Shrubland
BD-3	263547	3651220	Hills	Relatively Undisturbed	Chihuahuan Desert Grassland
BD-4	263627	3651004	Hills	Relatively Undisturbed	Chihuahuan Desert Grassland
BD-5	264706	3650991	Hills	Relatively Undisturbed	Chihuahuan Desert Grassland
BD-6	264716	3650838	Hills	Relatively Undisturbed	Chihuahuan Desert Grassland
BD-7	264788	3651116	Hills	Relatively Undisturbed	Chihuahuan Desert Grassland
BD-8	264797	3650967	Hills	Relatively Undisturbed	Chihuahuan Desert Grassland
BD-9	263718	3650681	Hills	Relatively Undisturbed	Chihuahuan Desert Grassland
BU-1	262530	3651053	Hills	Relatively Undisturbed	Chihuahuan Desert Grassland
BU-10	264457	3651476	Hills	Relatively Undisturbed	Chihuahuan Desert Grassland
BU-11	264583	3650016	Hills	Relatively Undisturbed	Chihuahuan Desert Grassland

Plot ID	Easting	Northing	ESD Name	General Current Condition	Sample Stratum
BU-12	264664	3651313	Hills	Relatively Undisturbed	Chihuahuan Desert Grassland
BU-13	264794	3649913	Hills	Relatively Undisturbed	Chihuahuan Desert Grassland
BU-14	264796	3651312	Hills	Relatively Undisturbed	Chihuahuan Desert Grassland
BU-15	265106	3649034	Hills	Relatively Undisturbed	Chihuahuan Desert Grassland
BU-16	265311	3650402	Hills	Relatively Undisturbed	Chihuahuan Desert Grassland
BU-17	265476	3650531	Hills	Relatively Undisturbed	Chihuahuan Desert Grassland
BU-18	266149	3650710	Gravelly	Misc. Disturbance	Disturbed Area/Waste Rock Pile
BU-19	266317	3650864	Gravelly	Relatively Undisturbed	Chihuahuan Desert Shrubland
BU-2	262635	3650739	Hills	Relatively Undisturbed	Chihuahuan Desert Grassland
BU-20	266382	3650707	Gravelly	Relatively Undisturbed	Chihuahuan Desert Shrubland
BU-21	266490	3650839	Gravelly	Relatively Undisturbed	Chihuahuan Desert Shrubland
BU-22	266564	3650757	Gravelly	Relatively Undisturbed	Chihuahuan Desert Shrubland
BU-23	266696	3650479	Gravelly	Relatively Undisturbed	Riparian
BU-24	266851	3649445	Gravelly	Relatively Undisturbed	Chihuahuan Desert Shrubland
BU-25	266860	3650367	Gravelly	Relatively Undisturbed	Chihuahuan Desert Shrubland
BU-26	266913	3649283	Gravelly	Relatively Undisturbed	Chihuahuan Desert Shrubland
BU-27	266990	3649029	Gravelly	Relatively Undisturbed	Chihuahuan Desert Shrubland
BU-3	262655	3651580	Hills	Relatively Undisturbed	Chihuahuan Desert Grassland
BU-4	263207	3650030	Hills	Relatively Undisturbed	Chihuahuan Desert Grassland
BU-5	263555	3649889	Hills	Relatively Undisturbed	Chihuahuan Desert Grassland
BU-6	263902	3649831	Hills	Relatively Undisturbed	Chihuahuan Desert Grassland
BU-7	263911	3651459	Hills	Relatively Undisturbed	Chihuahuan Desert Grassland
BU-8	264233	3651115	Hills	Relatively Undisturbed	Chihuahuan Desert Grassland
BU-9	264363	3649818	Hills	Relatively Undisturbed	Chihuahuan Desert Grassland
PI-1	262929	3650460	Hills	Pit	Pit
PI-10	263311	3650819	Hills	Pit	Pit
PI-2	263002	3650501	Hills	Pit	Pit
PI-3	263010	3650621	Hills	Pit	Pit

Plot ID	Easting	Northing	ESD Name	General Current Condition	Sample Stratum
PI-4	263084	3650561	Hills	Pit	Pit
PI-5	263135	3650618	Hills	Pit	Pit
PI-6	263254	3650917	Hills	Pit	Pit
PI-7	263257	3650718	Hills	Pit	Pit
PI-8	263295	3650729	Hills	Pit	Pit
PI-9	263298	3650884	Hills	Pit	Pit
TD-1	266504	3650118	Gravelly	Tailing Dam	Tailing Dam
TD-10	266552	3649955	Gravelly	Tailing Dam	Tailing Dam
TD-2	266510	3649075	Gravelly	Tailing Dam	Tailing Dam
TD-3	266525	3649010	Gravelly	Tailing Dam	Tailing Dam
TD-4	266529	3649226	Gravelly	Tailing Dam	Tailing Dam
TD-5	266532	3649519	Gravelly	Tailing Dam	Tailing Dam
TD-6	266533	3649429	Gravelly	Tailing Dam	Tailing Dam
TD-7	266542	3649789	Gravelly	Tailing Dam	Tailing Dam
TD-8	266544	3649594	Gravelly	Tailing Dam	Tailing Dam
TD-9	266550	3649891	Gravelly	Tailing Dam	Tailing Dam
TP-1	262639	3651045	Hills	Misc. Disturbance	Disturbed Area/Waste Rock Pile
TP-10	264167	3650424	Hills	Misc. Disturbance	Disturbed Area/Waste Rock Pile
TP-11	264578	3650464	Hills	Misc. Disturbance	Disturbed Area/Waste Rock Pile
TP-12	265126	3649279	Hills	Misc. Disturbance	Disturbed Area/Waste Rock Pile
TP-13	265187	3649868	Hills	Misc. Disturbance	Disturbed Area/Waste Rock Pile
TP-14	265323	3649119	Hills	Misc. Disturbance	Disturbed Area/Waste Rock Pile
TP-15	265397	3649502	Gravelly	Misc. Disturbance	Disturbed Area/Waste Rock Pile
TP-16	265485	3650305	Gravelly	Misc. Disturbance	Disturbed Area/Waste Rock Pile
TP-17	265601	3649276	Gravelly	Misc. Disturbance	Disturbed Area/Waste Rock Pile
TP-18	265699	3649518	Gravelly	Misc. Disturbance	Disturbed Area/Waste Rock Pile
TP-19	266002	3649459	Gravelly	Misc. Disturbance	Disturbed Area/Waste Rock Pile
TP-2	262704	3651075	Hills	Misc. Disturbance	Disturbed Area/Waste Rock Pile

Plot ID	Easting	Northing	ESD Name	General Current Condition	Sample Stratum
TP-20	266224	3650128.838	Gravelly	Misc. Disturbance	Disturbed Area/Waste Rock Pile
TP-21	266266	3649281	Gravelly	Misc. Disturbance	Disturbed Area/Waste Rock Pile
TP-22	266283	3648874	Gravelly	Misc. Disturbance	Disturbed Area/Waste Rock Pile
TP-23	266344	3649367	Gravelly	Misc. Disturbance	Disturbed Area/Waste Rock Pile
TP-24	266392	3649560	Gravelly	Misc. Disturbance	Disturbed Area/Waste Rock Pile
TP-3	262713	3650875	Hills	Misc. Disturbance	Disturbed Area/Waste Rock Pile
TP-4	262957	3650890	Hills	Misc. Disturbance	Disturbed Area/Waste Rock Pile
TP-5	263066	3650713	Hills	Misc. Disturbance	Disturbed Area/Waste Rock Pile
TP-6	263167	3650701	Hills	Misc. Disturbance	Disturbed Area/Waste Rock Pile
TP-7	263228	3650451	Hills	Misc. Disturbance	Disturbed Area/Waste Rock Pile
TP-8	264236	3650598	Hills	Misc. Disturbance	Disturbed Area/Waste Rock Pile
TP-9	264088	3650488	Hills	Misc. Disturbance	Disturbed Area/Waste Rock Pile
Arroyo 1	264344	3650005	Hills	Relatively Undisturbed	Arroyo
Diversion	262770	3650452	Hills	Diversion Channel	Arroyo
Arroyo 2	266126	3650704	Gravelly	Relatively Undisturbed	Arroyo

Table 4-3

Hink and Ohmart (H&O) Structure Types

Structure Type	Dominant Overstory Height (feet)	Overstory Cover (percent)	Understory Cover (percent)	General Description
Woody Structure Types				
1	>40	>25	>25	Tall trees with well-developed understory. Substantial foliage in all height layers.
2	>40	>25	<25	Tall trees with little or no understory. Most of foliage over 30–40 feet.
3	20a–40	>25	>25	Intermediate-sized trees with dense understory. Majority of foliage between 0–40 feet.
4	20–40	>25	<25	Open woodlands of intermediate-sized trees. Majority of foliage between 15–30 feet.
5	N/A	<25	>25	Taller shrubs or young trees (>5 feet tall). Most foliage between 0–15 feet.
6	N/A	<25	>25	Short statured shrubs or young trees and shrubs (<5 feet tall). Most foliage between 0–5 feet.
Non-Woody Structure Types				
MH	N/A	<25	<25	"Marsh Habitat," emergent wetland vegetation >5 feet tall.

Table 4-4
Hink and Ohmart (H&O) Species Acronyms

H&O Species Code	H&O Common Name	Scientific Name
AP	Apache Plume	*Fallugia paradoxa*
AS	Arizona Sycamore	*Plantanus wrightii*
B	Baccharis	*Baccharis emoryi, B. salicina, B. salicifolia*
BB	Burro Bush	*Hymenoclea monogyra*
C	Cottonwood	*Populus fremontii*
Ce	Cedar (cultivated)	Various Species
Cu	Culivated	Various Species
CW	Coyote Willow	*Salix exigua*
DW	Desert Willow	*Chilopsis linearis*
GO	Grey Oak	*Quercus grisea*
HM	Honey Mesquite	*Prosopis glandulosa*
LW	Little Walnut	*Juglans microcarpa*
MB	Mulberry	*Morus* sp.
NLH	Netleaf Hackberry	*Celtis laevigata*
PP	Ponderosa Pine (cultivated)	*Pinus ponderosa*
Qu	Oak	*Quercus* sp.
RB	Rubber Rabbitbrush	*Ericameria nauseosus*
SB	Soapberry	*Sapundus saporina*
SC	Saltcedar	*Tamarix* sp.
SE	Siberian Elm	*Ulmus pumila*
TH	Tree of Heaven	*Ailanthus altissima*
TW	Goodding's Willow	*Salix gooddingii*
VA	Velvet Ash	*Fraxinus velutina*

Table 4-5

Mean Lifeform Cover in Copper Flat Mine Permit Area Strata

Stratum	Perennial Grasses	Perennial Forbs	Shrubs/ Trees	Total Perennial	Annuals	Total Cover
Chihuahuan Desert Grassland	38%	4%	14%	**55%**	9%	**64%**
Chihuahuan Desert Shrubland	9%	8%	20%	**37%**	5%	**42%**
Disturbed Area/Waste Rock Pile	19%	4%	9%	**31%**	7%	**39%**
Tailing Dam	21%	1%	12%	**34%**	0%	**34%**
Pit	2%	1%	2%	**4%**	0%	**4%**
Arroyo	6%	0%	19%	**25%**	0%	**25%**

Table 4-6

Mean Primary Production (lbs/acre) in Copper Flat Mine Permit Area Strata

Stratum	Perennial Grasses	Perennial Forbs	Shrubs/ Trees	Total Perennial	Annuals	Total Annual Production
Chihuahuan Desert Grassland	952.7	112.1	200.7	1,265.5	167.9	1,433.4
Chihuahuan Desert Shrubland	260.3	172.3	654.0	1,086.6	187.5	1,274.1
Disturbed Area/Waste Rock Pile	417.9	98.1	310.2	826.2	91.4	917.6
Tailing Dam	396.9	3.6	406.9	807.4	14.6	822.0
Pit	96.5	0.0	150.8	247.3	0.8	248.1

Table 4-7

Mean Woody Plant Density (plants/acre) in Copper Flat Mine Permit Area Strata

Stratum	Mean Woody Plants per Acre
Chihuahuan Desert Grassland	2,381.7
Chihuahuan Desert Shrubland	3,249.5
Disturbed Area/Waste Rock Pile	2,779.0
Tailing Dam	1,951.4
Pit	291.5
Arroyo	6,005.4

Table 4-8

Copper Flat Mine Permit Area Plant Species List

Scientific Name	Common Name	Abbrev.	Lifeform	Life History	Transect Sample	State-listed Weed	Native or Non-native
Acourtia nana	Dwarf desert holly	ACNA	forb	perennial	yes	no	nat
Aloysia wrightii	High mass or Wright's lippia	ALWR	shrub	perennial	yes	no	nat
Amaranthus hybridus	Hybrid pigweed	AMHY	forb	annual	yes	no	non
Amaranthus palmeri	Palmer's pigweed	AMPA	forb	annual	yes	no	nat
Amaranthus powellii	Powell's pigweed	AMPO	forb	annual	yes	no	nat
Ambrosia artemisiifolia	Common ragweed	AMAR	forb	annual	no	no	nat
Ambrosia confertiflora *(A. confertifolia, Franseria tenuifolia, F. confertiflora)*	Slimleaf bursage	AMCO	forb	perennial	yes	no	nat
Amorpha fruticosa	False indigo bush	AMFR	shrub	perennial	yes	no	nat
Andropogon hallii	Sand bluestem	ANHA	grass-w	perennial	yes	no	nat
Aristida adscensionis	Six-weeks three-awn grass	ARAD	grass-w	annual	yes	no	nat
Aristida divaricata	Poverty three-awn grass	ARDI	grass-w	perennial	yes	no	nat
Aristida havardii	Havard's three-awn grass	ARHA	grass-w	perennial	yes	no	nat
Aristida purpurea	Purple three-awn grass	ARPU	grass-w	perennial	yes	no	nat
Aristida ternipes	Spider three-awn grass	ARTE	grass-w	perennial	yes	no	nat
Artemisia franserioides	Rageweed sage	ARFR	forb	perennial	yes	no	nat
Artemisia ludoviciana subsp. *ludoviciana*	Louisiana (prairie) sage	ARLUL	forb	perennial	yes	no	nat
Asclepias subverticillata	Poison milkweed	ASSU	forb	perennial	no	no	nat
Astragalus crassicarpus	Ground plum	ASCR	forb	perennial	yes	no	nat
Astragalus sp.	Milkvetch (species not identified)	AST	forb	perennial	yes	no	nat

Scientific Name	Common Name	Abbrev.	Lifeform	Life History	Transect Sample	State-listed Weed	Native or Non-native
Atriplex canescens	Four-wing saltbush	ATCA	shrub	perennial	yes	no	nat
Baccharis emoryi, B. salicina, or *B. salicifolia*	Emory baccharis, seepwillow, Baccharis	BAEM	shrub	perennial	yes	no	nat
Baccharis pteronioides	Yerba-de-pasmo	BAPT	shrub	perennial	yes	no	nat
Bahia absinthifolia	Sageleaf (or silverleaf) bahia	BAAB	forb	perennial	yes	no	nat
Baileya multiradiata	Desert marigold	BAMU	forb	perennial/ biennial	yes	no	nat
Boerhaavia coccinea	Scarlet spiderling	BOCO	forb	perennial	yes	no	nat
Boerhaavia erecta	Erect spiderling	BOER	forb	annual	no	no	nat
Boerhaavia spicata	Annual pink spiderling	BOSP	forb	annual	yes	no	nat
Boerhaavia sp.	Spiderling (unidentified)	BOE	forb	annual	yes	no	nat
Bothriochloa barbinodis	Cane bluestem	BOBA	grass-w	perennial	yes	no	nat
Bothriochloa laguroides (Andropogon saccharoides)	Silver bluestem	BOLA	grass-w	perennial	yes	no	nat
Bouteloua aristidoides	Needle grama	BOAR	grass-w	annual	yes	no	nat
Bouteloua barbata	Six-weeks grama	BOBA	grass-w	annual	yes	no	nat
Bouteloua curtipendula	Side oats grama grass	BOCU	grass-w	perennial	yes	no	nat
Bouteloua eriopoda	Black grama	BOER	grass-w	perennial	yes	no	nat
Bouteloua gracilis	Blue grama grass	BOGR	grass-w	perennial	yes	no	nat
Bouteloua hirsuta	Hairy grama grass	BOHI	grass-w	perennial	yes	no	nat
Brickellia californica	California brickelbush	BRCAL	shrub	perennial	yes	no	nat
Calliandra humilis	Low fairy duster	CAHU	forb	perennial	yes	no	nat
Calliandra eriophylla	Fairy duster or mesquitilla	CAER	shrub	perennial	yes	no	nat
Celtis leavigata (C. reticulata)	Netleaf hackberry	CELE	tree	perennial	yes	no	nat

Scientific Name	Common Name	Abbrev.	Lifeform	Life History	Transect Sample	State-listed Weed	Native or Non-native
Chaetopappa ericoides	Baby aster	CHER	forb	perennial	yes	no	nat
Chamaesaracha coronopus	Green-leaf five eyes	CHCO	forb	perennial	yes	no	nat
Chamaesaracha sordida (C. conioides)	Gray five-eyes	CHSO	forb	perennial	yes	no	nat
Chamaesyce albomarginata	Rattlesnake weed	CHAL	forb	perennial	yes	no	nat
Chamaesyce serpyllifolia	Thyme-leaved spurge	CHSE	forb	annual	no	no	nat
Chamaesyce sp.	Spurge (species not identified)	CHA	forb	perennial	yes	no	nat
Chamaesyce sp.	Spurge (species not identified)	CHA	forb	annual	yes	no	nat
Chenopodium album	Lamb's quarters	CHALM	forb	annual	yes	no	non
Chenopodium leptophyllum	Narrow-leaved goosefoot	CHLE	forb	annual	yes	no	nat
Chenopodium neomexicanum	New Mexico goosefoot	CHNE	forb	annual	yes	no	nat
Chenopodium sp.	Goosefoot (species unidentified)	CHE	forb	annual	yes	no	nat
Chilopsis linearis	Desert willow	CHLI	shrub	perennial	yes	no	nat
Chloris virgata	Feather finger grass	CHVI	grass-w	annual	yes	no	nat
Cirsium neomexicanum	New Mexico thistle	CINE	forb	perennial	no	no	nat
Cryptantha cinerea (C. jamesii)	Bownut popcorn flower (James' cat's-eye)	CRCI	forb	perennial	no	no	nat
Dalea aurea	Golden silkthumb	DAAU	forb	perennial	no	no	nat
Dalea formosa	Feather dalea (feather indigo)	DAFO	shrub	perennial	yes	no	nat
Dalea jamesii	James' dalea	DAJA	forb	perennial	yes	no	nat
Dalea lanata	Woolly dalea	DALA	forb	perennial	yes	no	nat
Dalea pogonathera	Bearded dalea	DAPO	forb	perennial	no	no	nat
Dasylirion wheeleri	Wheeler sotol	DAWH	shrub	perennial	yes	no	nat
Dasyochloa pulchella (Erioneuron pulchellum)	Fluff grass	DAPUL	grass-w	perennial	yes	no	nat

Scientific Name	Common Name	Abbrev.	Lifeform	Life History	Transect Sample	State-listed Weed	Native or Non-native
Descurainia pinnata	Western tansy mustard	DEPI	forb	annual	yes	no	nat
Descurainia sophia	Flixweed	DESO	forb	annual	no	no	non
Desmanthus cooleyi	Bundleflower	DECO	forb	perennial	yes	no	nat
Digitaria sp.	Crab grass	DIG	grass-w	annual	yes	no	non
Elymus longifolius (Sitanion hystrix)	Squirrel-tail (bottlebrush) grass	SIHY	grass-c	perennial	yes	no	nat
Enneapogon desvauxii	Spike pappusgrass	ENDE	grass-w	perennial	yes	no	nat
Ephedra trifurca	Big joint-fr (Mormon tea)	EPTR	shrub	perennial	yes	no	nat
Eragrostis cilianensis	Stinkgrass	ERCI	grass-w	annual	no	no	non
Eragrostis curvula	Weeping lovegrass	ERCU	grass-w	perennial	yes	no	non
Eragrostis intermedia	Plains lovegrass	ERIN	grass-w	perennial	yes	no	nat
Eragrostis lehmanniana	Lehmann's lovegrass	ERLEH	grass-w	perennial	yes	no	non
Eragrostis pectinacea	Carolina lovegrass	ERPE	grass-w	annual	yes	no	nat
Ericameria (Chrysothamnus) nauseosa	Rubber rabbitbrush	CHNA	shrub	perennial	yes	no	nat
Erigeron flagellaris	Whiplash daisy fleabane	ERFL	forb	biennial	yes	no	nat
Eriogonum effusum	Spreading buckwheat	EREF	forb (subshrub)	perennial	yes	no	nat
Eriogonum cf. pharnaceoides	Wirestem buckwheat	ERPH	forb	annual	yes	no	nat
Eriogonum rotundifolium	Round-leaf buckwheat	ERRO	forb	annual	yes	no	nat
Eriogonum sp.	Buckwheat (unidentified)	ERO	forb	perennial	yes	no	nat
Eriogonum wrightii	Wright's buckwheat	ERWR	forb (subshrub)	perennial	yes	no	nat
Erodium cicutarium	Red-stemmed filaree	ERCI	forb	biennial	no	no	non
Evolvulus nuttallianus	Hairy evolvulus	EVNU	forb	perennial	yes	no	nat

Scientific Name	Common Name	Abbrev.	Lifeform	Life History	Transect Sample	State-listed Weed	Native or Non-native
Fallugia paradoxa	Apache plume	FAPA	shrub	perennial	yes	no	nat
Festuca sp.	Fescue grass	FES	grass-c	perennial	yes	no	nat
Flourensia cernua	Tarbush	FLCE	shrub	perennial	yes	no	nat
Fouquieria splendens	Ocotillo	FOSP	shrub	perennial	yes	no	nat
Fraxinus velutina	Velvet ash	FRVE	tree	perennial	no	no	nat
Glandularia bipinnatifida	Pink (or Dakota) vervain	GLBI	forb	perennial/ biennial	yes	no	nat
Guilleminia densa	Small matweed	GUDE	forb	annual	yes	no	nat
Gutierrezia sarothrae	Broom snakeweed	GUSA	shrub	perennial	yes	no	nat
Gutierrezia wrightii	Matchweed	GUWR	forb	annual	no	no	nat
Halimolobos diffusus (Sisymbrium diffusum)	Mustard	HADI	forb	perennial/ biennial	yes	no	nat
Hesperostipa (Stipa) comata	Needle-and-thread grass	HECO	grass-c	perennial	yes	no	nat
Hoffmannseggia glauca	Hog potato	HOGL	forb	perennial	yes	no	nat
Hymenoclea monogyra	Burro bush	HYMO	shrub	perennial	yes	no	nat
Ipomopsis longiflora	Large trumpet gilia	IPLO	forb	annual	yes	no	nat
Isocoma tenuisecta	Goldenweed	ISTE	forb (subshrub)	perennial	no	no	nat
Janusia gracilis	Desert vine, janusia, or fermina	JAGR	forb	perennial	yes	no	nat
Juglans microcarpa	Little walnut	JUMI	tree	perennial	no	no	nat
Juniperus monosperma	One-seed juniper	JUMO	tree	perennial	yes	no	nat
Kallstroemia grandiflora	Caltrop or desert poppy	KAGR	forb	annual	no	no	nat
Kallstroemia parviflora	Warty carpetweed	KAPA	forb	annual	yes	no	nat
Kochia scoparia (Bassia scoparia)	Summer cypress (mock cypress, "kosha", burningbush)	KOSC	forb	annual	no	no	non

Scientific Name	Common Name	Abbrev.	Lifeform	Life History	Transect Sample	State-listed Weed	Native or Non-native
Lactuca serriola	Prickly lettuce	LASE	forb	biennial	no	no	non
Larrea tridentata	Creosote bush	LATR	shrub	perennial	yes	no	nat
Lepidium cf. montanum	Mountain pepperweed	LEMO	forb	perennial/ biennial	yes	no	nat
Leptochloa dubia	Green sprangletop	LEDU	grass-w	perennial	yes	no	nat
Linum neomexicanum	New Mexico yellow flax	LINE	forb	annual	yes	no	nat
Lycium pallidum	Pale wolfberry	LYPA	shrub	perennial	yes	no	nat
Lycium torreyi	Torrey wolfberry	LYTO	shrub	perennial	yes	no	nat
Lycurus phleoides	Common wolftail grass	LYPH	grass-w	perennial	yes	no	nat
Machaeranthera gracilis	Annual goldenweed	MAGR	forb	annual	yes	no	nat
Machaeranthera pinnatifida	Perennial goldenweed	MAPI	forb	perennial	yes	no	nat
Machaeranthera tanacetifolia	Tansy aster	MATA	forb	annual/biennial	yes	no	nat
Marrubium vulgare	Horehound	MAVU	forb	perennial	yes	no	non
Melampodium leucanthum	Ash-gray blackfoot daisy	MELE	forb	perennial	yes	no	nat
Melilotus officinalis	Yellow sweet clover	MEOF	forb	annual/ biennial/ perennial	no	no	non
Menodora scabra	Rough menodora	MESC	shrub	perennial	yes	no	nat
Mentzelia pumila	Blazing star stickleaf	MEPU	forb	biennial	yes	no	nat
Mimosa aculeaticarpa	Cat-claw mimosa or wait-a-bit	MIAC	shrub	perennial	yes	no	nat
Muhlenbergia depauperata	Six-weeks muhly	MUDE	grass-w	annual	yes	no	nat
Muhlenbergia porteri	Bush muhly grass	MUPO	grass-w	perennial	yes	no	nat
Opuntia chlorotica	Pancake prickly pear	OPCH	shrub (subshrub)	perennial	yes	no	nat

Scientific Name	Common Name	Abbrev.	Lifeform	Life History	Transect Sample	State-listed Weed	Native or Non-native
Opuntia phaeacantha	Brown-spine prickly pear	OPPH	shrub (subshrub)	perennial	yes	no	nat
Panicum capillare	Common witchgrass	PACA	grass-w	annual	yes	no	nat
Panicum obtusum	Vine mesquite	PAOB	grass-w	perennial	yes	no	nat
Parthenium confertum (P. lyratum)	Rubberbush	PACO	forb	perennial	no	no	nat
Parthenium incanum	Mariola	PAIN	shrub	perennial	yes	no	nat
Pectis angustifolia	Lemonweed or limoncillo	PEAN	forb	annual	yes	no	nat
Pectis filipes	Threadstem chinchweed	PEFI	forb	annual	yes	no	nat
Pectis longipes	Barestem chinchweed	PELO	forb	perennial	yes	no	nat
Phacelia sp.	Scorpion weed (unidentified)	PHA	forb	annual	yes	no	nat
Phaseolus metcalfei	Metcalf limabean	PHME	forb	perennial	no	no	nat
Phemeranthus aurantiacus (Talinum auranticacum)	Orange flame-flower	PHAU	forb	perennial	yes	no	nat
Piptatherum micranthum (Oryzopsis micrantha)	Little-seed ricegrass	PIMI	grass-c	perennial	yes	no	nat
Plantago patagonica	Woolly plantain	PLPA	forb	annual	yes	no	nat
Pleuraphis mutica	Tobosa grass	PLMU	grass-w	perennial	yes	no	nat
Polanisia dodecandra	Clammy weed	PODO	forb	annual	yes	no	nat
Populus fremontii	Fremont's cottonwood, Plains cottonwood	POFR	tree	perennial	no	no	nat
Portulaca pilosa (P. mundula)	Rose purslane or verdolaga	POPI	forb	perennial	yes	no	nat
Portulaca suffrutescens	Copper purslane	POSU	forb	perennial	no	no	nat
Prosopis glandulosa	Honey mesquite	PRGL	shrub	perennial	yes	no	nat
Quercus emoryi	Emory oak	QUEM	tree	perennial	yes	no	nat
Quercus turbinella	Scrub live oak	QUTU	tree	perennial	yes	no	nat

Scientific Name	Common Name	Abbrev.	Lifeform	Life History	Transect Sample	State-listed Weed	Native or Non-native
Rhus microphylla	Little-leaf sumac	RHMI	shrub	perennial	yes	no	nat
Rhus trilobata	Three-leaf sumac	RHTR	shrub	perennial	yes	no	nat
Salsola tragus (S. kali)	Russian thistle or tumbleweed	SATR	forb	annual	yes	no	non
Salix exigua	Coyote willow or sandbar willow	SAEX	shrub	perennial	no	no	nat
Salix gooddingii	Goodding's willow	SAGO	tree	perennial	no	no	nat
Sapundus saponaria	Soapberry	SASA	tree	perennial	no	no	nat
Scleropogon brevifolius	Burrograss	SCBR	grass-w	perennial	yes	no	nat
Senecio flaccidus	Threadleaf groundsel	SEFL	shrub (subshrub)	perennial	yes	no	nat
Senna bauhinioides	Twinleaf	SEBA	forb	perennial	yes	no	nat
Setaria leucopila	Plains bristle grass	SELE	grass-w	perennial	yes	no	nat
Sida abutifolia (S. filicaulis, S. procumbens)	Spreading fanpetals	SIAB	forb	perennial	yes	no	nat
Sisymbrium altissimum	Tumble mustard	SISA	forb	annual/ biennial/ perennial	no	no	non
Solanum elaeagnifolium	Silver-leaf nightshade	SOEL	forb	perennial	yes	no	nat
Solanum rostratum	Buffalo burr	SORO	forb	annual	yes	no	nat
Sphaeralcea angustifolia	Narrowleaf globemallow	SPAN	forb	perennial	yes	no	nat
Sphaeralcea grossulariifolia	Gooseberryleaf globemallow	SPGR	forb	perennial	yes	no	nat
Sphaeralcea hastulata	Wrinkled globemallow	SPHA	forb	perennial	yes	no	nat
Sporobolus contractus	Spike dropseed	SPCON	grass-w	perennial	yes	no	nat
Sporobolus cryptandrus	Sand dropseed	SPCR	grass-w	perennial	yes	no	nat
Sporobolus giganteus	Giant dropseed	SPGI	grass-w	perennial	yes	no	nat
Stephanomeria pauciflora	Wire lettuce	STPA	forb	perennial	yes	no	nat

Scientific Name	Common Name	Abbrev.	Lifeform	Life History	Transect Sample	State-listed Weed	Native or Non-native
Tamarix chinensis	Saltcedar or tamarisk	TACH	tree	perennial	yes	yes	non
Thymophylla acerosa (Dyssodia acerosa)	Spiny dogweed	THAC	shrub (subshrub)	perennial	yes	no	nat
Thymophylla pentacheata	Five-needle dogweed	THPE	forb	perennial	yes	no	nat
Tidestromia lanuginosa	Woolly honeysweet	TILA	forb	annual	yes	no	nat
Tragia sp.	Noseburn	TRA	forb	perennial	yes	no	nat
Tridens muticus	Slim tridens grass	TRMU	grass-w	perennial	yes	no	nat
Verbesina encelioides	Cowpen daisy or golden crownbeard	VEEN	forb	annual	yes	no	nat
Yucca elata	Soaptree yucca	YUEL	shrub	perennial	yes	no	nat
Zinnia grandiflora	Wild zinnia	ZIGR	forb	perennial	yes	no	nat

Table 4-9

General Shannon-Weiner (S-W) Index Results Based on Percent Cover for Copper Flat Mine Permit Area Strata

Stratum	Perennial Plant Species Cover	Cover All Plant Species
Chihuahuan Desert Grassland	2.89	3.04
Chihuahuan Desert Shrubland	3.01	3.3
Disturbed Area/Waste Rock Pile	3.03	3.34
Tailing Dam	1.74	1.79
Pit	1.62	1.62
Arroyo	1.28	1.28

Table 4-10

Species Richness Based on Species Intercepts at Cover Transects for Copper Flat Mine Permit Area Strata

Stratum	Perennial Plant Species Cover	Cover All Plant Species
Chihuahuan Desert Grassland	2.89	3.04
Chihuahuan Desert Shrubland	3.01	3.3
Disturbed Area/Waste Rock Pile	3.03	3.34
Tailing Dam	1.74	1.79
Pit	1.62	1.62
Arroyo	1.28	1.28

Table 4-11

Number of Transects Required to Meet Sample Adequacy (as ± 10% of the mean) for Copper Flat Mine Permit Area Strata

Stratum	Sample Adequacy Perennial Plant Species Cover	Sample Adequacy All Plant Species Cover	Sample Adequacy Total Cover	Total Number of Transects Actually Recorded
Chihuahuan Desert Grassland	8.9	12.6	2.5	29
Chihuahuan Desert Shrubland	38.8	49.1	13.1	19
Disturbed Area/Waste Rock Pile	104.3	86.8	17.5	25
Tailing Dam	9.7	10.0	0.2	10
Pit	3,032.1	3,032.1	231.5	10
Arroyo	257.8	257.8	31.3	3
				96

Table 4-12

Threatened, Endangered, and Plant Species of Concern with Occurrences in Sierra County

Species Name	Common Name	Habitat Notes	Agency Status		Habitat Present (Y/N)
			USFWS	NM	
Agastache cana	Grayish-white giant hyssop	Crevices and bases of granite cliffs or in canyons with small-leaved oaks at the upper edge of the desert and lower edge of the piñon-juniper zone, at 1,400-1,800 m (4,600-5,900 ft).	–	Species of Concern	No
Astragalus castetteri	Castetter's milkvetch	Dry, rocky slopes in montane scrub and open juniper woodland; 1,520 - 2,150 m (5,000 - 7,050 ft).	–	Species of Concern	No
Chenopodium cycloides	Sandhill goosefoot	Open sandy areas especially around blowouts on sand dunes; 800 - 1,500 m (2,600 - 5,000 ft).	Species of Concern	Species of Concern	No
Cirsium wrightii	Wright's marsh thistle	Wet, alkaline soils in spring seeps and marshy edges of streams and ponds; 1,130 -2,600 m (3,450 - 8,500 ft).	–	Endangered	No
Cuscuta warneri	Warner's dodder	Grows on Phyla in open wet areas that support the host species; 1,430 - 1,460 m (4,700 - 4,800 ft.)	–	Species of Concern	No
Desmodium metcalfei	Metcalfe's ticktrefoil	Rocky slopes, canyons in grasslands, oak/pinion-juniper woodland, and riparian forests at 1,310 - 2,000 m (4,000 - 6,500 ft.)	–	Species of Concern	No
Draba mogollonica	Mogollon whitlowgrass	Cool, moist northern slopes of mountains, ravines and canyons on volcanic rocks and soil in montane forests at 1,500 - 2,900 m (5,000 - 9,000 ft.)	–	Species of Concern	No
Draba standleyi	Standley's whitlowgrass	Igneous rock faces, bases of overhanging cliffs, clefts of porphyritic and andesitic rocks and soil; 1,675-1,980 m (5,500-6,500 ft).	–	Species of Concern	No
Erigeron scopulinus	Rock fleabane	Crevices in cliff faces of rhyolitic rock in lower montane coniferous forests at 1,800 - 2,800 m (6,000 - 9,000 ft).	–	Species of Concern	No
Escobaria (Corypantha) duncanii	Duncan's pincushion cactus	Cracks in limestone and limy shale in broken terrain in Chihuahuan desert scrub at 1,550 (5,100 ft).	Species of Concern	Endangered	Possible but not observed
Escobaria sandbergii	Sandberg pincushion cactus	Rocky, igneous and limestone soils in Chihuahuan desert scrub and open oak and pinion-juniper woodland in mountainous terrain; 1,300 - 2,250 m (4,200 - 7,400 ft).	–	Species of Concern	Possible but not observed

Species Name	Common Name	Habitat Notes	Agency Status		Habitat Present (Y/N)
			USFWS	NM	
Grindelia arizonica var. *neomexicana*	New Mexico gumweed	Rocky slopes and ledges in pinion-juniper woodland and lower montane coniferous forests at 2,000 - 2,300 m (6,500 - 7,500 ft.)	–	Species of Concern	No
Hedeoma todsenii	Todsen's pennyroyal	Plants grow in loose, gypseous-limestone soils associated with or position immediately below the Permian Yeso Formation; usually on steep north or east-facing slopes in pinon-juniper woodland at 1,900 - 2,300 m (6,200 - 7,400 ft).	Endangered	Endangered	No
Hexalectris spicata var. *arizonica*	Arizona coralroot	In heavy leaf litter in oak, pine, or juniper woodlands over limestone.	–	Endangered	No
Hymenoxys vaseyi	Vasey's bitterweed	Dry sites with coarse soils in montane scrub and pinon-juniper woodland at 2,100 - 2,500 m (6,900 - 8,200 ft).	–	Species of Concern	No
Penstemon metcalfei	Metcalfe's penstemon	Cliffs or steep, north-facing slopes in lower and upper montane coniferous forest at 2,000 - 2,900 m (6,600 - 9,500 ft).	–	Species of Concern	No
Perityle staurophylla var. *homoflora*	San Andres rock daisy	Crevices in limestone clifss, usually on protected north and east exposures at about 1,950-2,150 m (6,400 - 7,000 ft).	–	Species of Concern	No
Perityle staurophylla var. *staurophylla*	New Mexico rock daisy	Crevices in limestone cliffs and boulders, usually on protected north and east exposures; 1,500 - 2,100 m (4,900 - 7,000 ft).	–	Species of Concern	No
Physaria gooddingii	Goodding's bladderpod	Open areas in piñon-juniper woodland and ponderosa pine forest. It occurs occasionally on highway rights-of-way where some populations may be susceptible to disturbance.	–	Species of Concern	No
Silene plankii	Plank's campion	Igneous cliffs and rocky outcrops, 1,500 - 2,800 m (5,000 - 9,200 ft.)	–	Species of Concern	No
Silene thurberi	Thurber's campion	In protected locations on rocky areas and slopes; in arroyos and mountains at elevations possibly between 1,520 - 2,130 m (5,000 - 7,000 ft.)	–	Species of Concern	Possible but not observed

Species Name	Common Name	Habitat Notes	Agency Status		Habitat Present (Y/N)
			USFWS	NM	
Silene wrightii	Wright's campion	Cliffs and rocky outcrops in Rocky Mountain montane and subalpine conifer forests; about 2,070 - 2,440 m (6,800 - 8,000 ft).	–	Species of Concern	No
Talinum humile (Phemeranthus humilis)	Pinos Altos flame flower	Shallow, gravelly, usually clayey soils overlying rhyolite, usually on rock benches in sloping terrain, but also in soil pockets overlying rock in nearly level areas; Madrean grassland, oak woodland or pinion-juniper woodland; often growing with *Nolina microcarpa* and *Agave parryii*.	Species of Concern	Species of Concern	No

Table 4-13

Structure Type Acreage in the Detailed Arroyo/Riparian Mapping for the Permit Area Study Site

Structure Type	Acres
1	0.0
2	0.0
3	7.4
4	5.9
5	34.0
6	2.4
MH	0.1
TOTAL	**49.8**

Table 4-14

Summary of the Acres in which Species were Considered (Co-) Dominants in the Detailed Arroyo/Riparian Mapping for the Permit Area Study Site

H&O Species Code	Common Name	Acres
AP	Apache Plume	10.0
B	Baccharis	22.2
BB	Burro Bush	15.5
C	Cottonwood	5.0
HM	Honey Mesquite	13.8
NLH	Netleaf Hackberry	2.5
Qu	Oak	6.6
RB	Rubber Rabbitbrush	0.4
SC	Saltcedar	7.6
TW	Goodding's Willow	1.8
VA	Velvet Ash	0.7

Table 4-15

Plant Species Encountered in the Pipeline Corridor

Scientific Name	Common Name
Acourtia nana	Dwarf desertpeony
Amaranthus powellii	Powell's amaranth
Ambrosia acanthicarpa	Flatspine bur ragweed
Ambrosia confertiflora	Weakleaf bur ragweed
Ambrosia trifida	Great ragweed
Andropogon hallii	Sand bluestem
Aristida adscensionis	Sixweeks threeawn
Aristida purpurea	Purple threeawn
Aristida ternipes	Spidergrass
Astragalus crassicarpus	Groundplum milkvetch
Atriplex canescens	Fourwing saltbush
Baccharis pteronioides	Yerba de pasmo
Baileya multiradiata	Desert marigold
Bothriochloa laguroides	Silver beardgrass
Bouteloua barbata	Sixweeks grama
Bouteloua curtipendula	Side-oats grama
Bouteloua eriopoda	Black grama
Bouteloua gracilis	Blue grama
Brickellia californica	California brickellbush
Celtis laevigata	Netleaf hackberry
Chamaesyce albomarginata	Whitemargin sandmat
Cirsium neomexicanum	New Mexico thistle
Cirsium ochrocentrum	Yellowspine thistle
Corispermum americanum	American bugseed
Cuscuta sp.	Dodder
Cylindropuntia imbricata	Tree cholla
Cylindropuntia leptocaulis	Christmas cactus
Dalea formosa	Featherplume
Dasyochloa pulchella	Low woollygrass
Datura wrightii	Sacred thorn-apple
Dyssodia papposa	Fetid marigold
Echinocereus coccineus	Scarlet hedgehog cactus
Ephedra trifurca	Big jointfir
Eragrostis curvula	Weeping lovegrass
Eriogonum effusum	Spreading buckwheat

Scientific Name	Common Name
Evolvulus nuttallianus	Shaggy dwarf morning-glory
Fallugia paradoxa	Apache plume
Flourensia cernua	Tarbush
Gutierrezia sarothrae	Broom snakeweed
Hoffmannseggia glauca	Indian rushpea
Koeberlinia spinosa	Crown of thorns
Lappula occidentalis	Flatspine stickseed
Larrea tridentata	Creosote
Leptochloa dubia	Green sprangletop
Lycium pallidum	Pale wolfberry
Lycium torreyi	Torrey wolfberry
Machaeranthera gracilis	Slender goldenweed
Menodora scabra	Rough menodora
Muhlenbergia porteri	Bush muhly
Opuntia engelmannii	Cactus apple
Opuntia macrocentra	Purple pricklypear
Panicum obtusum	Vine mesquite
Parthenium incanum	Mariola
Pectis angustifolia	Lemonscent
Pleuraphis mutica	Tobosagrass
Prosopis glandulosa	Honey mesquite
Rhus microphylla	Littleleaf sumac
Scleropogon brevifolius	Burrograss
Solanum elaeagnifolium	Silverleaf nightshade
Sphaeralcea hastulata	Spear globemallow
Stephanomeria pauciflora	Brownplume wirelettuce
Thelesperma megapotamicum	Greenthread
Thymophylla acerosa	Spiny dogweed
Tidestromia lanuginosa	Woolly tidestromia
Yucca baccata	Banana yucca
Yucca elata	Soaptree yucca
Ziziphus obtusifolia	Graythorn

Table 4-16

Structure Type Acreage in the Detailed Arroyo/Riparian Mapping for the Las Animas Creek Study Site

Structure Type	Acres
1	230.8
2	47.7
3	59.0
4	118.2
5	0.0
6	0.0
Cultivated	7.3
TOTAL	**462.9**

Table 4-17

Summary of the Acres in which Species were Considered (Co-) Dominants in the Detailed Arroyo/Riparian Mapping for the Las Animas Creek Study Site

H&O Species Code	Common Name	Acres
C	Cottonwood	213.1
SE	Siberian Elm	1.8
VA	Velvet Ash	175.7
NLH	Netleaf Hackberry	226.0
Qu	Oak	1.6
BB	Burro bush	85.3
LW	Little Walnut	22.7
CW	Coyote Willow	25.7
TW	Goodding’s Willow	52.9
SC	Saltcedar	0.7
B	Baccharis	51.6
Cu	Culivated	10.7
HM	Honey Mesquite	71.6
SB	Soapberry	3.2
AS	Arizona Sycamore	261.6
GO	Grey Oak	3.1
MB	Mulberry	0.2

Table 4-18

Height, Diameter Breast Height, and Condition of Arizona Sycamore Reference Trees in the Las Animas Creek Study Area

Tree Tag	Diameter Breast Height (in)	Height (ft)	% Dead	% Stress	Photo File Name
882	15.0, 16.2	53	1%	0%	2996
886	76.9	65	1%	0%	2997
878	5.3	19	5%		3005
893	33.8	93	5%		3006-3009
899	88.5	116	<1%		3010-3012
892	0.7	7.2	0%	0%	3041
891	7.7, 5.0	23	0%	0%	3046-3047
428	13.7	40.5	<1%	0%	3053
894	42.1	87	0%	0%	3054
889	2.8	16	0%	<1%	3055
879	8	24.5	0%	1-5%	3059
900	13.7, 11.5	57.5	0%	0%	3058
896	0.2	5.3	0%	1-5%	3060
895	49.3	65	1%	0%	3061-3062
888	28.5, 29.0, 23.1, 35.2, 47.7	97	1-5%	1-5%	3063-3064
885	76.8	115	10%	10%	2981-2983
897	20.0, 6.1, 5.1	25.5	25%	25-50%	3065-3066
993	72.2, 34.1	111	1-5%	1-5%	3067-3069
887	42.1	58	<1%	0%	3072-3074
1000	43.4	90	<1%	0%	3075-3077
996	1	6.4	0%	0%	3078-3080
994	11.5	59.5	5%	1-5%	3081
995	5.7, 2.6	23.5	25-50%	10-25%	3082-3083
999	9.5	32.5	0%	0%	3084-3085
997	26.2	45	1-5%	5-10%	3086-3088

Table 4-19

Structure Type Acreage in the Detailed Arroyo/Riparian Mapping for the Percha Creek Study Site

Structure Type	Acres
1	11.3
2	34.7
3	156.9
4	91.3
5	654.6
6	0.0
Bedrock/No Vegetation	1.4
TOTAL	**950.2**

Table 4-20

Summary of the Acres in which Species were Considered (Co-) Dominants in the Detailed Arroyo/Riparian Mapping for the Percha Creek Study Site

H&O Species Code	Common Name	Acres
C	Cottonwood	154.6
SE	Siberian Elm	22.3
VA	Velvet Ash	43.2
NLH	Netleaf Hackberry	152.0
BB	Burro Bush	636.0
DW	Desert Willow	34.2
LW	Little Walnut	45.2
CW	Coyote Willow	13.4
TW	Goodding's Willow	50.5
B	Baccharis	419.4
TH	Tree of Heaven	4.5
PP	Ponderosa Pine (cultivated)	8.3
Ce	Cedar (cultivated)	8.3
HM	Honey Mesquite	319.7

Figures

Appendix 4-A

Detailed Plant Cover Summaries by Stratum and Transect in the Copper Flat Mine Permit Area

Appendix 4-B

Detailed Primary Plant Production Summaries by Stratum and Transect in the Copper Flat Mine Permit Area

Appendix 4-C

Detailed Shrub Density Summaries by Stratum and Transect in the Copper Flat Mine Permit Area

Appendix 4-D

Hink and Ohmart Vegetation Mapping in the Copper Flat Mine Permit Area

Appendix 4-E

Hink and Ohmart Vegetation Mapping in the Las Animas Creek Study Area

Appendix 4-F

Hink and Ohmart Vegetation Mapping in the Percha Creek Study Area

5 Wildlife Survey Results

5.1 Introduction

Parametrix, Inc. was contracted by New Mexico Copper Corporation to complete a wildlife assessment within the Copper Flat Mine permit area and off-site reference areas, as well as surrounding riparian habitats along Las Animas Creek and Percha Creek. This chapter summarizes the approach and results for characterizing wildlife abundance and habitat quality throughout the study sites, with a particular focus on species of concern. The study approach implemented for this report was adapted from the wildlife section of the Copper Flat SAP (Parametrix, 2010). Agency review comments and requests were incorporated into the methodology.

The area of the Copper Flat Mine is located within the Mexican Highlands section of the Basin and Range Physiographic Province. The dominant plant communities are Chihuahuan Desert Grassland (CDG), Chihuahuan Desert Shrubland (CDS), Arroyos, and heavily disturbed areas, some of which have been reclaimed. There is relatively little water on the permit area, except for the man-made pit lake, the area immediately east of the tailing dam where surface water collects, a stock pond in the southern portion of the site, and intermittent pools created by storms in the bottom of Greyback Arroyo. Greyback Arroyo, though intermittent, does support some riparian vegetation such as willows and saltcedar, which provides important wildlife habitat. Off-site reference areas provided comparison areas with the Arroyo, CDG, and CDS sites, though similarly little perennial water is present, except at the pond which was used for a reference area for the bat surveys. Animas and Percha Creeks, which were evaluated with differing methodologies from those used at the mine and reference areas, have perennial water and significantly different vegetation. Habitats delineated and described in Chapter 4 (Vegetation) are the same used for discussion of wildlife habitats.

5.2 Study Area

5.2.1 Copper Flat Mine Permit Area

The Copper Flat Mine permit area consists of several terrestrial habitats within the approximately 2,200-acre Copper Flat Mine permit area (Figure 5-1) and the pipeline corridor east of the mine site. Quantitative data collection was completed by stratum in the permit area, while walking surveys were implemented along the pipeline corridor. Observations from the pipeline surveys regarding the presence and absence of species were incorporated into the results of this report. A separate Biological Assessment (Parametrix, 2011) is also being drafted by Parametrix biologists (Appendix 5A). Please see that report for conditions and observations specific to the pipeline corridor. Habitat areas in the mine permit study area included:

<u>Chihuahuan Desert Shrubland</u>. Areas mostly on the eastern half of the site consist of flatter land with gravelly soils and surface vegetation dominated by shrubs (honey mesquite [*Prosopis glandulosa*], American tarwart [*Flourensia cernua*], and creosote bush [*Larrea tridentata*]); grasses (low woolygrass [*Dasyochloa pulchella*], sixweeks grama [*Bouteloua barbata*], and tobosa grass [*Pleuraphis mutica*]); and forbs (whitemargin sandmat [*Chamaesyce albomarginata*], wooly tidestromia [*Tidestromia lanuginosa*], and hairyseed bahia [*Bahia absinthifolia*]). For sampling on the mine site, areas were grouped into those expected either to be disturbed during mining activities or anticipated to remain undisturbed.

<u>Chihuahuan Desert Grassland</u>. Areas mostly on the western half of the site consist of hillier land with rocky soils and surface vegetation dominated by shrubs (broom snakeweed [*Gutierrezia sarothrae*], honey mesquite, and pricklyleaf dogweed [*Thymophylla acerosa*]) and scattered one-seed juniper (*Juniperus monosperma*); grasses (sideoats grama [*Bouteloua curtipendula*], black grama [*Bouteloua eriopoda*], and tobosa grass); and forbs

(fivebrack cinchweed [*Pectis filipes*], spreading buckwheat [*Eriogonum effusum*], and slender goldenweed [*Machaeranthera gracilis*]). For sampling on the mine site, areas were grouped into those expected either to be disturbed during mining activities or anticipated to remain undisturbed.

Pit. The pit is a heavily disturbed area created by previous mining activity. The little existing surface vegetation in the pit is dominated by brickellbush (*Brickellia californica*), silver beardgrass (*Bothriochloa laguroides*), and longstalk cinchweed (*Pectis longipes*).

Pit Lake. The pit includes a 5-acre freshwater lake at the bottom of the pit. The lake is perennially wet, as it sits at the level of the SF Group aquifer.

Arroyo. The Arroyo consists of several intermittent drainages such as Greyback Arroyo and other arroyos. Denser stands of more mesic trees and shrubs such as Emory oak (*Quercus emoryi*), saltcedar (*Tamarix ramosissima*), Emory's baccharis (*Baccharis emoryi*), and burro brush (*Hymenoclea monogyra*) are located in the Arroyo.

Tailing Dam. The approximately 200 ft wide and 4,600 ft long dam consists of compacted soil and rock. The dam is more heavily vegetated than the disturbed area/waste rock pile and is dominated by silver beardgrass, honey mesquite, and featherplume (*Dalea formosa*).

Disturbed Area/Waste Rock Pile (DA/WR). The DA/WR habitat consists of both partially reclaimed and generally loose rock piles and mostly flat and disturbed areas west of the tailing dam and in the areas previously disturbed by the previous mine processing and operational activities. The Disturbed Areas are dominated by grasses such as sideoats grama, cane bluestem (*Bothriochloa barbinodis*), and black grama, and forbs such as spreading buckwheat. The Waste Rock Piles are dominated by shrubs (broom snakeweed, honey mesquite, and Apache plume [*Fallugia paradoxa*]); grasses (low woolygrass, sideoats grama, and silver beardgrass); and forbs (spreading buckwheat and hairyseed bahia).

5.2.2 Off-Site Reference Areas

Off-site reference areas (Figures 5-2 through 5-7) were chosen by relative proximity to the mine and similarity in elevation and habitat, though no in-depth vegetation mapping was done in these areas. For some sites (e.g., the upland terrestrial sites where mammal trapping was done), it was relatively easy to locate similar habitat close to the mine. For other areas (e.g., the riparian and perennial wet areas where bat boxes were placed), locating similar habitat was more difficult. Habitat areas in off-site reference areas included:

- Chihuahuan Desert Shrubland. (See description above)
- Arroyo. (See description above)
- Lake/Riparian. Consisting of stock ponds and other areas of dense vegetation with permanent or intermittent water.

5.2.3 Las Animas Creek, Percha Creek / Percha Box, and Isolated Springs

Surface water and the habitat it creates are of particular interest because these sites often provide higher quality wildlife habitat and greater wildlife species density than surrounding desert areas, especially in desert areas (Hubbard, 1971; Carothers et al., 1974; Rice et al., 1983) similar to those present at the Copper Flat Mine permit area. In addition, concern has been voiced about the potential impacts to surface water from mine operations, particularly in Las Animas Creek. This is a riparian area that supports a diverse botanical and wildlife community that includes one of the very few active stands of Arizona sycamore (*Platanus wrightii*) trees east of the Continental Divide in New Mexico. Several riparian areas were examined, including approximately 12 km of Las Animas Creek and 24 km of Percha Creek (Figures 5-3 and 5-4). The bird and other wildlife data also refer to areas of the Upper Las Animas Creek on the Ladder Ranch that were not surveyed by Parametrix but have been visited by bird watchers and other observers. Other habitat areas of potentially high wildlife value that could have been examined in this study included isolated springs and springs and seeps. However, these areas were nearly all on private land and inaccessible.

Habitat in Las Animas and Percha Creeks was characterized by riparian forests and woodlands, burro bush (*Hymenoclea monogyra*), and/or seep willow (*Baccharis* sp.) arroyo shrublands. The vegetation chapter of this report (Chapter 4) includes detailed mapping and descriptions of riparian and arroyo habitat types in these areas. Riparian forests in the Percha Creek study area were typically dominated by cottonwood (*Populus fremontii*) and willow (*Salix* sp.). The Las Animas Creek study area contained large groves of Arizona sycamore (along with cottonwood and velvet ash (*Fraxinus velutina*). Willow trees and shrubs were also sometimes encountered along Las Animas Creek. Short segments of flowing water were observed along both creeks.

5.3 Methodology

5.3.1 Copper Flat Mine Permit Area

5.3.1.1 Sampling Objectives

The wildlife sampling objectives for the Copper Flat Mine permit area were to:

- Map current habitat, including disturbed areas.
- Describe wildlife use with:
    a. Big game fecal pellet group counts for mule deer (*Odocoileus hemionus*), elk (*Cervus elaphus*), pronghorn (*Antilocapra americana*), and lagomorphs, especially desert cottontails (*Sylvilagus audubonii*) and black-tailed jackrabbits (*Lepus californicus*).
    b. Walking transects for birds, with recorded observations of reptiles, amphibians, and mammals or their sign.
    c. Ultrasonic recordings for bats.
    d. Pit-fall traps, funnel traps, and visual observations for reptiles.
    e. Sherman trap lines for small mammals.
    f. Incidental observations of other wildlife.
- Create a species inventory set for birds, mammals, reptiles, and amphibians through researching past studies, lists created by other workers and other agencies, and our own observations.
- Complete a threatened or endangered species survey by comparing known records and habitat requirements with current field conditions to determine the likelihood of occurrence of any federal and state listed wildlife species.
- Describe species distribution by habitat and season, where appropriate.
- Identify other key habitat areas (e.g., cliffs, talus slopes, ponds, springs, riparian areas, known nests).

5.3.1.2 Data Collection

5.3.1.2.1 Special Status Species

This study included a search of online databases, published books, and reports; as well as communication with local experts to determine the potential occurrence and habitat needs of state and federally listed and sensitive species in Sierra County. We also examined the potential presence and habitat for special status species. Special status species are those found on public lands administered by the BLM or other agencies whose survival is of concern due to their limited distribution, low number of individuals and/or populations, or potential threats to habitat. The BLM uses the term "special status" to include federal endangered, threatened, proposed, and candidate species; and state endangered, threatened, and rare species.

Although non-federally listed species do not carry the same legal protection as federally listed species, it is useful to know of their presence or potential habitat for management considerations. The compiled information was compared with the conditions on site to determine if each species would likely be present in the project area.

5.3.1.2.2 Birds

When gathering bird data for this study, 37 bird transects were established running north-south across the project area (Figure 5-5). The transects were 125 meters apart in all habitats except the disturbed areas/waste rock pile where the transects were 250 meters apart. (The disturbed areas/waste rock pile, being nearly devoid of surface vegetation, was expected to contain relatively few birds and was deemed to provide good visibility for the few that were observed.) The transects ranged in length from 150 meters to slightly more than 5,000 meters long. Each transect was walked once during the breeding season beginning near sunrise until approximately 9:00 a.m., after which bird activity declined due to heat. The transects were not walked during high wind or when conditions would not allow species identification. Information was recorded about all birds seen or heard, including the quantity, age, and sex (if discernible); the habitat it was using; and the approximate distance from the observer. The location of any nests found was also recorded; however, not much time was spent searching for nests.

In addition to field surveys, on-line databases were searched for bird records by other observers. The databases included the New Mexico Ornithological Society for Sierra County database (New Mexico Ornithological Society, 2011), the ebird database of the Cornell Lab of Ornithology for Sierra County (Cornell Lab of Ornithology 2011), and the records of the New Mexico Audubon Society (Audubon Society, 2011a, 2011b, and 2011c). Discussions were also conducted with local experts and birders from around the state who have spent time birding in the area, including birders from the Mesilla Valley Audubon Society, and Wings West Tours.

A winter bird survey was also completed during December 2011. Methods and results from that assessment are included in Appendix 5-B.

5.3.1.2.3 Large Mammals

Due to their wariness, large mammals are often difficult to observe directly. Pellet plot counts were used in this study, which have been shown to be an effective indirect index of relative abundance (Neff, 1968; Davis and Winstead, 1972). Thirty random pellet plot locations were generated across all habitat types at the mine site (Figure 5-6). Field staff navigated to each spot with a handheld GPS unit, establishing a transect of ten 0.01-acre (435.6 ft^2) circular transects. The transects were marked by hammering an 18-inch rebar into the ground at the plot center, looping an 11.75-foot length of rope over the rebar (the 11.75-foot radius produced the circular 0.01-acre area). All pellets within this radius were tallied, identified to species (mule deer, elk, predator, cottontail, black-tailed jackrabbit, or other/unidentified), and removed from the plot so a future reading of the plot would count only pellets left since the previous reading. Eastern cottontail and white-tailed deer may also be present at the mine (J. Frey, pers comm., 2011), but it was assumed that the signs found were of the more abundant desert cottontail and mule deer.

5.3.1.2.4 Small Mammals

Small mammals were sampled using 2-inch by 2-inch by 8-inch folding aluminum Sherman live traps baited with oats, peanut butter, and molasses. Traps were set in the CDS, CDG, and Arroyo habitats (Figure 5-7). In total, 8 sets of 10 traps each were established on the mine site (one set had 13 traps), spaced approximately 10 meters apart. Traps were opened and baited in the late afternoon, and checked early in the morning, at which time the traps were closed, to avoid trapping animals during the heat of the day. The trapped animals were released into a clear plastic Ziploc bag. The animals were weighed and the length of the body, tail, ear, and hind foot were measured to aid in species identification. The captured animals were then marked with either magic marker or nail polish on the head to differentiate between newly captured animals and recaptured ones (which were not re-measured). The animals were then photographed and released at the spot of capture. The field staff took precautions against Hantavirus and other infectious diseases by wearing respirators and rubber gloves, and cleaning tools and hands with diluted bleach.

5.3.1.2.5 Bats

Bat presence was recorded using a Songmeter SM2BAT 384kHz ultrasonic recorder placed in the CDG (Bat 4), Pit Lake (Bat 5), and Arroyo (Bat 1) habitats at the mine site, and in the Arroyo (Bat 2), CDG (Bat 3), and lake habitats (Bat 6) off-site (Figure 5-2). The Songmeter is an automated device that records and stores the echolocation ultrasound signals of bats and other creatures. Detection ability varies with geography, weather, and microphone placement, but the device will typically record calls within a few hundred ft of the microphone. The unit is enclosed in a weatherproof case and placed on an elevated pole. Two (or, for one location, one) omni-directional microphones were used with a sensitivity of -36+/-4dB (0dB=1V/pa@1kHz), a frequency response of flat 20Hz-20 kHz, and a signal-to-noise ratio of >62dB. Full specifications of the unit can be found in Wildlife Acoustics (2011). The boxes were placed near likely feeding or flying areas, including ponds, water sources, riparian corridors, and passes between hills. Boxes were left in place for between 7 and 10 nights. (The units have a battery-saving timer, which was utilized to turn the unit on approximately one hour before sunset and off one hour after sunrise.) The data was then downloaded onto a laptop computer and the bat box moved to the next sampling location. After the calls were analyzed, a species list was developed for each site, which was analyzed by Dr. Jennifer Frey, a mammalogist who is very familiar with the species of southern New Mexico. Because sonograph recording and analysis does not guarantee 100 percent accuracy in species identification, species identified fewer than three times by the Songmeter software or that would be considered by experts as highly unusual for the area were removed from the database.

5.3.1.2.6 Reptiles and Amphibians

Reptiles and amphibians were searched for during walking bird transects and during the course of other field work. These species were recorded when possible. Field staff made two failed attempts to capture and identify reptiles. The SAP initially called for establishing drift fences and pitfall traps using silt fence and 5-gallon buckets. However, the soil at the mine site and surrounding area was too rocky to enable digging holes for the pitfall traps. Wire mesh funnel traps were constructed and placed along drift fences. These types of traps have been shown to be effective in some cases (Finch, 1951; Greenberg et al., 1994) in similar habitats. Although six drift fence arrays were set up, no reptiles were trapped in this manner. Instead, published reference materials

(Degenhardt et al., 1996; Stebbins, 1985) and discussions with local experts were used to develop a species list of reptiles and amphibians that could possibly occur at the site based on range and habitat.

5.3.2 Off-Site Reference Areas

5.3.2.1 Sampling Objective

The sampling objective for using off-site reference areas was for comparison of species with similar existing habitats that were present in established, undisturbed areas outside of the project boundary. This data was used to record the presence of the same taxa tallied at the mine site.

5.3.2.2 Data Collection

5.3.2.2.1 Special Status Species

Survey methods for special status species in off-site reference areas were the same as for the Copper Flat Mine permit area.

5.3.2.2.2 Birds

A total of 18 bird transects were established in off-site reference areas in the CDG and CDS habitats. Reference areas for the Pit, Pit Lake, Tailing Dam, and Disturbed Areas/Waste Rock Pile habitats were not surveyed as areas of this kind would have been almost impossible to locate. The research and discussions described for the Copper Flat area were also used in off-site reference areas. Off-site transect locations were selected in the field. Areas with habitat conditions similar to undisturbed strata in the mine permit area were targeted.

5.3.2.2.3 Large Mammals

A total of 10 pellet plot transects were established in off-site reference areas in the CDG and CDS habitats (Figure 5-6), but reference areas for the Pit, Pit Lake, Tailing Dam, and Disturbed Areas/Waste Rock Pile habitats were not found. The same protocols were used as for on-mine site plots. Plot locations were hand-selected in areas with habitat conditions similar to undisturbed strata in the mine permit area, and also where access was permitted.

5.3.2.2.4 Small Mammals

Four small mammal trapping transects were established in off-site reference areas in the Arroyo, CDG, and CDS habitats (Figure 5-7), but reference areas for the Pit, Pit Lake, Tailing Dam, and Disturbed Areas/Waste Rock Pile habitats were not found. The protocols that were used for on-mine site trapping were used for off-site trapping.

5.3.2.2.5 Bats

Three bat detection stations were established in off-site reference areas in the Arroyo, Lake, and CDG habitats, but no reference areas for the Pit, Tailing Dam, and Disturbed Areas/Waste Rock Pile habitats were found. The CDG and Arroyo sites were within approximately 1 mile of the boundary of the Copper Flat Mine permit area (Figure 5-2). The “Lake Site” consists of a 32-foot-diameter stock pond on Ladder Ranch approximately 2 miles from the boundary of the Copper Flat Mine permit area.

5.3.2.2.6 Reptiles and Amphibians

As with surveys on the Copper Flat Mine permit area, reptiles and amphibians were searched for during walking bird transects and during the course of other field work. Species were recorded when possible.

5.3.3 Las Animas Creek, Percha Creek, Percha Box, and Isolated Springs

5.3.3.1 Sampling Objectives

The sampling objectives for the off-site riparian areas were to conduct a reconnaissance of the habitat, describe the potential for wildlife habitat, and record any notable wildlife species or signs present.

5.3.3.2 Data Collection

5.3.3.2.1 Special Status Species

Survey methods for special status species in off-site reference areas were the same as for the Copper Flat Mine permit area and the off-site reference areas.

5.3.3.2.2 Birds

In October 2011, field staff visited Las Animas Creek and Percha Creek, including Percha Box, to evaluate wildlife habitat and make incidental bird observations. In the weeks following the visit, on-line research was conducted, along with phone interviews with people knowledgeable about the wildlife in these areas. Research included using the database of the New Mexico Ornithological Society (New Mexico Ornithological Society, 2011); the ebird database of the Cornell Lab of Ornithology (Cornell Lab of Ornithology, 2011); records of the New Mexico Audubon Society (Audubon Society, 2011a, 2011b, and 2011c), and discussions with local experts and birders from around the state who have spent time birding in the area. Several groups or individuals have extensive records for Las Animas Creek. It should be noted that bird records are by their nature spotty and inexact. Bird records are highly biased based on when visits were made. For example, many more records are in the database for winter, when the Christmas bird counts occur in these areas. Also, bird records in the databases do not necessarily specify where the sightings were made. For example, a sighting for Las Animas Creek might be anywhere from the headwaters to the mouth of the creek, or even areas outside the riparian zone. Finally, many sightings, probably the vast majority, never make it into these databases. These cautions aside, there has been considerable birding done in the area (especially along Las Animas Creek) by very knowledgeable birders, and their records provide excellent information on what species have occurred along these creeks at one time or another.

5.3.3.2.3 Large Mammals

During October 2011, field staff recorded sightings and signs of animals in these areas. On-line research was conducted, as well as interviews with observers that are familiar with the area.

5.3.3.2.4 Small Mammals

Aside from the occasional squirrel, no small mammals were observed or recorded during the site visits in October 2011. Some gopher mounds were encountered. On-line research was used instead to develop possible species lists.

5.3.3.2.5 Bats

Bats were not surveyed in and along Animas or Percha Creeks. It is likely that species lists developed for the Copper Flat Mine permit area and reference sites would apply to this area. One bat box was placed on the Ladder Ranch, approximately 2.5 km from Las Animas Creek.

5.3.3.2.6 Reptiles and Amphibians

Few reptiles were observed during the field visits. It is assumed that species lists developed for the Copper Flat Mine permit area and reference sites would apply to these sites.

5.4 Baseline Data Results

5.4.1 Copper Flat Mine Permit Area

5.4.1.1 Special Status Species

Five special status species were identified that occur in the Copper Flat Mine area: Texas horned lizard (*Phrynosoma cornutum*), loggerhead shrike (*Lanius ludovicianus*), Townsend’s pale big-eared bat (*Corynorhinus townsendii pallescen*s), fringed myotis (*Myotis thysanodes thysanodes*), and Yuma myotis (*Myotis yumanensis yumanensis*) (Table 5-1). None of these species is federally listed as endangered or threatened. Habitat appears to exist that could support up to ten other listed or sensitive species, at least marginally or during migration, that are known to occur in Sierra County: aplomado falcon (*Falco femoralis*), American peregrine falcon (*Falco peregrinus anatum*), Arctic peregrine falcon (*Falco peregrinus tundrius*), ferruginous hawk (*Buteo regalis*), Baird’s sparrow (*Ammodramus bairdii*), gray vireo (*Vireo vicinior*), Allen’s big-eared bat (*Idionycteris phyllotis*), desert pocket gopher (*Geomys arenarius brevirostris*), common hog-nosed skunk (*Conepatus leuconotus mearnsi*), and western spotted skunk (*Spilogale gracilis*) (Table 5-1). The aplomado falcon is the only species of these that is federally-listed as endangered. It has not been documented near the site, but does occur in Sierra County in habitats similar to those near the mine site. No critical habitat has been designated for this species.

5.4.1.2 Birds

There were 46 species of birds identified on the transects during the breeding season (Table 5-2), and eight additional species were encountered during other work. The diversity of species in different habitats was also considered. One measure of biological diversity is the Shannon-Weaver Index (H’), which uses the following algorithm to calculate relative diversity:

$$H' = -\sum_{i=1}^{S}(p_i \ln p_i)$$

Where:

S is the total number of species encountered

pi is the frequency of the *i*th species (the probability that any given individual belongs to the species)

The use of this index avoids the difficulty of identifying habitats with large populations of individuals as necessarily diverse. Areas that have high numbers of one or two individuals and very few of all others will receive a low diversity score, while areas that have numbers of individuals, even perhaps fewer total but spread more evenly over many species (in other words, habitats that support a greater array of species) will score higher. This algorithm was used for the analysis of the bird and small mammal survey results.

The number of bird species recorded in this study was 39 in the Arroyo habitat, 15 in the CDS, 38 in the CDG, 4 in the Pit Lake habitat, and 21 in the Disturbed Areas/Waste Rock Pile habitat (Table 5-2). In addition to having the most species, the Arroyo and CDG habitat were the most diverse. (See Chapter 4 for a full definition of the habitats and lists of plant species occurring there).

Research indicated that at least 78 additional species that occur in Sierra County have potential habitat at the Copper Flat Mine permit area at some time during the year (Table 5-3).

5.4.1.3 Large and Medium-Sized Mammals

Mule deer signs were encountered on 16 of the 30 (53 percent) transects read. Most of the signs were in the western half of the project area, in the CDG habitat, though signs were found in all parts of the mine. Deer were frequently observed in the Greyback Arroyo and other arroyos on the site. Desert cottontail signs were found on 29 of 30 (97 percent) of the transects, black-tailed jackrabbit signs were found in 23 of 30 (77 percent) of the transects, and predators or other signs were found on 4 of 30 (13 percent) of the transects.

In addition, one pronghorn (*Antilocapra americana*) was encountered during walking the transects on the southeastern portion of the Copper Flat Mine permit area. Also, signs of collared peccary (*Pecari tajacu*) mountain lion (*Puma concolor*), bobcat (*Lynx rufus*), coyote (*Canis latrans*), and fox, likely gray fox (*Urocyon cinereoargenteus*) were noted during field work. Other large to medium mammals that are likely present on the Copper Flat Mine permit area but were not encountered are listed in Table 5-4, which was developed by consulting range maps and species lists in published reports, including Bailey (1932), Chapman and Feldhammer (1982), Findley et al. (1975), and Frey (1998, 2010), and by consulting with local experts (J. Frey, pers. comm., 2011).

5.4.1.4 Small Mammals

A total of 86 individuals of eight species of small mammals were trapped at the Copper Flat Mine permit area: brush mouse (*Peromyscus boylii*), desert cottontail, Merriam's kangaroo rat (*Dipodomys merriami*), Northern grasshopper mouse (*Onchomys leucogaster*), Mearn's grasshopper mouse (*Onychomys arenicola*), rock pocket mouse (*Chaetodipus intermedius*), white-footed mouse (*Peromyscus leucopus*), and white-throated woodrat (*Neotoma albigula*) (Table 5-5). Species noted as "unknown" or "sp." in the table are mostly animals that escaped from the trap or handling before the species of the animal could be identified.

For analysis, the trapping effort was standardized to compensate for different effort required in the different habitats and to eliminate sprung traps from consideration (if a trap is sprung, often by a coyote or other curious animal, it cannot trap a small mammal, and should not be counted toward the trapping effort). Effort is represented as number of animals per 100 trap nights of open traps. Diversity of small mammals was highest in CDS, where six species were trapped. The greatest number of animals trapped per effort was in the Arroyo site, followed by the CDS and CDG sites. Diversity, however, was greatest in the CDS habitat, followed by the CDG and Arroyo habitats. Although a relatively high density of individuals was trapped in the Arroyo, only two species were encountered: brush mouse and one unknown (escaped) species. Six species of small mammals were trapped in the CDS and five in the CDG.

In addition to trapping, research was conducted with several sources (see above) to determine species of mammals in the region that might be present and not detected during trapping (Table 5-4).

5.4.1.5 Bats

A total of 12 species of bats was detected at the Copper Flat Mine permit area (Table 5-6, Figure 5-2): pallid bat (*Antorzus pallidus*), Townsend's pale big-eared bat (*Corynorhinus townsendii*), big brown bat (*Eptesicus fuscus*), silver-haired bat (*Lasionycteris noctivagans*), southern hoary bat (*Lasiurus cinereus*), western small-footed myotis (*Myotis ciliolabrum*), California myotis (*Myotis californicus*), Arizona myotis (*Myotis occultus*), fringed myotis (*Myotis thysanodes*), Yuma myotis (*Myotis yumanensis*), canyon bat (*Parastrellus hesperus*), and Brazilian free-tailed bat (*Tadarida brasiliensis*). Species detected and identified by the Sonobat software but not observed were quality checked by local experts, who suggested changes to the list (J. Frey, pers. comm., 2011). Species that were detected but are of questionable occurrence (e.g., they would be very rare if detected) are denoted with a "?". At least three other species were not detected, but likely occur in the region and have appropriate habitat at or near the Copper Flat Mine permit area (Table 5-6).

The number of calls by species at each site was also briefly examined. Though this provides an index of short-term relative abundance, results should be interpreted with caution as more calls do not necessarily correlate to more individuals using a site (for example, 100 calls could mean one bat calling 100 times, or 100 bats calling once). However, it can be relatively safe to assume that more calls and more activity indicate a higher density of prey. The most species and the most calls were detected at the Pit Lake, where insects provide the greatest feeding opportunities. The second highest abundance and diversity was from the CDG, followed by the Arroyo.

In addition to feeding habitat at the Lake, roosting habitat is provided by crevices in the rocky hills at the Copper Flat Mine permit area and, probably more importantly, by the many abandoned mine shafts. A thorough survey of shafts was not conducted for bat activity.

5.4.1.6 Reptiles and Amphibians

Pitfall and funnel trapping of reptiles and amphibians was not successful. Mine site soils were too rocky to effectively dig pitfall traps, and constructed wire mesh funnel traps failed to trap any reptiles. During walking transects and other survey efforts, nine species of reptiles were encountered at the mine site: coachwhip (*Masticophis flagellum*), whiptail lizard (*Cnemidophorus* sp.), bullsnake (*Pituophis melanoleucus*), Texas horned lizard, roundtail horned lizard (*Phrynosoma modestum*), desert spiny lizard (*Sceloporus magister*), black-tailed rattlesnake (*Crotalus molossus*), lesser earless lizard (*Holbrookia maculata*), and rock rattlesnake (*Crotalus lepidus*). Whiptails were the most abundant species seen, but field staff were unable to capture one to identify the species (six species occur in Sierra County).

Research was also conducted on the species that likely or possibly occur at the mine site based on expected range and the habitat present (Degenhardt et al., 1996; Stebbins, 1985). Up to forty-three species of reptiles and amphibians that are known to occur in Sierra County have suitable habitat present at the mine site (Table 5-7).

5.4.2 Off-Site Reference Areas

5.4.2.1 Special Status Species

Fourteen special status species were identified that occur in Sierra County, with habitat that occurs in off-site reference areas (Table 5-1). Although only three of these species (all bats) were encountered, it is likely that other species occur at other times. The only federally-listed species in the group, aplomado falcon, has not been detected near the mine site, but it has been recorded in Sierra County in habitat similar to that which occurs in the mine site reference areas. Sprague's pipit (*Anthus spraguei*), a federal candidate species, has been documented in CDG near the mine (B. West, pers. comm., 2011).

5.4.2.2 Birds

Field staff recorded 28 species of birds in off-site reference areas (Table 5-2), including 13 species in the Arroyo habitat, 7 species in the CDS, and 19 species in the CDG. Overall diversity was highest in the Arroyo, followed by the Grassland and Shrubland.

5.4.2.3 Large Mammals

One species of ungulate, mule deer, was recorded in the pellet transects in the off-site reference areas. The presence and relative abundance of desert cottontail and black-tailed jackrabbit was also noted. In addition, elk, pronghorn, and collared peccary have been reported in similar habitat just off the mine site. Other mammals that definitely, or likely, occur in off-site reference areas are listed in Table 5-4.

5.4.2.4 Small Mammals

Eight species of small mammals were trapped on the reference sites: brush mouse, white-footed mouse, Merriam's kangaroo rat, Mearn's grasshopper mouse, rock pocket mouse, Mexican woodrat, and white-throated woodrat (Table 5-5). Species noted as unknown or "sp." in the table are mostly animals that escaped from the trap or handling before the species of the animals could be identified. One species, Mexican woodrat, was trapped in reference areas and was also trapped at Copper Flat Mine permit area. Both abundance and diversity of reference area small mammals was highest in the Arroyo habitat, followed by the CDS and CDG. All reference sites had a higher diversity, though not a higher abundance, of small mammals than the Copper Flat Mine permit area.

5.4.2.5 Bats

Sonobat detectors were placed at three off-site reference areas (Figure 5-2): the Arroyo, CDG, and Lake habitats. Ten species were detected (Table 5-6). Additionally, habitat likely exists for five other species (Table 5-6). Bat abundance, diversity, and bat use was highest by far at the Pit Lake, followed by the CDG and Arroyo habitats.

5.4.2.6 Reptiles and Amphibians

Pitfall and funnel trapping of reptiles and amphibians was not successful. Six species of reptiles were encountered along transects at off-site reference areas: coachwhip, whiptail, bullsnake, Texas horned lizard, roundtail horned lizard, and lesser earless lizard. Whiptails were the most abundant species seen; however, field staff were unable to capture one to identify the species (six species occur in Sierra County). The Sierra County species list (Table 5-7), which is drawn from Degenhardt et al. (1996), Stebbins (1985), and discussions with local experts, presents species likely to occur in reference areas near the mine site.

5.4.3 Las Animas Creek, Percha Creek, Percha Box, and Isolated Springs

5.4.3.1 Special Status Species

Animas and Percha Creeks provide important habitat and, despite being a relatively small area in the region, have a much higher proportion of sensitive species. This is largely, if not exclusively, due to the presence of intermittent to occasional perennial surface water fed by a shallow aquifer that supports a diverse and unique riparian area. A gallery forest of Arizona sycamore is present at Las Animas Creek, a habitat that is very rare east of the continental divide. Percha Creek, which does not contain sycamore, does have perennial water for approximately 4 miles. Portions of Percha Creek support a diverse riparian community. Ten special status species are known from this area and nine others likely occur based on their known distribution in Sierra County and habitat present in this area (Table 5-1). The federally threatened Chiricahua leopard frog (*Rana chiricahuensis*) is being cooperatively managed on the Ladder Ranch, and the federally threatened Mexican spotted owl (*Strix occidentalis lucida*), has been detected there.

5.4.3.2 Birds

Because surveys of Las Animas and Percha Creeks were not part of the original scope of work, bird surveys were not conducted at these sites, aside from making incidental observations during one brief visit in October 2011. However, considerable work has been done by birders. Using several sources (Audubon Society, 2011a, 2011b, and 2011c; Cornell Lab of Ornithology, 2011; B. West, pers. comm., 2011; D. Cleary, pers. comm., 2011; D. Griffin, pers. comm., 2011), a preliminary list of seasonal bird presence for Las Animas and Percha Creeks (Table 5-3) has been developed. In addition to listed species such as spotted owl and candidate species such as the yellow-billed cuckoo (*Coccyzus americanus*), the area contains many sensitive, rare, and endemic species that are found in a very limited range in the state, including common black hawk (*Buteogallus anthracinus*), gray hawk (*Buteo nitidus*), zone-tailed hawk (*Buteo albonotatus*), bald eagle (*Haliaeetus leucocephalus*), peregrine falcon, elf owl (*Micrathene whitneyi*), summer tanager (*Piranga rubra*), brown-crested flycatcher (*Myiarchus tyrannulus*), Hammond's flycatcher (*Empidonax hammondii*), vermilion flycatcher (*Pyrocephalus mexicanus*), Bell's vireo (*Vireo bellii*), Brewer's sparrow (*Spizella breweri*), red-naped sapsucker (*Sphyrapicus nuchalis*), bridled titmouse(*Baeolophus wollweberi*), and hooded oriole (*Icterus cucullatus*). The area has been listed as an "Important Bird Area" by the Audubon Society.

5.4.3.3 Large Mammals

Surveys were not conducted for large mammals at Las Animas or Percha Creeks, though other observers have described some species abundance there. Most of the species documented for the Copper Flat Mine permit area and reference areas would all be expected to be present along Animas and Percha Creeks (Table 5-4), with a few differences. Pronghorn are less abundant, and collared peccary, elk, and American black bear (*Ursus americanus*) are more abundant. Frey (pers. comm., 2011) noted that white-tailed deer (*Odocoileus virginianus*) are possible in the upper reaches of Las Animas Creek. Other species that would be expected along these creeks but were not observed include ringtail (*Bassariscus astutus*), and porcupine (*Erethrizon dorsatum*).

5.4.3.4 Small Mammals

No small mammals were documented in these areas. Published literature and discussions with local experts were used to develop a list of possible species (Table 5-5).

5.4.3.5 Bats

One bat box was placed at the Ladder Ranch (Figure 5-2) within 4.0 miles of Las Animas Creek. The Ladder Ranch site was considered as one of the reference areas; however, most of the bats are close enough to the creek to support an assumption that the bats use the creek area for feeding and, for many of the species, roosting habitat as well. Eleven species of bats were detected at this site: pallid bat, silver-haired bat, southern hoary bat, western small-footed myotis, California myotis, Arizona myotis, fringed myotis, long-legged myotis, Yuma myotis, canyon bat, and Brazilian free-tailed bat. In addition, the riparian habitat likely provides habitat for up to five additional species that are known to occur in Sierra County (Table 5-4).

5.4.3.6 Reptiles and Amphibians

Reptiles and amphibians were not sampled in this study. A few, however, were observed during field visits. The species listed in Table 5-7 present those that are known to occur in the area, or are known to occur in Sierra County in habitat that is present in Animas Creek or Percha Creek.

In summary, several overall observations can be noted from the field and other data collected for this study:

- Arroyo habitat provides relatively high diversity for small mammals, songbirds, reptiles, and amphibians.
- Habitat along Percha Creek, and especially Las Animas Creek, provides very high biodiversity and habitat for several federally listed, state, and BLM listed or sensitive, or rare species, of birds and other wildlife.
- Concentrated sources of water provide feeding habitat for a diverse array of bats.
- Chihuahuan Desert Grasslands provide good habitat for big game, especially mule deer.

5.5 References

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Tables

Table 5-1

Listed and Sensitive Species with Known Occurrence or Habitat at Copper Flat Mine Permit Area, Las Animas Creek, or Percha Creek

					Species Present Habitat Present	
Common Name	**Scientific Name**	**Federal**	**State**	**BLM**	**CF Mine Site**	**Animas/ Percha**
• = Recoded species; ○ = Not detected but habitat present/species occur in the region						
Reptiles and Amphibians						
Chiricahua Leopard Frog	*Rana chiricahuensis*	T	S	-		•
Arizona Toad	*Bufo microscaphus microscaph.*	-	S	S		○
Texas Horned Lizard	*Phrynosoma cornutum*	-	-	S	•	
Birds						
Common Black Hawk	*Buteogallus anthracinus*	S	T	-		•
Varied Bunting	*Passerina versicolor*	-	T	-		
Yellow-billed Cuckoo	*Coccyzus americanus occid.*	C	S	-		•
Bald Eagle	*Haliaeetus leucocephalus*	-	T	-		•
Aplomado Falcon	*Falco femoralis septent.*	E	E	-	○	○
Peregrine Falcon	*Falco peregrinus anatum*	S	T	-	○	
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	S	T	-	○	
Southwest Willow Flycatcher	*Empidonax traillii extimus*	E	E	-		
Ferruginous Hawk	*Buteo regalis*	-	-	S	○	
Mexican Spotted Owl	*Strix occidentalis lucida*	T	-	-		•
Loggerhead Shrike	*Lanius ludovicianus excub.*	-	S	S	•	•
Baird's Sparrow	*Ammodramus bairdii*	S	T	S		•
Sprague's Pipit	*Anthus spragueii*	C	-	-		
Bell's Vireo	*Vireo bellii arizonae*	S	T	-		○
Gray Vireo	*Vireo vicinior*	-	T	-	○	
Mammals						
Allen's Big-eared Bat	*Idionycteris pyllotis*	S	S	S	○	○
Townsend's Pale Big-eared Bat	*Corynorhinus townsendii pall.*	S	S	S	•	•
Fringed Myotis Bat	*Myotis thysanodes thysanodes*	-	S	S	•	•
Yuma Myotis Bat	*Myotis yumanensis yuman.*	-	S	S	•	•
Desert Pocket Gopher	*Geomys arenarius brevirostris*	S	S	-	○	
Ringtail	*Bassariscus astutus*	-	S	-		○

Common Name	Scientific Name	Federal	State	BLM	Species Present Habitat Present	
					CF Mine Site	Animas/ Percha
• = Recoded species; ○ = Not detected but habitat present/species occur in the region						
Common Hog-nosed Skunk	*Conepatus leuconotus mearnsi*	-	S	-	○	○
Western Spotted Skunk	*Spilogale gracilis*	-	S	-	○	○
Other Taxa						
Obsolete Viceroy Butterfly	*Basilarchia archippus obsoleta*	S	-	-		○

Note: Abbreviations: Endangered, Threatened, Sensitive, Species of Concern, Candidate Species

Table 5-2

Bird Species Recorded by Habitat at the Copper Flat Mine Permit Area

Species	Copper Flat Mine Permit Area					Reference Sites		
	Arroyo	CDS	CDG	Pit	DA/WR	Arroyo	CDS	CDG
American Kestrel	•		•					
American Robin	•		•					
Ash-throated Flycatcher	•	•	•		•	•		•
Barn Swallow				•				
Bewick's Wren			•					
Black-chinned Hummingbird	•		•					
Black-throated Sparrow	•	•	•	•	•	•	•	•
Blue Gray Gnatcatcher	•		•		•			•
Blue Grosbeak			•		•			•
Broad-tailed Hummingbird	•				•			
Brown-headed Cowbird	•		•			•		
Bullock's Oriole			•					
Cactus Wren	•	•	•	•	•		•	
Canyon Towhee	•		•			•		•
Canyon Wren	•		•			•		
Common Nighthawk		•					•	
Common Raven	•	•	•		•	•	•	•
Crissal Thrasher		•						
Curve-billed Thrasher	•		•				•	
Flycatcher sp.	•		•		•			•
Gambel's Quail	•	•	•		•	•	•	
Great Horned Owl	•							
Greater Roadrunner								
Horned Lark			•					•
House Finch	•	•			•			
Lesser Goldfinch	•		•			•		
Loggerhead Shrike					•			
Montezuma Quail			•					
Mourning Dove	•	•	•		•		•	•
Northern Flicker			•					•
Northern Mockingbird	•	•	•		•	•		•
Oriole sp.	•		•					
Red-tailed Hawk	•	•	•					

Species	Copper Flat Mine Permit Area					Reference Sites		
	Arroyo	CDS	CDG	Pit	DA/WR	Arroyo	CDS	CDG
Rock Wren	•		•		•	•		•
Rufous-crowned Sparrow	•		•					•
Say's Phoebe	•	•	•		•	•		
Scaled Quail	•		•					
Sparrow sp.	•							
Spotted Towhee	•							
Swainson's Hawk	•			•				
Swallow sp.					•			
Thrasher sp.	•		•			•		
Townsend's Warbler	•							
Turkey Vulture	•		•		•			•
Unknown	•	•	•		•	•		•
Violet-green Swallow	•	•	•		•			
Warbler sp.	•		•					
Western Kingbird	•		•		•			•
Western Meadowlark			•					
Western Wood-Pewee	•	•	•					•
White-winged Dove	•							•
Wilson's Warbler	•							
Wren sp.			•					•
Total Species Encountered:	**39**	**15**	**38**	**4**	**21**	**13**	**7**	**19**
Shannon-Weaver Diversity Score:	**15.1**	**5.3**	**16.9**	**2.3**	**9.9**	**11.3**	**2.6**	**10.8**

Table 5-3

Bird Species Recorded or Likely Present at Copper Flat Mine Permit Area, Las Animas Creek, and Percha Creek

Species	Copper Flat Mine Permit Area				Las Animas/Percha Creeks			
	Spr	Sum	Fal	Win	Spr	Sum	Fal	Win
• = Recoded species; ○ = Not recorded but likely occurs in proper habitat								
Canada Goose								•
Gadwall								•
Mallard					○	○	○	•
Northern Shoveler								•
Northern Pintail								•
Green-winged Teal								•
Redhead					•			•
Ring-necked Duck								•
Common Merganser						•		•
Scaled Quail	○	○	○	○	○	○	○	•
Gambel's Quail		•			•	•	•	•
Montezuma Quail	○	○	○	○	•	○	○	•
Ring-necked Pheasant								•
Wild Turkey					•	•	○	○
Pied-billed Grebe								•
Bl.-crowned Night Heron		•				○		
Cattle Egret						○		
Snowy Egret					•		•	
Great Blue Heron	○	○	○	○	•	○	○	•
Green Heron					•			
White-faced Ibis						•		
Turkey Vulture		•				•	•	
Bald Eagle						•		•
Northern Harrier		○		○	•			•
Sharp-shinned Hawk	○	○	○	○	•	○	○	•
Cooper's Hawk	○	○	○	○	•	○	○	•
Swainson's Hawk		•					•	
Red-tailed Hawk	○	•	○	○	•	•	○	•
Ferruginous Hawk	○		○	○	○	•	○	•
Gray Hawk						•		
Zone-tailed Hawk					•	•		

Species	Copper Flat Mine Permit Area				Las Animas/Percha Creeks			
	Spr	Sum	Fal	Win	Spr	Sum	Fal	Win
• = Recoded species; ○ = Not recorded but likely occurs in proper habitat								
Common Black Hawk					•	•		
Golden Eagle	○	○	○	○	•			
American Kestrel	○	•	○	○	•	○	•	•
Merlin	○		○	○	○		○	•
Peregrine Falcon					•	•		
Prairie Falcon	○	○	○	○				•
Sora					•			
American Coot						○		
Sandhill Crane							○	•
Killdeer	○	○	○	○	•	•	•	
Black-necked Stilt						○		
American Avocet						○		
Spotted Sandpiper	○	○	○	○		○		
Common Snipe						○		○
Ring-billed Gull								•
Rock Dove	○	○	○	○	○	○	○	•
Eur. Collared-Dove	○	○	○	○	•	○	•	•
White-winged Dove	○	•	○	○	•	•	•	•
Mourning Dove					•	•	•	•
Common Ground Dove						○		
Yellow-billed Cuckoo						•		
Greater Roadrunner	○	•	○	○	•	○	○	•
Western Screech-Owl	○	○	○	○	•	○	○	•
Great Horned Owl	○	•	○	○	•	•	○	•
Barn Owl	○	○	○	○	○	○	○	•
Burrowing Owl	○					•		
Northern Pygmy Owl	○	○	○	○	○	○	○	•
Mexican Spotted Owl					•			
Elf Owl					•	•		
Lesser Nighthawk		○				•		
Common Poorwill		○			•	•		
White-throated Swift		•			•	•		
Bl.-chinned Hummingbird		•			•	•	•	
Br.-tailed Hummingbird		•					•	

Species	Copper Flat Mine Permit Area				Las Animas/Percha Creeks			
	Spr	Sum	Fal	Win	Spr	Sum	Fal	Win
• = Recoded species; ○ = Not recorded but likely occurs in proper habitat								
Belted Kingfisher					•	•	•	•
Lewis's Woodpecker								•
Red-headed Woodpecker					•			•
Red-naped Sapsucker								•
Acorn Woodpecker					•	•	•	•
Red-naped Sapsucker					•		•	•
Yel.-bellied Sapsucker								•
Lad.-backed Woodpecker					•	•		•
Downy Woodpecker	○	○	○	○	•	○	○	•
Hairy Woodpecker	○	○	○	○	•	○	○	○
Northern Flicker	○	•	○	○	•	○	•	•
Western Wood-Pewee		•				•	•	
Hammond's Flycatcher					•			•
Willow Flycatcher					•			
Brown-crested Flycatcher						•		•
Eastern Phoebe								•
Black Phoebe		•			•	•		•
Say's Phoebe	○	•	○	○	•	•	•	•
Vermilion Flycatcher		○			•	•		•
Ash-throated Flycatcher		•				•		
Brown-crested Flycatcher						•	•	
Dusky Flycatcher					•			
Dusky-capped Flycatcher						•		
Cassin's Kingbird						•	•	
Western Kingbird		•				•	•	
Loggerhead Shrike	○	•	○	○	•	•	○	•
Bell's Vireo						•		
Plumbeous Vireo						•		
Warbling Vireo							•	
Hutton's Vireo		○		○			•	•
Steller's Jay								•
Western Scrub-Jay	○	○	○	○	○	○	•	•
American Crow	○	○	○	○	○	○		•
Chihuahuan Raven				○	•	○	•	•

Species	Copper Flat Mine Permit Area				Las Animas/Percha Creeks			
	Spr	Sum	Fal	Win	Spr	Sum	Fal	Win
• = Recoded species; ○ = Not recorded but likely occurs in proper habitat								
Common Raven	○	•	○	○	•	○	•	•
Horned Lark	○	•	○	○	•	○	○	•
N. Rough-winged Swallow		○			•	•		
Violet-green Swallow	○	•	○		•	•	○	
Barn Swallow	○	•	○		•	•	•	
Cliff Swallow		○				•		
Mountain Chickadee				○				•
Bridled Titmouse	○	○	○	○	•	•	○	•
Juniper Titmouse	○	•	○	○				•
Verdin	•				•		•	•
Bushtit	○	○	○	○	○	○	○	○
Red-breasted Nuthatch								•
White-breasted Nuthatch					•	•	•	•
Brown Creeper	○	○	○	○	○	○	○	•
Cactus Wren	○	•	○	○	•	○	•	•
Rock Wren	○	•	○	○	•			•
Canyon Wren	○	•	○	○		•		
Bewick's Wren	○	○	○	○	•	•	•	•
House Wren	○							•
Winter Wren								•
Bl.-tailed Gnatcatcher	○					•		
Blue-Gray Gnatcatcher		○					•	
Golden-crowned Kinglet								•
Ruby-crowned Kinglet	○	○	○	○	•	○	○	•
Eastern Bluebird								•
Western Bluebird	○	○	○	○	•	○	○	•
Mountain Bluebird	○	○	○	○			•	
Townsend's Solitaire				○	•			•
Hermit Thrush					•			•
Rufous-backed Robin					•			•
American Robin	○	•	○	○	•	•	○	•
Northern Mockingbird	○	•	○	○	•	•	○	•
American Dipper						•		
Curve-billed Thrasher	○	•	○	○	•		•	•

Species	Copper Flat Mine Permit Area				Las Animas/Percha Creeks			
	Spr	Sum	Fal	Win	Spr	Sum	Fal	Win
• = Recoded species; ○ = Not recorded but likely occurs in proper habitat								
Crissal Thrasher	○	•	○	○	•			•
Bendire's Thrasher								
Brown Thrasher		•						•
European Starling	○	○	○	○	•	•	•	•
American Pipit								•
Sprague's Pipit			○					
Cedar Waxwing					•			•
Phainopepla	○	○	○	○	•	○	•	•
Orange-crowned Warbler	○	○	○				•	•
Bl.-throated Gray Warbler	○				○			
Lucy's Warbler		○			•	•		
Virginia's Warbler		○			•		•	
Grace's Warbler						•		
MacGillivray's Warbler							•	
Northern Parula					•			
Yellow-rumped Warbler	○	•	○	○	•	○	•	•
Red-faced Warbler						•		
Wilson's Warbler	○	○	○				•	
Pine Warbler								•
Tennessee Warbler					•		•	
Yellow-breasted Chat		○				•		
Ch.-collared Longspur								•
Green-tailed Towhee		•						•
Spotted Towhee		•			•	○	○	•
Rufous-crowned Sparrow		•			•			•
Canyon Towhee		•			•	•	•	•
Chipping Sparrow	○	○	○	○	•	○	○	•
Brewer's Sparrow	○		○	○	•		•	•
Vesper Sparrow	○	○	○	○				•
Lark Sparrow		○					•	
Black-throated Sparrow	○	•	○	○	•		•	•
Black-chinned Sparrow	○					•		
Sage Sparrow	○		○	○				•
Baird's Sparrow	○							•

Species	Copper Flat Mine Permit Area				Las Animas/Percha Creeks			
	Spr	Sum	Fal	Win	Spr	Sum	Fal	Win
• = Recoded species; ○ = Not recorded but likely occurs in proper habitat								
Grasshopper Sparrow								•
Clay-colored Sparrow								•
Lark Bunting	○		○	○	•			
Indigo Bunting						•		
Lazuli Bunting					•			
Varied Bunting						•		
Song Sparrow				○	•		•	•
Lincoln's Sparrow	○		○	○	•		•	•
White-crowned Sparrow	○		○	○	•		•	•
White-throated Sparrow								•
Swamp Sparrow								•
American Tree Sparrow								•
Dark-eyed Junco	○	○	○	○	•		•	•
Summer Tanager					•	•	•	•
Hepatic Tanager					•			
Western Tanager					•			
Northern Cardinal						○		
Pyrrhuloxia				○	•	•		•
Blue Grosbeak		•			•	•	•	
Red-winged Blackbird	○	○	○	○	•	○	•	•
Western Meadowlark	○	•	○		•	○	○	•
Yellow-headed Blackbird	○	○		○				•
Brewer's Blackbird	○	○	○	○				•
Rusty Blackbird								•
Common Grackle					•			
Great-tailed Grackle	○	○	○	○	•	○	○	•
Brown-headed Cowbird		•				•		•
Hooded Oriole	○				•	•		
Bullock's Oriole	○						•	
Scott's Oriole	○					•		
Purple Finch								•
Cassin's Finch		•	○	○				•
House Finch	○	•	○	○	•	•	•	•
Red Crossbill								•

Species	Copper Flat Mine Permit Area				Las Animas/Percha Creeks			
	Spr	Sum	Fal	Win	Spr	Sum	Fal	Win
• = Recoded species; ○ = Not recorded but likely occurs in proper habitat								
Pine Siskin	○	○	○	○				•
Lesser Goldfinch		•			•	•	•	•
Lawrence's Goldfinch								•
American Goldfinch			○		•			•
Evening Grosbeak								•
House Sparrow		•			•	•	•	•

Table 5-4

Mammal Species Recorded or Likely Present at Copper Flat Mine Permit Area, Las Animas Creek, and Percha Creek

Species	Scientific Name	Encountered or Possible at Copper Flat Mine Permit Area	Known or Possible at Animas/ Percha Creeks
• = Detected; ○ = Not detected but habitat present and species occurs in the region			
Large Mammals			
Pronghorn	*Antilocapra americana*	•	
Coyote	*Canis latrans*	•	•
Elk	*Cervus elaphus*	○	•
Bobcat	*Lynx rufus*	•	•
Mule Deer	*Odocoileus hemionus*	•	•
White Tailed Deer	*Odocoileus virginianus*		○
Collared Peccary	*Pecari tajacu*	○	•
Mountain Lion	*Puma concolor*	•	•
Gray Fox	*Urocyon cineroargenteneus*	•	•
American Black Bear	*Ursus americanus*	○	•
Bats			
Pallid Bat	*Antorzus pallidus*	•	•
Townsend's Pale Big-eared Bat	*Corynorhinus townsendii*	•	○
Big Brown Bat	*Eptesicus fuscus*	•	•
Spotted Bat	*Euderma maculatum*	○	○
Allen's Big-eared Bat	*Idionycteris phyllotis*	○	○
Silver-haired Bat	*Lasionycteris noctivagans*	•	•
Western Red Bat	*Lasiurus blossevillii*	•	○
Southern Hoary Bat	*Lasiurus cinereus*	•	•
Southwestern Myotis	*Myotis auriculus*	○	○
California Myotis	*Myotis californicus*	•	•
Arizona Myotis	*Myotis occultus*		○
Fringed Myotis	*Myotis thysanodes*	•	•
Long-legged Myotis	*Myotis volans*	•	○
Yuma Myotis	*Myotis yumanensis*	•	•
Canyon Bat	*Parastrellus hesperus*	•	○
Brazilian Free-tailed Bat	*Tadarida brasiliensis*	•	•

Species	Scientific Name	Encountered or Possible at Copper Flat Mine Permit Area	Known or Possible at Animas/ Percha Creeks
• = Detected; ○ = Not detected but habitat present and species occurs in the region			
Medium-sized Mammals			
Ringtail	*Bassariscus astutus*		○
Coatimundi	*Nasua narica*		○
American Beaver	*Castor canadensis*		○
American Hog-nosed Skunk	*Conepatus leuconotus*	○	○
Black-tailed Jackrabbit	*Lepus californicus*	•	○
Hooded Skunk	*Mephitis macroura*	○	○
Striped Skunk	*Mephitis mephitis*	○	○
Long-tailed Weasel	*Mustela frenata*	○	○
Raccoon	*Procyon lotor*	○	○
Western Spotted Skunk	*Spilogale gracilis*	○	○
Desert Cottontail	*Sylvilagus audubonii*	•	○
Eastern Cottontail	*Sylvilagus floridanus*		
Kit Fox	*Vulpes macrotis*		
American Badger	*Taxidea taxus*	○	○
Small Mammals			
Merriam's Kangaroo Rat	*Dipodomys merriami*	•	○
Ord's Kangaroo Rat	*Dipodomys ordii*	○	○
Banner-tailed Kangaroo Rat	*Dipodomys spectabilis*	○	○
North American Porcupine	*Erethrizon dorsaturn*		○
Mogollon Vole	*Microtus mogollonensis*	○	
House Mouse	*Mus musculus*	○	○
White-throated Woodrat	*Neotoma albigula*	•	○
Mexican Woodrat	*Neotoma mexicana*	○	
Southern Plains Woodrat	*Neotoma micropus*	•	
Desert Shrew	*Notiosorex crawfordi*	○	○
Mearn's Grasshopper Mouse	*Onchomys arenicola*	•	
Northern Grasshopper Mouse	*Onchomys leucogaster*	•	○
Silky Pocket Mouse	*Peognathus flavus*	•	
Brush Mouse	*Peromyscus boylii*	•	
Cactus Mouse	*Peromyscus eremicus*	○	
White-footed Mouse	*Peromyscus leucopus*	•	○
Piñon Mouse	*Peromyscus truei*	○	
Western Harvest Mouse	*Reithrodontomys megalotis*	○	○

Species	Scientific Name	Encountered or Possible at Copper Flat Mine Permit Area	Known or Possible at Animas/ Percha Creeks
• = Detected; ○ = Not detected but habitat present and species occurs in the region			
Arizona Gray Squirrel	*Sciurus arizonensis*		○
Tawny-bellied Cotton Rat	*Sigmodon fulviventer*		○
Hispid Cotton Rat	*Sigmodon hispidus*		○
Spotted Ground Squirrel	*Spermophilus spilosoma*	○	
Rock Squirrel	*Spermophilus variegatus*	○	○
Cliff Chipmunk	*Tamias dorsalis*	○	
Botta's Pocket Gopher	*Thomomys bottae*	○	

Table 5-5

Number and Diversity of Small Mammals Trapped in Copper Flat Mine Permit Area and Reference Areas, Standardized to Animals Per 100 Trap Nights

Note: Some rounding error may make columns not sum correctly

Species	Copper Flat Mine Permit Area			Reference Areas		
	Arroyo	**CDS**	**CDG**	**Arroyo**	**CDS**	**CDG**
Desert Cottontail		0.9				
Brush Mouse	22.7	0.9	11.0	6.3	1.8	1.6
Mearn's Grasshopper Mouse					1.8	
Northern Grasshopper Mouse		0.9			1.8	
White-footed Mouse		9.0	2.5		1.8	
Kangaroo Rat sp.				3.1	3.5	
Rock Pocket Mouse			0.8			4.9
Merriam's Kangaroo Rat		15.5		3.1	8.8	
Mexican Woodrat				3.1		
White-throated Woodrat		2.6	1.7	6.3		4.9
Woodrat sp.			0.8	3.1		1.6
Unknown sp.	4.5					
Total Animals/100 Trap Nights:	**27.3**	**29.7**	**16.9**	**25.0**	**19.3**	**13.1**
Shannon-Weaver Score:	**1.6**	**3.4**	**2.6**	**5.7**	**4.7**	**3.5**
Nights Trapped	5	15	20	5	5	10
Total Trap Nights	50	140	210	50	60	100
Trap Nights Sprung	28	24	92	18	3	39
Net Trap Nights	22	116	118	32	57	61

Table 5-6

Bat Species Detected by Habitat at Copper Flat Mine Permit Area and Reference Areas

Species	Scientific Name	Copper Flat Mine Permit Area			Reference Areas		
		Arroyo	**CDG**	**Lake**	**Arroyo**	**CDG**	**Lake**
• = Detected; ○ = Not detected but habitat present/species occur in the region; ? = detected but record uncertain							
Pallid Bat	*Antorzus pallidus*	○	•	•	○	•	•
Townsend's Big-eared Bat	*Corynorhinus townsendii*	○	○	•	○	○	○
Big Brown Bat	*Eptesicus fuscus*	○	○	•	•	○	○
Spotted Bat	*Euderma maculatum*	○	○	○	○	○	○
Allen's Big-eared Bat	*Idionycteris phyllotis*	○	○	○	○	○	○
Silver-haired Bat	*Lasionycteris noctivagans*	○		•	?		?
Southern Hoary Bat	*Lasiurus cinereus*	○		•	?		•
Southwestern Myotis	*Myotis auriculus*	○	○	○	○	○	○
W Small-footed Myotis	*Myotis ciliolabrum*	•	•	•	•	•	•
California Myotis	*Myotis californicus*	○	○	•	•	•	•
Arizona Myotis	*Myotis occultus*		•	•		○	•
Fringed Myotis	*Myotis thysanodes*		•	•		○	•
Yuma Myotis	*Myotis yumanensis*	○		•	•		•
Canyon Bat	*Parastrellus hesperus*		•	•		•	•
Brazilian Free-tailed Bat	*Tadarida brasiliensis*	○	•	•	•	•	•

Table 5-7

Reptiles Observed or Possibly Occurring at Copper Flat Mine Permit Area, Reference Areas, Las Animas Creek, and Conchas Creek

Species	Scientific Name	Copper Flat Mine Permit Area	Las Animas or Percha Creeks
• = Encountered; ○ = Not encountered but habitat present and species occurs in Sierra County			
Salamanders			
Tiger Salamander	*Ambystoma tigrinum*	•	•
Frogs and Toads			
Couch's Spadefoot Toad	*Scaphiopus couchii*	○	○
Plains Spadefoot	*Spea bombifrons*	○	
New Mexico Spadefoot	*Spea multiplicata*	○	○
Great Plains Toad	*Bufo congnatus*	○	○
Green Toad	*Bufo debilis*		
Arizona Toad	*Bufo microscaphus*		○
Red-spotted Toad	*Bufo punctatus*	○	○
Woodhouse's Toad	*Bufo woodhouseii*	○	○
Canyon Tree Frog	*Hyla arenicolor*		•
Bullfrog	*Rana catesbiana*		•
Chiricahua Leopard Frog	*Rana chiricahuensis*		•
Plains Leopard Frog	*Rana blairi*		•
Northern Leopard Frog	*Rana pipiens*		○
Turtles			
Ornate Box Turtle	*Terrapene ornata*		○?
Lizards			
Collared Lizard	*Crotaphytus collaris*	○	○
Greater Earless Lizard	*Cophosaurus texanus*	○	
Lesser Earless Lizard	*Holbrookia maculata*	•	
Texas Horned Lizard	*Phrynosoma cornutum*	•	
Short-horned Lizard	*Phrynosoma douglasii*	•	
Roundtail Horned Lizard	*Phrynosoma modestum*	•	
Clark's Spiny Lizard	*Sceloporus clarkii*	○	
Desert Spiny Lizard	*Sceloporus magister*	•	
Crevice Spiny Lizard	*Sceloporus poinsetti*	○	
Prairie Lizard	*Sceloporus undulatus*	○	○
Tree Lizard	*Urosaurus ornatus*	○	○
Side-blotched Lizard	*Uta stansburiana*	•	
Chiricahua Spotted Whiptail	*Cnemidophorus exsanguis*	○	○

Species	Scientific Name	Copper Flat Mine Permit Area	Las Animas or Percha Creeks
• = Encountered; ○ = Not encountered but habitat present and species occurs in Sierra County			
Checkered Whiptail	*Cnemidophorus grahamii*	○	○
Little Striped Whiptail	*Cnemidophorus inornatus*	○	
New Mexico Whiptail	*C. neomexicanus*	○	
Western Whiptail	*Cnemidophorus tigris*	○	
Desert Grassland Whiptail	*Cnemidophorus uniparens*	○	○
Many-lined Skink	*Eumeces multivirgatus*		○
Great Plains Skink	*Eumeces obsoletus*	○	○
Madrean Alligator Lizard	*Elgaria kingii*	○	○
Snakes			
Texas Blind Snake	*Leptotyphlops dulcis*	○	
Western Blind Snake	*Leptotyphlops humilis*	○	
Glossy Snake	*Arizona elegans*	○	
Ringneck Snake	*Diadophus punctatus*		○
Western Hooknose Snake	*Gyalpion canum*	○	
Western Hognose Snake	*Heterodon nasicus*	○	
Night Snake	*Hypsiglena torquata*	○	○
Common Kingsnake	*Lampropeltis pyromelana*		○
Coachwhip	*Masticophus flagellum*	•	
Striped Whipsnake	*Masticophus taeniatus*	○	
Gopher Snake	*Pituophis melanoleucus*	•	○
Longnose Snake	*Rhinochelius lecontei*		○
Big Bend Patchnose Snake	*Salvadora deserticola*	○	
Mountain Patchnose Snake	*Salvadora grahamiae*	○	
Ground Snake	*Sonora semiannulata*		○
Plains Black-headed Snake	*Tantilla nigriceps*		
Blackneck Garter Snake	*Thamnophis cyrtopsis*		○
W. Terrestrial Garter Snake	*Thamnophis elegans*		○
Checkered Garter Snake	*Thamnophis marcianus*		○
Lyre Snake	*Trimorphodon biscutatus*	○	
W. Diamondback Rattlesnake	*Crotalus atrox*	○	○
Rock Rattlesnake	*Crotalus lepidus*	•	
Blacktail Rattlesnake	*Crotalus molossus*	•	○
Western Rattlesnake	*Crotalus viridis*	○	
Massassagua	*Sistrurus catenatus*		

Figures

Appendix 5-A

Biological Resources Survey Report, Copper Flat Pipeline and Well Sites, Sierra County, New Mexico

Appendix 5-B

Winter Bird Survey Report

6 Topsoil Survey and Sampling Results

6.1 Summary

A successful reclamation program is dependent, in part, upon the quantity and quality of material available for use during the reclamation process. To this end, Stetson Engineers Inc. was retained by New Mexico Copper Corporation to conduct a soil survey of the Copper Flat Baseline Study Area (See Figure 6-1 below) to assess the quantity of available topdressing material that would be available for mine reclamation.

An Order 2 Soil Survey (1:12000) was completed in May, 2011 within the 2190-acre permit area. Approximately 1000 acres with potential topdressing sources were identified for characterization in an Order 1 Soil Survey (1:6000). The Order 1 Survey logged soil characteristics on 183 sites. These data were used to select 21 representative sites for full profile descriptions using freshly dug pits. Evaluation of these data resulted in classification of twelve soil taxonomic units and seventeen map units on about 425 acres with topdressing materials that met the suitability criteria. The median depth of available topdressing material in the map units ranged from 1 to 14 ft. These map units will yield approximately 3,391,000 cubic yards, or 2,100 acre-ft of suitable topdressing materials. The complete report Copper Flat Mine Order 1 Soil Survey of Permit Area is attached as Appendix 6-A to this report.

The Sierra County Area, New Mexico Soil Survey is in MLRA 42, Southern Desertic Basins, Plains, and Mountains. An Order 3 survey, mapped at a scale of 1:48,000, exists for the portion of the county where the permit area is located. This level of detail maps primarily at the association or consociation level, with soil consociations named after the dominant soil. Four map units occur within the permit area.

6.2 Order 2 Survey

The existing Order 3 survey was reviewed by Stetson Engineers, Inc., prior to conducting an Order 2 Soil Survey, which was mapped at a 1:12000 (1" = 1000') scale. Descriptions were made at 21 sites in the permit area to develop map unit concepts, in order to identify areas that are potential topdressing sources. The Order 2 Soil Survey identified 12 map units, of which several were identified for closer examination in the Order 1 Soil Survey.

6.3 Order 1 Survey

An Order 1 Soil Survey was conducted on approximately 1000 acres. Transects were identified across every occurrence of all Order 2 map units to delineate boundaries and determine the variability in properties existing within map units. There were 183 log sites chosen along these transects. Approximately 80 log sites were described outside the tailing storage facility, 70 inside it, and 30 on the west end around the mine.

After evaluating the 183 log sites, several variations within the original Order 2 map units were found. These were evaluated and 21 sites were chosen to evaluate for the Order 1 Soil Survey at a 1:6000 (0.5" = 1000') scale. Pits were dug at 21 sites for descriptions of soil profiles (pedons) and sample collection.

Pedons followed standard NRCS Soil Survey Staff protocols (Soil Survey Staff, 1996), including depth, boundaries, dry & moist colors, texture by feel, structure, consistence, visual estimate of gravel & cobbles, effervescence, presence of roots, and presence of redoximorphic features, illuvial clays, carbonate accumulations, gypsum accumulations, and other notable features. Following these descriptions, soil diagnostic horizons were identified and the soil was classified to the family level in Soil Taxonomy (Soil Survey Staff, 2010). Interpretations from the profile descriptions include drainage, permeability, and available water holding capacity. Samples were collected from representative horizons for lab testing (See Section 6.5).

Characterization of these profiles resulted in the selection of representative profiles for each of the twelve taxonomic units. Those twelve taxonomic units were further subdivided into map units based upon the thickness of suitable topdressing material. Map units are described in detail in Appendix 6-A.

6.4 Determination of Suitability for Topdressing Material

Three suitability categories were identified, based on such factors as slope, texture, sand/silt/clay content, water holding capacity, percent cobbles/boulders, calcium carbonate accumulations, pH, and salinity: good, fair, and unsuitable. Each pedon included in the attached report received a good or fair rating. The suitability criteria standards for these soil and landscape features (Table 6-1) have been adapted from those used by the Natural Resources Conservation Service, and New Mexico Mining and Minerals Division. They were modified by project soil scientists to reflect the conditions that exist within the Copper Flat area.

Tailings substrata were considered unsuitable as top dressing because of their processed origins, though none of the available element levels were present in amounts likely to be toxic to plants or to bioaccumulate in animals as they were within or below the normal ranges of these elements commonly found in soil (Baker and Pilbeam, 2007; Havlin et al., 1999).

6.5 Laboratory Testing

Representative samples from each soil taxonomic unit were collected for laboratory analysis. Lab tests performed include standard USDA tests: soil texture, pH, electrical conductivity, calcium, magnesium, and sodium adsorption ratio (on all samples), as well as soil organic matter by loss on ignition, nitrate-nitrogen, phosphorus, calcium carbonate equivalent, and sand size fraction (on specified samples). Samples inside the tailing facility or mine were screened for arsenic, boron, cadmium, calcium, copper, iron, magnesium, manganese, molybdenum, potassium, nickel, sodium, sulfur, zinc, chloride, mercury, and selenium, as well as for acid-base potential. Plant available fractions were determined with AB-DTPA extraction and ICP detection. Detailed laboratory results are included in Appendix 6-A.

6.6 Quantity of Suitable Material

Surveys identified about 425 acres that will yield approximately 3,391,000 cubic yards, or 2,100 acre-ft of suitable topdressing materials (detailed maps are included in Appendix 6-A).

6.7 Tailing Discussion

Though available copper, iron, zinc, molybdenum and selenium were elevated in mine tailing, available research suggests these values are not toxic (Baker and Pilbeam, 2007; Havlin et al., 1999). These conditions apparently have little negative impact on the plant communities currently growing on soils underlain by tailings. However, because of their origins as processed mine material, the tailings were deemed unsuitable for use as top dressing.

6.8 References

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Soil Survey Staff. 1996. National Soil Survey Handbook, Title 430-VI. USDA-Natural Resources Conservation Service. US Gov. Printing Office, Washington, DC.

Soil Survey Staff. 2010. Keys to Soil Taxonomy, 11th ed. USDA-Natural Resources Conservation Service, Washington, DC.

Table

Table 6-1

Soil and Site Evaluation as Source for Topdressing, Copper Flat Mine, New Mexico

Property	Good	Fair	Unsuitable	Feature
Slope %	<15	15-25	>25	Too Steep
Texture	-	SCL, CL, SiCL	C, SiC, SC	Too Clayey
Texture	-	LVFS, LCOS, LS, LFS	COS, S, FS, VFS	Too Sandy
Cobble + Gravel %	<35	35-60	>60	Too Cobbly
Stones %	<5	5-15	>15	Too Stony
$CaCO_3$ Eq. %	<15	15-40	>40	Excess Lime
AWHC (in/in)	>0.1	0.05-0.1	<0.05	Droughty
Soil pH	<8.5	<8.5	≥8.5	Too Alkaline
Salinity (ECe, dS/m)	<4	4-8	>8	Excess Salt
SAR	<ECe x 5	<ECe x 5	<ECe x 5	Excess Sodium
Selenium (ppm)	<0.1	<0.1	≥0.1	Excess Selenium
Boron (ppm) DTPA, available	<6.0	<6.0	≥6.0	Excess Boron
Acid/Base Potential	> -5 tons $CaCO_3$/1000 T	> -5 tons $CaCO_3$/1000 T	≤ -5 tons $CaCO_3$/1000 T	High acid-forming potential

Figure

Appendix 6-A

Copper Flat Mine
Order 1 Soil Survey of Permit Area

7 Geology

This section provides an overview of the regional and local stratigraphy and structural geology, as well as the mineralization at the Copper Flat Mine Permit Area (Site). The information has been summarized primarily from Dunn (1982, 1984), the BLM Preliminary Final Environmental Impact Statement (PFEIS) for Copper Flat (BLM, 1999), Raugust (2003), and SRK (2010). NMCC has built upon the site-wide geochemistry investigations conducted in 1995 and 1997 by SRK for a previous effort to re-establish the mine by Alta Gold Corporation. NMCC retained SRK to expand the Copper Flat geochemistry with additional sampling and analysis in 2010 and 2011. The combined results of these investigations are described in this Section. Section 8 describes the local and regional aquifers and springs.

7.1 Regional Geologic Setting

The Copper Flat Mine lies within the Mexican Highlands portion of the Basin and Range Physiographic Province. It is located in the Hillsboro Mining District in Las Animas Hills, which are part of the Animas Uplift, a horst on the western edge of the Rio Grande valley (Raugust, 2003). The Animas Uplift is separated from the Rio Grande by nearly 20 miles of Santa Fe Group alluvial sediments, referred to as the Palomas Basin of the Rio Grande valley. To the west of the Animas Uplift is the Warm Springs valley, a graben that parallels the Rio Grande valley (BLM, 1999; Raugust, 2003). Further west, the Black Mountains form the backbone of the Continental Divide, rising to about 9,000 ft above mean sea level (amsl). The surface geology of the Copper Flat region is shown in Figure 7-1, and a schematic geologic cross section is shown in Figure 7-2.

Basement rocks in the area consist of Precambrian granite and Paleozoic and Mesozoic sandstones, shales, limestones, and evaporites. Sedimentary units that crop out within the Animas Uplift include the Ordovician Montoya Limestone, the Silurian Fusselman Dolomite, and the Devonian Percha Shale. The Cretaceous-age Laramide orogeny, which was characterized by the intrusion of magma associated with the subduction of the Farallon plate beneath the North American plate, affected this region between 75 and 50 million years ago (Ma). Volcanic activity during the late Cretaceous and Tertiary periods resulted in localized flows, dikes, and intrusive bodies, some of which were associated with the development of the nearby Tertiary Emory and Good Sight-Cedar Hills cauldrons (Figure 7-3); later basaltic flows resulted from the tectonic activity associated with the formation of the Rio Grande rift. Tertiary and Quaternary alluvial sediments of the Santa Fe Group and more recent valley fill overlie the older Paleozoic and Mesozoic units in the area. The regional stratigraphy of the lower Rio Grande Valley is summarized in Table 7-1 (BLM, 1999).

The geologic structure of the region is characterized by block and rift faulting (Figure 7-3). The Tertiary cauldrons associated with the earlier block faulting formed between 35 and 45 Ma. Rift faulting and associated north-south block faulting associated with continental extension and the formation of the Rio Grande rift began approximately 25 to 30 Ma. Las Animas Hills are bounded by faults associated with rifting (Dunn, 1982). Continental extension continues to the present, as evidenced by north-south trending grabens represented by the Rio Grande and Warm Springs valleys.

7.2 Geology of Copper Flat Mine Site

7.2.1 Stratigraphy

As shown in Figure 7-4, the dominant geologic feature of the Animas Hills and Hillsboro district is the Copper Flat strato-volcano, a circular body of Cretaceous andesite that is 4 miles in diameter (Raugust, 2003). The andesite is generally fine-grained with phenocrysts of plagioclase (andesine) and amphibole in a groundmass of plagioclase and potassium feldspar and rare quartz. Some agglomerates or flow breccias are locally present, but the andesite is generally massive. Magnetite is a common association with the mafic phenocrysts, and accessory apatite is found in nearly every thin section (Dunn, 1984).

The strato-volcano is eroded to form a topographic low; the total depth of erosion is uncertain (SRK, 2010). To the east of the Site, this andesite body is in fault contact with Santa Fe Group sediments, which are at least 2,000 ft thick in the immediate area of Copper Flat and thickening to the east. Near-vertical faults characterize the contacts on the remaining perimeter of the andesite body; these faults juxtapose the andesite with Paleozoic sedimentary rocks. Drillholes indicate the andesite is more than 3,000 ft thick. This feature, combined with the concentric fault pattern, indicate that the local geology represents a deeply eroded Cretaceous-age volcanic complex (Dunn, 1982).

The core of the volcanic complex is a Cretaceous-age quartz monzonite stock that intruded into the center of the andesite body at the intersection of two principle structures that trend approximately N50W and N20E. Known as the Copper Flat Quartz Monzonite (CFQM), this irregular-shaped stock underlies a surface area of approximately 0.25 square miles and has been dated to approximately 75 million years before present (BLM, 1999; McLemore et al., 2000; Raugust, 2003). The monzonite crops out in only a few isolated areas, and the andesite at these contacts shows no obvious signs of contact metamorphism (Dunn, 1984). The CFQM is a medium- to coarse-grained, holocrystalline porphyry composed primarily of potassium feldspar, plagioclase, hornblende, and biotite; trace amounts of magnetite, apatite, zircon, and rutile are also present, along with localized mineralized zones containing pyrite, chalcopyrite, and molybdenite (McLemore et al., 2000). About 15 percent of the monzonite is quartz, which occurs both as small phenocrysts and as part of the groundmass; however, quartz is absent in some parts of the stock (Dunn, 1984).

Numerous dikes, mostly latite, radiate from the CFQM stock, some nearly a mile in length. Most of the dikes trend to the northeast or northwest and represent late stage differentiation of the CFQM stock (Raugust, 2003). Immediately south of the quartz monzonite, the andesite is coarse-grained, perhaps indicating a shallow intrusive phase. An irregular mass of andesite breccia along the northwestern contact of the quartz monzonite contains potassium feldspar phenocrysts and andesitic rock fragments in a matrix of sericite with minor quartz; this may represent a pyroclastic unit. Magnetite, chlorite, epidote, and accessory apatite are also present in the andesite breccia (Dunn, 1984).

The southwestern edge of the andesite body was intruded by the Warm Springs Quartz Monzonite pluton, which dates to approximately 73 Ma (Hedlund, 1974). Unlike the CFQM and the andesite, this monzonite body is not cut by the latite dikes (SRK, 2010), indicating that the dikes were emplaced prior to the Warm Springs Quartz Monzonite.

The Sugarlump Tuff (35 Ma) and the Kneeling Nun Tuff (34 Ma) unconformably overlie the local andesite flows. These tuffs erupted from the Emory caldera, and indicate that the Copper Flat volcanic/intrusive complex was buried during the Oligocene and exhumed during Miocene uplift (around 21.7 ±3.6 Ma) (Kelley and Chapin, 1997). Both the andesite and the quartz monzonite intrusions are cut by black, scoriaceous basalt dikes. These dikes remain unaltered, and appear to be associated with locally abundant Pliocene alkali basalt flows from around 4 Ma (Seager et al., 1984).

7.2.2 Structure

Three principal structural zones are present at the Site and surrounding area, the most prominent of which is a northeast-striking fault that trends N20-40E that includes the Hunter and parallel faults. In addition, west-northwest striking zones of structural weakness (N50-70W) are marked by the Patten and Greer faults, and east-northeast striking zones are marked by the Olympia and Lewellyn faults. All faults have a near-vertical dip; the

Hunter fault system dips 80°W, the Patten dips approximately 70°S-80°S, and both the Olympia and Lewellyn fault systems dip between 80°S and 90°S (Dunn, 1984; SRK, 2010). These three major fault zones appear to have been established prior to the emplacement of the CFQM and controlled subsequent igneous events and mineralization (SRK, 2010).

The CFQM emplacement is largely controlled by the three structural zones. The southern contact parallels and is cut by the Greer fault, although the contact is cut by the fault, and the southeastern and northwestern contacts are roughly parallel to the Olympia and Lewellyn faults, respectively. The CFQM stock is principally elongated along the Patten fault, as well as along the Hunter fault system. Whether there was movement along the fault zones before the emplacement of the stock has not been determined (Dunn, 1984; SRK, 2010).

Although latite dikes strike in all the three principal fracture directions, most of the dikes strike northeast. A narrow zone of fault gouge commonly occurs along the contact between the dikes and the andesite, with the mineralization post-dating fault movement (Harley, 1934). The northeast fault zones contain a high proportion of wet gouge, often with no recognizable rock fragments. Underground exposures of the Hunter fault zone (in previously existing mine workings) material has the same consistency as wet concrete and has been observed to flow in underground headings. However, the material in the east-northeast fault zones contains only highly broken rock and little obvious gouge. The width of the fault zones in both systems varies along strike from less than a foot to nearly 25 ft in the Patten fault east of the Project. Despite intense brecciation, the total displacement along the faults does not appear to exceed a few tens of ft (Dunn, 1984). At the western edge of the Site, a younger porphyritic dike was emplaced in a fault that had offset an early latite dike, indicating that fault movement occurred during the time that dikes were being emplaced (Dunn, 1984).

Post-dike movement is evident in all the three principal fault zones, and both the Hunter and Patten fault systems show signs of definite post-mineral movement. Fault movement has smeared sulfide deposits and offset the breccia pipe as well as the zones within the breccia pipe. Post-mineral movement along faults has resulted in wide, strongly brecciated fault zones. Some of the post-mineral dikes have been emplaced within these fault zones (Dunn, 1984; SRK, 2010).

NMCC has mapped the pit area and diversion cuts in detail at 1 inch equals 40 ft (1:480) and has examined the pre- and post-mineral stress orientations in the andesites and CFQM. Findings indicate no significant difference in the stress fields before and after mineralization (SRK, 2010).

7.3 Description of the Ore Body

Copper Flat is an alkalic copper-gold mineralized breccia pipe, associated with and genetically-linked to an alkalic porphyry system. Copper Flat is situated along the eastern edge of the Cretaceous Arizona-Sonora-New Mexico porphyry copper belt and along with Tyrone, New Mexico, forms a linear mineralized feature known as the Santa Rita lineament (SRK, 2010; McLemore et al., 2000). Copper Flat is the easternmost and one of the oldest known porphyry deposits in the southwestern U.S. (Hedlund, 1974; Dunn, 1982; Titley, 1982). Analogous deposits include Terrane Metal's Mount Milligan, British Colombia deposit and the Continental breccia pipe located in the Central Mining district of New Mexico (SRK, 2010).

7.3.1 Structure and Model

Mineralization at the Site is principally distributed within but not exclusive to a breccia pipe in the CFQM stock (Dunn, 1984; BLM, 1999; Raugust, 2003). There is a general elongation of the breccia pipe and the hosting stock along the N50W trend of the Patten fault system. The breccia pipe is characterized by biotite-breccia generally hosting higher grade copper mineralization, and quartz k-feldspar-breccia, and this pipe generally dips to the

S-SW. The breccia pipe has generally higher copper grades than the surrounding CFQM, hosting nearly half of the copper at the Site (SRK, 2010).

Drillholes spaced approximately 100 ft apart within the center of the deposit indicate the breccia pipe occurs as a single, continuous body, approximately 1,300 ft long by approximately 600 ft wide at the surface with the long axis parallel to the Patten fault (N50W) and perpendicular to the Hunter fault system (N20E) (Dunn, 1984). It is exposed in only a few places, but extends vertically to over 1,000 ft. Figure 7.5 illustrates the general trends and distribution of the breccia and the CFQM, as well as the principle NE and NW structures controlling mineralization.

Mineralized precious metals-bearing quartz veins, which are commonly associated with the dikes that radiate outward from the central stock, have been the target of some of the historical mining activities in the Hillsboro district. The breccia pipe zone has been cut by numerous, randomly oriented, irregular veins that are thicker and coarser grained than the narrow fracture-controlled veinlets in the surrounding stock.

Copper porphyry mineralization appears to have been contemporaneous with pipe formation (SRK, 2010). The lack of rock flour or gouge in the matrix suggests that brecciation was not the result of tectonic movement, while the apparent lack of appreciable movement between the fragments and the gradational contact between the breccia and the zone of stockwork veining indicate that an explosive mechanism was not the source of the brecciation. Likewise, the process of mineralization stoping described by Locke (1926), which would have resulted in appreciable downward movement and mixing of the fragments, is not supported by field observations. Thus the mechanism responsible for the formation of the Copper Flat mineralized breccia pipe appears to be auto-brecciation resulting from retrograde boiling, a phenomenon that occurs when the pressure of the mineralizing hydrothermal fluid exceeds the confining pressure (Phillips, 1973). The matrix of the breccia, the irregular veins in the surrounding crackle breccias, and the open space filling in the breccias consist of hydrothermal minerals and part of the second stage mineralization occurred as replacement, which modified the original breccia texture (SRK, 2010).

Unlike most deposits in the southwestern U.S., Copper Flat shows very little supergene enrichment or the symmetrical and telescoped zoning of alteration types that is considered typical of most porphyry copper deposits. This is likely due to erosion rates that exceed time required for supergene deposition and formation of significant oxide mineral formation. Instead, hypogene mineralization and alteration, including the formation of the breccia pipe, was the result of the final crystallization of the CFQM melt and related dikes (SRK, 2010).

The current model used by NMCC for further exploration at the Site is based on Richards (2003), who interprets the area as an eroded volcano. According to this model, mineralization occurred at similar depths to that found at El Teniente in Chile; since the Copper Flat breccia pipe now crops out at the surface, this assumption indicates that approximately 0.5 to 2 kilometers (km) of volcanic rocks have been eroded from the central zone of mineralization. Fluid inclusion work by Norman et al. (1989) and McLemore et al. (2000) suggest that the breccia pipe and veins formed at a depth of 1 to 2 km bgs and at temperatures ranging from 226° to 360°C.

7.3.2 Mineralization

During the early mining days, a 20- to 50-ft leached oxide zone existed over the ore body, but this material was stripped during the mining activities that occurred in the early 1980s. Most of the remaining ore is unoxidized and consists primarily of chalcopyrite and pyrite with some molybdenite and traces of galena and sphalerite. Appreciable amounts of silver and gold are also present (BLM, 1999; SRK, 2010).

The breccia consists largely of fragments of mineralized CFQM, with locally abundant mineralized latite where dikes exposed in the CFQM projected into the brecciated zone. Andesite occurs only as mixed fragments partially in contact with intrusive CFQM and appears to represent the brecciation of andesite xenoliths in the

CFQM (Dunn, 1984). The matrix contains varying proportions of quartz, biotite (phlogopite), potassium feldspar, pyrite, and chalcopyrite, with magnetite, molybdenite, fluorite, anhydrite, and calcite locally common. Apatite is a common accessory mineral. Much of the quartz-feldspar matrix has a pegmatitic texture. Breccia fragments are rimmed with either biotite or potassium feldspar, and the quartz and sulfide minerals have generally formed in the center of the matrix (Dunn, 1984).

The andesite in contact with the CFQM, dikes, and veins is typically altered into one of three types of mineral assemblages: biotite-potassic, potassic, or sericitic alteration (Fowler, 1982). The highest copper grades are associated with the biotite-potassic alteration, which is characterized by hydrothermal biotite, potassium feldspar, quartz, and pyrite, and which occurs in veinlets and as replacement assemblages in the monzonite (McLemore et al., 2000).

The total sulfide content ranges from 1 percent (by volume) in the eastern part of the breccia pipe and the surrounding CFQM to 5 percent in the CFQM to the south and west (SRK, 2010). Sulfide content is highly variable within the breccia, with portions containing as much as 20 percent sulfide minerals. Sulfide mineralization is concentrated in the CFQM and breccia pipe, and drops significantly at the andesite contact. Minor pyrite mineralization extends into the andesite along the pre-mineral dikes (Dunn, 1984; SRK, 2010).

Pyrite and chalcopyrite are disseminated within the CFQM and also occur along fracture-controlled veinlets and as disseminations associated with mafic minerals. Typically, pyrite is more abundant than chalcopyrite in two areas (SRK, 2010):

- A narrow zone that surrounds and overlies the western end of the breccia pipe, which has the highest grade CFQM mineralization, characterized by abundant chalcopyrite in quartz-sulfide veinlets and breccia zones.
- Outcrops to the southeast of the breccia and south of Grayback Wash, where disseminated chalcopyrite is present with no associated pyrite.

Molybdenite occurs occasionally in quartz veins or as thin coatings on fractures. Minor sphalerite and galena are present in both carbonate and quartz veinlets in the CFQM stock (Dunn, 1984). Preliminary 2011 evaluations of the mineralization at Copper Flat indicate that copper mineralization concentrates and trends along the N50W structural influences, whereas the molybdenum, gold and silver appear to favor a N10-20E trend.

7.4 Copper Flat Material Types

The proposed Copper Flat ore body to be mined is composed chiefly of potassic altered quartz monzonite porphyry with minor argillic overprinting. The intensity of argillic alteration varies considerably from weak development along fractures and exposed rock faces to alteration of groundmass feldspars along with hematite precipitation (moderate) to alteration of groundmass and phenocrysts, often associated with more intense hematite development in fracture zones and occasional jarosite (strong). In addition, weak meteoric oxidation products of iron and copper are present in the uppermost reaches of the exposed deposit and are best developed along the Sternberg lode. Other than this, a supergene sulfide enrichment zone or oxidation zone is absent from the deposit. Propylitic alteration is observed in the distal quartz monzonite and andesite but this is likely to be outside the current proposed mining zone. Molybdenite is observed in mineralized rocks within the current pit but is a minor component overall in the ore body. The lithological and alteration material types of importance to the proposed mining operations are as shown in Table 7-2.

7.5 Geochemical Characterization

As defined in the INTERA (2010) report, NMCC has conducted a geochemical characterization program to address the potential for waste rock, pit walls and tailing material to create acid rock drainage (ARD), to degrade surface or groundwater quality, or to cause a hindrance to reclamation. This demonstration is a requirement of MMD's Mine Permit and will generate data sufficient to address concerns about the potential for geologic materials present within the permit boundary to generate ARD or degrade surface or groundwater.

The recent geochemical characterization program augments geochemical sampling and test work performed by Alta Gold Corporation in 1995 and 1997 with additional geochemical sampling conducted by NMCC in 2010. The geochemical characterization programs were all designed and conducted by SRK Consulting (SRK) out of SRK's Reno, Nevada and Cardiff, UK offices. The objective of the recent geochemical characterization program is to update the previous geochemical characterization and modeling work to the revised standards outlining the characterization of mine waste that have been developed since the 1995 and 1997 work was conducted.

Below is a summary of the geochemical characterization work completed in the 1990s and 2010.

7.5.1 Overview of Current and Historic Geochemical Characterization Programs

7.5.1.1 Pre-1996 Geochemical Program

As part of the initial planning and baseline studies completed on behalf of Alta Gold, SRK collected a small suite of samples from drill core, tailings and waste rock for Acid Base Accounting (ABA), short term leachate and kinetic humidity cell testing. The kinetic testing program was run for 28 weeks. The review of this testwork was reported in the Geochemical Review of Waste Rock, Pit Lake Water Quality and Tailings (SRK, 1996). The testwork results were also utilized to develop predictive geochemical models to assess potential pit lake water quality. For reference, the SRK 1996 report is presented as Appendix 7-A.

7.5.1.2 1997 Geochemical Program

A geochemical sampling and testwork program was carried out by SRK as part of the 1997 Copper Flat Waste Rock Management Plan. The purpose of the program was to produce geological and geochemical characterization of the exposed material on the waste rock dumps and pit walls. A total of 141 surface grab samples were collected as part of the 1997 characterization program and these samples were analyzed for field paste chemistry to assess the short-term reactivity of the materials. Forty six of these samples were then subject to laboratory ABA testwork and 59 samples were submitted for Net Acid Generation (NAG) testwork in order to assess the acid generating potential of existing waste rock on site. This work was reported in Appendix A of the Copper Flat Preliminary Mine Waste Management Plan, New Mexico Copper Corporation (NMCC June 2011). For reference, Appendix A of the Waste Management Plan is presented as Appendix 7-B.

7.5.1.3 2010 Geochemical Program

Additional samples were collected by SRK representatives during a site visit in April 2010. The purpose of the 2010 sampling and testwork program was to augment the previous geochemical characterization and modeling work carried out from 1995 to 1997 and to comply with subsequent revisions to standards outlining the characterization of mine waste, which have evolved since the previous assessment was carried out. A number of statutory regulations have also been reviewed and modified since the initial assessment, including the modification of BLM and 43 CFR 3809 regulations in addition to changes to the standards applied to both EIS and New Mexico State permit applications.

The 2010 geochemical characterization program includes an assessment of waste rock geochemistry designed to predict the potential geochemical reactivity of waste rock and pit wall rock that has been and will be exposed during the proposed mining operation, and to provide input into a future pit lake hydrogeochemical model. This assessment also includes characterization of ore-grade materials that will be processed and deposited as tailings in the tailing impoundment.

During the site visit, two types of samples were collected including:

1. 50 drill core samples were collected at depth from exploration core holes drilled within the footprint of the Copper Flat pit in 2009 and 2010. The sample intervals were selected to represent the range of low grade ore and waste rock material types that will be encountered in the pit during mining operations.
2. 24 bulk surface grab samples from pit wall exposures, existing waste rock dumps, and the tailings impoundment. These samples provide an opportunity to compare fresh rock samples to weathered rock samples of the same material types that have been exposed to oxygen and water for over 20 years.

Samples collected as part of the 2010 characterization program augment the existing (1995-1997) geochemical dataset and are being used to update the geochemical characterization and modeling work to meet current standards. Figure 7.6 presents the locations of 1997 samples and the 2010 samples, both collected by SRK.

SRK has prepared four Technical Memorandums that describe the progress of NMCC's 2010 geochemical program. These memorandums are attached as Appendix 7-C, 7-D, 7-E, and 7-F and summarized below,

1. *Copper Flat Static Testwork Summary and Kinetic Test Recommendations* dated December 2010. This memorandum details the results of the initial characterization of the collected materials and includes recommendations for additional kinetic testwork;
2. *Copper Flat Geochemical Characterization Program* dated February 2011. This memorandum provides additional detail on the current geochemical characterization program and addresses some of the comments that were generated from the MMD's and NMED's review of the SAP;
3. *Copper Flat Geochemical Characterization Program; Incorporation of the 1997 Static Test Data* dated March 2011. This memorandum summarizes how the three data sets from 1996, 1997, and 2010 will ultimately provide key information to address the ARD concerns of NMED as well as the requirement of the MMD Mine Permit application; and,
4. *Copper Flat Kinetic Testwork Update* dated July 2011. NMCC is currently undertaking a kinetic geochemical characterization study to assess the Acid Rock Drainage and Metal Leaching (ARDML) characteristics of potential waste rock from the Copper Flat deposit. This work follows on from the static testwork program previously undertaken by NMCC as described in Memorandums 1 and 2 above. Twenty-one samples representative of potential waste rock are currently undergoing humidity cell testing (HCT) at McClelland Laboratories in Sparks, Nevada. At the time that this memorandum was prepared, the cells had been operating for a 24-week period, and the purpose of the memorandum was to provide an overview of the test methods and results to week 16 and to provide recommendations for continuation of the kinetic testwork program. Per SRK's recommendations, NMCC extended the humidity cell testing for an additional 20 weeks (cumulative 40 weeks).

The geochemical testing component of the this program addresses mineralogy, bulk geochemical characteristics, and the potential of the waste rock, pit wall rock and processed ore (tailings) to generate acid or net-neutral drainage. This program will also generate data to form the basis for prediction of future water quality that would result from precipitation contacting the material, and prediction of the impacts this water may have on groundwater, surface water, and pit lake quality at the Site. The data generated from this program will be used to develop source term chemistry for the final pit walls to define the control that the pit wall rocks will have on the chemistry of a pit lake that will form after closure. The geochemical analysis combined with the hydrologic modeling will form the basis for determining whether abatement measures are, or will be required, to mitigate ARD at the Site.

Upon completion of the kinetic humidity cell program, SRK will provide a single comprehensive report of the complete geochemistry program including both static and kinetic testing analysis and results. The report will also include the predicted source term chemistry for the pit wall rock and final pit lake. The following subsections contain a general description of the geochemical characterization program.

7.5.2 Geochemical Characterization Program Summary

7.5.2.1 Data Review and Material Type Delineation

On behalf of NMCC, SRK has reviewed all data available from the previous and current exploration drilling programs, including the drillhole database, drill logs, assay data, and bulk element geochemistry. From this review, the main rock types, alteration types, and oxidation states identified by SRK in the late 1990s were updated and are identified in Appendix 7-C through 7-F. The combination of these parameters was used to define material types for the project that are the focus of the geochemical characterization program.

A recent review by NMCC of the exploration database revealed discrepancies between the 2009/2010 and 2011 core logging procedures and the overall geologic interpretation of the deposit. These changes reflect the significant expansion in the knowledge of copper porphyries, in particular the Copper Flat deposit. The change in geologic interpretation prompted a re-log of the drill core samples intervals included in the 2010 geochemical characterization program. These changes have resulted in a slight revision of the material types defined for the project. These changes will be carried forward in subsequent data evaluation and final reporting.

7.5.2.2 Sample Collection

In late 1997, SRK collected 46 samples for ABA testing, 59 for NAG testing, 1 for short-term leach testing, and 5 for humidity cell kinetic testing. In addition, 14 samples were collected from the historic tailing impoundment for static test analysis, and approximately 130 samples from waste rock and pit walls were collected for paste chemistry. Figure A.1.2 of Appendix 7-B shows the locations of the surface samples collected in 1997.

For the 2010 characterization program, a total of 74 additional samples were collected to create a sample database that is vertically and horizontally representative of potential low grade ore and waste rock associated with the current project. The sample set consists of both surface grab samples and drill core samples that were characterized based on lithology, alteration, oxidation, and absence/presence of sulfides. Drill core samples consist of coarse reject material from the recent exploration drill programs representative of waste rock. These samples were generated by collecting material from consecutive intervals within the same drillhole, and each sample consisted of a single material type as defined by rock type, alteration type, and oxidation state as defined by the exploration database. These samples were submitted to certified laboratories in Reno, Nevada, for sample preparation and laboratory testing. All 74 samples were submitted for ABA, NAG, and multi-element analysis. In addition, 40 of these samples were selected and analyzed using the Meteoric Water Mobility Procedure (MWMP), and 21 samples were selected for humidity cell testing beginning in January 2011. Figure 7-6 shows the 2009/2010 drillhole locations as well as the locations of the 2010 surface grab samples.

NMCC's approach to sample selection was designed to ensure that samples with end-member reactivity are sufficiently represented in the program to provide a comprehensive and representative understanding of the full range of geochemical characteristics for each of the material types. To this end, NMCC has focused on understanding the geological controls on the geochemical behavior of the different materials as the basis for sample selection.

7.5.2.3 Field Screening Program

Field tests including determination of paste pH and electrical conductivity (EC) were used in the 1997 geochemical characterization program to identify the presence of surficial/soluble salts in the waste rock dumps that could affect water quality. Because these tests are inexpensive and quick, a significant amount of data can be collected quickly with minimal cost. By using the field screening to define a representative sample set, the "representativeness" of the sample set is more defensible and the number of samples selected for the more expensive static test suite can be minimized. Based on the material type and paste results for that material, samples were selected for additional laboratory analysis. Samples included in the field screening program consisted of fine material (<5 mm chips) that was collected from a 1 cubic meter area on the waste rock dump surface. This method is employed because water quality in a dump is largely controlled by the fines and this is a good indication of reactivity. The paste test comprises mixing a 1:1 solid to liquid ratio of fines with distilled water and measuring EC and pH of the resulting solution. If the resulting leachate was blue in color, the sample was analyzed for copper and sulfate by field colorimetric spectrometry.

7.5.2.4 Static Test Program

The samples collected for the 2010 geochemical program were submitted to a certified laboratory for sample preparation and the first phase of static testing as follows:

1. Whole rock analysis using four-acid digest and ICP analysis to determine total metal and metalloid chemistry for 48 elements (ALS Chemex Method ME-MS61).
2. ABA using the modified Sobek method (Memorandum No. 96-79) with sulfur speciation.
3. NAG test reporting final NAG pH and final NAG value after a two-stage hydrogen peroxide digest.

This work was supervised by SRK at McClelland Laboratories of Sparks, Nevada, with analysis by Western Environmental Testing Laboratory (WETLab) of Sparks, Nevada; ALS Chemex of Reno, Nevada; and SVL Laboratories of Kellogg, Idaho.

The first phase of geochemical testing was completed to assess the range of reactivity of each of the material types and the results were used to select samples for MWMP testing with geochemical analysis of the leachate for applicable constituents. Samples demonstrating end-member reactivity, as determined from the first phase of static laboratory testing, were selected for MWMP testing to provide a comprehensive and representative understanding of the leaching characteristics of the major material types associated with the Copper Flat deposit. The results of the static testing are described in detail in Appendices 7-C, 7-D and 7-E.

7.5.2.5 Kinetic Testing Program

Based on the results of the static testing described above, any material types that exhibited uncertain or highly variable geochemical behavior were selected for further characterization using kinetic test methods to determine the rates and character of longer-term leaching. Because the static test work assumes that all minerals that have the potential to generate acid, buffer acid, or leach metals will react completely, they can only define the total acid generation and metal leaching potential of the rock and do not take into account reaction rates that will ultimately control whether the material will actually generate acid, buffer acid, or leach metals under field conditions.

Twenty-one samples were selected for humidity cell testing (as per ASTM D-5744-96-7 methodology), which was initiated in January 2011. Appendix 7-F provides documentation of the humidity cell results through Week 16. Based on the Week 16 data, SRK recommended, and NMCC approved, the continuation of the humidity cell testing through 40 weeks, which extends the humidity cell testing into Q4, 2011.

7.5.2.6 Data Validation and Compilation

The geochemical data are being reviewed as they are received to ensure the quality of data and consistency in analyses. NMCC's contractor will verify the quality of all data and confirm that no anomalies are related to laboratory error prior to interpretation and reporting. At a minimum, NMCC's contractor will utilize their internal standard data validation procedures, although guidance from other sources may also be considered (e.g., U.S. Environmental Protection Agency). All static geochemical data collected as part of the static testing program is being compiled into a single database for evaluation and the kinetic test data is being compiled into a separate database. This updated and quality checked database will be made available in the final geochemical report described in Section 7.5.3.

7.5.2.7 Geochemical Modeling

The Copper Flat Plan of Operations calls for leaving waste rock from previous mining activities in place and extending the waste rock facilities to accommodate waste rock from proposed new mining activities.

Existing and new waste rock have the potential to affect land and water resources through mobilization and transport of mine rock materials, whether as solid or dissolved phases, from the facilities to the surrounding environment. Potential receptors include soils, surface water, and groundwater resources near the facilities.

Static testing and geochemical analyses of existing waste rock and potential future waste rock and pit wall materials revealed a range of results. Some samples were characterized as having acid generation potential, whereas other samples demonstrated a potential to be acid consuming or neutral using the BLM waste rock guidelines for static testing. Kinetic testing of a subset of these mine rock samples began in January 2011 and still underway.

Upon completion of the testing program, a conceptual model will be developed to describe predicted geochemical trends of reactivity from waste management facilities, final pit walls and the tailing facility. The characterization study will also include a review of baseline groundwater chemistry and any hydrogeological studies in as far as they influence the understanding of geochemical dispersion, development of potential environmental pathways and limitations on this in the environment.

Following development of the conceptual geochemical model, it will be necessary to provide quantitative numerical predictions of the potential impacts of seepage or runoff from mining facilities to regional groundwater. In this instance, numerical predictions are proposed to use the USGS-developed software PHREEQC in order to develop a source term for the waste rock dumps, pit wall rocks, tailing impoundment and future pit lake. Data collected during the geochemical characterization program will be used to develop source term chemistry. For calculation of the waste rock dump and tailings facility source terms, the chemistry of the solution will be mass balanced to the predicted geological composition of the facilities, field solid-water ratio, contact times and then allowed to form a chemical equilibrium with rainwater and atmospheric oxygen. The resulting chemistry would be the predicted overall potential seepage chemistry from the facilities, assuming the total declared volume of meteoric water infiltrating the dumps or impoundment is fully mixed. These data, evaluated in conjunction with other data from the site (e.g., groundwater chemistry), will provide a basis for risk assessment and the evaluation of options for construction and closure of the waste rock and tailing impoundment facilities.

Data collected during the geochemical characterization program will also be used to develop source term chemistry for geologic material that will be exposed in the final pit walls that is needed for subsequent pit lake modeling efforts. The post-closure and long term geochemistry of a pit lake depends on the potential for rock exposed in the pit highwall to contribute acidity, metals, and other solutes to the pit lake during filling. Meteoric water contacting the pit walls enables desorption and dissolution of solutes from wall rock. The resultant chemistry of surface water reporting to the pit can be represented as the weighted sum of the water chemistry associated with each type of exposed rock. Pit lake chemistry will also be influenced by inflowing groundwater that will flow through the pit wall, where it will pick up additional solute load from secondary weathering products that are the result of oxidation that will occur during the period of dewatering. Previous studies demonstrated the current pit acts as a local terminal sink so no outflow is anticipated (See Section 8.0).

7.5.3 Ongoing Geochemical Assessments

NMCC believes the geochemical work being conducted will be sufficient to address the baseline data conditions and meet the MMD requirements to fully characterize the potential for waste rock, low grade ore and final pit walls to generate acid and leach metals, and evaluate potential degradation of surface or groundwater quality. At the conclusion of the humidity cell testing, SRK will prepare a detailed report with the results of the static and kinetic testing as well as the results of the predictive numerical modeling described in Section 7.4.7. NMCC will provide this report to the MMD and NMED as it becomes available in 2012 and believes the report will conclude the geochemical characterization with respect to the baseline data condition. To support both exploration and environmental evaluations, additional geochemical work is being executed. However, the results of these studies will principally be to satisfy NMCC's internal understanding of the site geology and long term environmental concerns supervised by the NMED.

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Tables

Table 7-1
Stratigraphy of the Copper Flat Area

Age	Geologic Unit		Thickness (ft)
Cenozoic 0–65 million years ago (Ma)	Pleistocene and Holocene valley alluvium		10–70
	Pleistocene river, arroyo, and fan deposits		50–100
	Pliocene basalt flows, dikes, and plugs		50–200
	Upper Santa Fe Group fanglomerates (Palomas Formation)		300–100
	Santa Fe Group, Rincon Formation		1000–2000
	Tertiary volcanics		1000
Mesozoic 65–225 Ma	Quartz latite dikes	**Copper Flat volcanic and intrusive (mineralization associated with emplacement)**	>3000
	Intermediate composition intrusive		
	Late Cretaceous andesite dikes		
	Late Cretaceous silicic intrusives		
	Sandstone		
	Mancos Shale (not exposed)		300–400
	Dakota Sandstone (not exposed)		100–200
Paleozoic 225–570 Ma	Manzano Group sedimentary rocks. Abo Sandstone, Yeso Formation shales, sandstones, and gypsum deposits, and San Andres Limestone. Not exposed west of Rio Grande at Site.		1000–2000
	Pennsylvanian carbonate rocks including Syrena, Oswaldo, and Magdalena Groups, minor conglomeratic sandstone and cherty massive limestone.		400–1000
	Devonian and Mississippian carbonate rocks (Kelly Limestone, Lake Valley Limestone, Caballero Formation) and Percha Shale.		200–500
	Ordovician Montoya Group and Fusselman Dolomite.		250–600
	Cambrian-Ordovician Bliss Sandstone and El Paso Group Limestone.		500–700
Precambrian 570–1,500 Ma	Precambrian massive granite		

Source: BLM, 1999, Tables 3-1 and 3-2

Table 7-2

Major Material Types in Proposed Copper Flat Mining Project

Lithology	Primary Alteration	Secondary Alteration	Coding	Abundance
Quartz Monzonite	Potassic	Meteoric	QMK-ox	1%
Quartz Monzonite	Potassic	Argillic/Meteoric	QMKA ox	1%
Quartz Monzonite	Potassic	Argillic	QMKA	32%
Quartz Monzonite	Potassic		QMK	18%
Quartz Monzonite	Argillic		QMA	1%
Quartz Monzonite	Meteoric		QMM	1%
Biotite Breccia	Potassic	Argillic	BBKA	4%
Biotite Breccia	Potassic		BBK	3%
Quartz Breccia	Potassic	Argillic	QBKA	4%
Quartz Breccia	Potassic		QBK	7%
Andesite	Uncharacterized	Uncharacterized	AND	9%
Coarsely Crystalline Porphyry	Uncharacterized	Uncharacterized	CCP	18%

Figures

Appendix 7-A

Geochemical Review of Waste Rock, Pit Lake Water Quality and Tailings (SRK 1996)

Appendix 7-B

Copper Flat Preliminary Waste Management Plan,
New Mexico Copper Corporation
(NMCC June 2011)

Appendix 7-C

Copper Flat Static and Kinetic Test Recommendations (SRK Dec 2010)

Appendix 7-D

Copper Flat Geochemical Characterization Program
(SRK Feb 2011)

Appendix 7-E

Copper Flat Geochemical Characterization Program Incorporation of the 1997 Static Test Data

(SRK Mar 2011)

Appendix 7-F

Copper Flat Kinetic Testwork Update
(SRK July 2011)

8 Surface Water and Groundwater Information

8.1 Surface Water

8.1.1 Introduction

The Copper Flat Mine Permit Area is located in the Lower Rio Grande watershed, as defined by the New Mexico Water Quality Control Commission (WQCC). The Lower Rio Grande watershed includes approximately 5,000 square miles in Catron, Socorro, Sierra, and Doña Ana Counties and is dominated by the Rio Grande and its tributaries as well as the two large reservoirs of Elephant Butte and Caballo. Numerous tributaries drain into the Rio Grande from the west, but none contribute perennial flow to the Rio Grande.

The Mine Permit Area is drained by ephemeral streams (arroyos) within the Greenhorn Arroyo Drainage Basin (Figure 8-1). Within the Mine Permit Area, the open pit that was created during mining in the early 1980s now contains a lake. Two creeks drain basins directly to the north and south of the Greenhorn Arroyo Drainage Basin: Las Animas Creek to the north and Percha Creek to the south (Figure 8-1). Both Las Animas and Percha Creeks have ephemeral, intermittent, and perennial reaches. Both Las Animas and Percha Creeks have perennial reaches that support fisheries.

Surface water in the Mine Permit Area and vicinity was investigated by SRK in 1995 (SRK, 1995). SRK collected flow and water quality data from Grayback Arroyo, Percha Creek, and Las Animas Creek. Newcomer et al. (1993) performed a hydrologic assessment of the Greenhorn Arroyo Drainage Basin, measuring flow and water quality along Grayback Arroyo and at a number of seeps and springs. The oldest known surface water investigation for surface water resources in the area of the Mine was performed by Davie and Spiegel (1967), who collected flow data for Las Animas Creek. Results of these investigations were compiled by Raugust (2003) and are also summarized in the BLM's PFEIS for Copper Flat (1999). Flow rate data for streams in the vicinity of the Mine Permit Area are limited by the generally intermittent and ephemeral nature of flows. Historical field parameters and flow measurements are provided in Table 8-1.

The proposed sample locations, frequency, and methods of measurement and sample collection used during sampling activities in 2010 and 2011 are described within the Sampling and Analysis Plan (SAP) (INTERA, 2010). Overall, these data characterize baseline volumetric flow and water quality conditions of surface water resources within the Mine Permit Area and the surrounding Baseline Study Area that would be potentially affected by operations and reclamation.

8.1.2 Surface Water Sampling and Analysis by Drainage Basin

The surface water flow and water quality data provided in this BDR are organized according to the three primary drainage basins in the vicinity of the Mine Permit Area: the Outlet Las Animas Creek Basin, the Percha Creek Basin, and the Greenhorn Arroyo Basin (Figure 8-1). These drainage basins are 6th level sub-watersheds as defined by the USGS Hydrologic Unit classification system (Seaber et al., 1987). For each drainage basin, a description is provided followed by historical flow data, present (baseline data collection period) flow data, and seasonal flow patterns for streams. These data are followed by the historical water quality data, present water quality data, and seasonal patterns in the water quality data for the streams. This format is repeated for the springs in each drainage basin, concluding with a summary of modifications to the SAP during the sampling events and a brief discussion of the hydrologic consequences of mine operation on the drainage basin.

8.1.2.1 Outlet Las Animas Creek Drainage Basin

8.1.2.1.1 Drainage Basin Description

Two creeks drain basins directly to the north and south of the Greenhorn Arroyo Drainage Basin: Las Animas Creek to the north and Percha Creek to the south (Figure 8-1). Las Animas Creek originates in the Black Range, approximately 20 miles west of the Mine Permit Area, and has ephemeral, intermittent, and perennial reaches.

In 1967, William Davie, Jr., and Zane Spiegel published a hydrograph survey report of Las Animas Creek for the New Mexico Office of the State Engineer (NMOSE). The report details the hydrogeology of the region and stream flow measurements, and provides an inventory of surface water diversions, wells, and irrigated lands along Las Animas Creek.

The Percha Shale, which underlies Las Animas Creek west of the Animas Uplift (west of TI5S R7W - TI5S R6W boundary) (Figure 8-1), likely prevents groundwater movement up into the creek and eastward (Davie and Spiegel, 1967). Most of the water in the western, upstream portion of Las Animas Creek likely discharges to the surface west of the Animas Uplift. Groundwater emerges in a number of springs near the outcrop of Percha Shale in Section 34, T14S, R7W, upstream of measurement location LAC-A (Figure 8-2). Groundwater entering Las Animas Creek from Pennsylvanian rocks, particularly NWS spring (Figure 8-2), was measured at a temperature of about 27 degrees Celsius (°C), which is about 9°C higher than normal shallow groundwater temperatures in the area, indicating groundwater origination from greater depths (Davie and Spiegel, 1967). The temperatures measured at NWS in 2010 and 2011 were also recorded at approximately 27°C. Davie and Spiegel (1967) believed this temperature indicates groundwater from NWS is coming from a depth of at least 800 ft below land surface.

The construction of diversion ditches and shallow wells along Las Animas Creek has caused local and seasonal changes in the alluvial groundwater and in surface flow (Davie and Spiegel, 1967). The pumping of groundwater from deep wells, which started around 1938, has likely had an impact on upward leakage of groundwater into the alluvium of Las Animas Creek (Davie and Spiegel, 1967). However, the increase of irrigation return flows from irrigated agriculture supplied by groundwater well pumping has also increased seasonal surface water in Las Animas Creek. Long-term monitoring of these impacts has not taken place, although the USGS has performed some limited water level monitoring from wells completed in the alluvium.

The upper portion of the Outlet Las Animas Creek Drainage Basin contains only a few dwellings; however, Ladder Ranch utilizes the water in Las Animas Creek and shallow alluvium for irrigation and stock ponds. The lower portion of Las Animas Creek, beginning approximately 1 mile upstream of LAC-E to Caballo reservoir, contains a large number of ranches, small farms, and home sites (Figure 8-2). A number of diversion ditches and return-flow ditches exist along this reach of the valley. In addition, many of the home sites have shallow wells, including some artesian flowing wells that are used for irrigated agriculture.

8.1.2.1.2 Las Animas Creek

Flow

Historical Data

Streamflow in Las Animas Creek varies from perennial to ephemeral from the area near sampling site LAC-C to Caballo Reservoir (Figure 8-2). For example, Davie and Spiegel (1967) show flow rates ranging from about 1.0 to 2.0 cubic feet per second (cfs) in the upper reach (T14S R7W, Sections 34 through 36, near sampling sites LAC-A and LAC-B in Figure 8-2) and middle reach (within T15S R5W) (near sampling sites LAC-C and LAC-D) of the creek;

according to Davie and Spiegel, these reaches are “losing reaches” of the creek. Two measurements of flow rate are recorded for Las Animas Creek. Davie and Spiegel (1967) reported flows of between 1.0 and 2.0 cfs in the creek’s upper reaches and between 1.0 and 1.5 cfs in its middle reaches (BLM, 1999). Adrian Brown Consultants made a single flow measurement near LAC-E in 1996, reporting flow of 0.546 cfs (ABC, 1996a). These measurements are reported in Table 8-1. Later, multiple measurements were made near LAC-E from April 1996 through March 1998 during the spring runoff season with flow rates ranging from 0.87 to 0.06 cfs (ABC, 1998). As shown in Table 8-2, no flow was reported from April 10, 1996, through December 17, 1996 (ABC, 1998). On January 15, 1997, a flow of 11.2 cfs was reported, and on March 18, 1997, a flow rate of 37.7 cfs was reported (ABC, 1998). Flow was measured at 22.7 cfs on August 15, 1997, but then ceased for the remainder of 1997. Flow increased again on January 12, 1998, for which a flow rate of 60.3 cfs was reported (Table 8-2) (ABC, 1998). Though the NMED SWQB has collected flow data along Las Animas Creek, there are no historical flow data available in published reports.

Baseline Data

In August 2010, November 2010, January 2011, and April 2011, flow measurements were collected as part of the baseline data collection program from a number of measurement locations along accessible perennial and intermittent reaches of Las Animas Creek (Figure 8-2). The data are presented in Appendix 8-A. The objective of the flow measurements was to characterize the baseline volumetric flow of the springs and streams within the Outlet Las Animas Creek Drainage Basin (INTERA, 2010). Perennial stream reaches and springs were sampled four times over a one-year period, while ephemeral and intermittent reaches and springs were sampled during opportunistic sampling events after precipitation events over a one-year period. One auto-sampler was installed along an intermittent reach of Las Animas Creek. This auto-sampler, installed near LAC-E (Figure 8-2), did not collect a sample due to low flow in the creek during the sampling period.

Flow rates ranged from 0.04 to 7.09 cfs along Las Animas Creek from August 2010 to April 2011 (Appendix 8-A). Measurement location LAC-B had the greatest flow during each of the quarterly measurements except during the fall measurement, in November 2010. The summer measurements, in August 2010, consisted of the greatest flow volumes for all of the Las Animas Creek measurement locations, likely due to increased precipitation during summer months (see Section 2 [Climate] for further details).

In addition to the baseline flow measurements collected from August 2010 to April 2011, flow measurements were collected at six locations along Las Animas Creek on June 28, 2011 (inset, Figure 8-2). The measurement locations are identified as LAC-1 through LAC-6 and the data collected from these locations are summarized in Table 8-3. The results of these measurements are summarized in Appendix 8-B. Access to Las Animas Creek was not permitted upstream of LAC-1. In June 2011, calculated discharge rates were lower at each location along the creek relative to previously observed values measured from August 2010 to April 2011. Only two perennial reaches were observed along the accessible portion of Las Animas Creek. The maximum flow rate of the first reach was approximately 0.37 cfs at LAC-2. The maximum flow rate of the second measurable reach was 0.02 cfs at LAC-6.

As described in detail in Appendix 8-B, at the time of measurement, Las Animas Creek was predominately a losing stream, i.e., water was leaving the stream and entering the subsurface. The stream appears to gain water from the subsurface within two short reaches. The first gaining reach extends approximately 920 ft from the start of flow (SoF) to LAC-2 (inset, Figure 8-2) (Table 8-3 and Table 8-4). Las Animas Creek is then a losing stream from approximately 1,000 ft downstream of SoF to approximately 3,530 ft, where the stream dries out downstream of LAC-4. Approximately 5,200 ft downstream of SoF, Las Animas Creek is once again a gaining stream to LAC-5, approximately 5,830 ft downstream of SoF. At LAC-5, the surface water is very low and slow but does flow along the surface for approximately 950 ft before disappearing below the surface of the creek alluvium approximately 100 ft downstream of LAC-6.

Seasonal Patterns

The greatest flow rates measured in Las Animas Creek during the period August 2010 to April 2011 were recorded in the summer quarter in August (Figure 8-3). With the exception of LAC-B, all of the measurement locations showed a decrease in stream flow for each quarter (Figure 8-3). The flow rates in November were substantially lower than those recorded in August, and the measured rates trend toward a decrease with each quarter. In addition, the flow rates measured in June 2011 were considerably lower than all previously measured rates (Table 8-3). The June 2011 measurements were conducted prior to any late-summer rain events to determine low flow conditions. The seepage rates determined from the June 2011 flow measurements are provided in Table 8-4.

Water Quality

Historical Data

The water quality of Las Animas Creek was examined by Adrian Brown Consultants (1996a) and for the PFEIS (BLM, 1999). Adrian Brown Consultants obtained a single sample at LAC-E with a pH of 7.81, a sulfate concentration of 18 milligrams per liter (mg/L), and total dissolved solids (TDS) of 300 mg/L. The PFEIS reports that Las Animas Creek water quality is dominated by calcium or sodium bicarbonate, with pH in the range 7.0 to 8.0, sulfate in the range 20 to 70 mg/L, and TDS in the range 300 to 400 mg/L. Occasionally, sodium and chloride are higher, with chloride concentrations as high as 300 to 400 mg/L, possibly due to agricultural practices along the creek (BLM, 1999). Complete analytical results for Las Animas Creek are compiled in Appendix 8-C.

The New Mexico Environment Department (NMED) Surface Water Quality Bureau (SWQB) Monitoring and Assessment Section also collected water quality data in 2004 from three sampling stations along Las Animas Creek. Water quality and biological samples collected from these locations were part of a larger survey of the Lower Rio Grande and its perennial tributaries from the international boundary with Mexico to Elephant Butte Reservoir. Water quality monitoring included analysis of total nutrients, total and dissolved metals, major anions and cations, and field parameters. Biological surveys, which included the monitoring of fecal coliform and E. coli as well as the collection of macroinvertebrates and physical habitat characteristics, were conducted at select stations (NMED SWQB, 2009). Results from water quality sampling at locations along Las Animas Creek found no exceedances of water quality criteria for total nutrients, total and dissolved metals, major anions and cations, bacteria, and field parameters such as dissolved oxygen, pH, and temperature (NMED SWQB, 2009). The results of this analysis indicated that the low dissolved oxygen (DO) values documented in Las Animas Creek are likely the result of a significant groundwater input and therefore these sites were determined by NMED to be Fully Supporting its aquatic life use with respect to DO. This work, including the water quality data, is summarized in NMED SWQB (2009).

Baseline Data

In August 2010, November 2010, January 2011, and April 2011, field parameters and water quality samples were collected from various measurement locations along accessible perennial and intermittent reaches of Las Animas Creek (Figure 8-2). In April 2011, one sediment sample was collected along Las Animas Creek (Figure 8-2). Field parameters are presented in Appendix 8-A. Analytical results are presented in Appendix 8-C.

The water quality data for Las Animas Creek, as shown in Appendix 8-C, were similar to historical water quality data. For the samples collected from August 2010 to April 2011, the pH levels were slightly higher, in the range of 7.74 to 8.47, and the sulfate and TDS concentrations were lower, in the range 7.5 to 29 mg/L for sulfate and 173 to 357 mg/L for TDS. The sodium concentrations measured in Las Animas Creek range from 12 to 69 mg/L, and the chloride concentrations range from 2.8 to 74 mg/L. In general, the greater concentrations of sulfate, TDS, sodium, and chloride were measured from the NWS spring. The lower pH values were also measured at the NWS spring.

In April 2011, a sediment sample was collected at LAC-E in addition to the water sample. The results of both the water quality analysis and the sediment analysis were similar. Arsenic, barium, calcium, magnesium, potassium, silicon, sodium, uranium, and zinc concentrations were lower in the sediment sample than in the water sample, while aluminum, boron, iron, and manganese concentrations were higher in the sediment sample.

Seasonal Patterns

The concentrations of sulfate, TDS, sodium, and chloride increased as flow rates decreased during the baseline study period. The pH values of Las Animas Creek also increased as flow in the creek decreased (Appendix 8-C).

8.1.2.1.3 Springs

In 1967, Davie and Spiegel identified four spring or seeps within the Outlet Las Animas Creek Basin, however minimal historical data are available. As a result, there is little information on the flow rates or the quality of the springs and seeps. Two springs in the Outlet Las Animas Creek Drainage Basin were identified for sampling for baseline characterization.

Flow

Historical Data

Spring and seep flow rates are infrequently reported in the available literature for the Mine Permit Area and surrounding areas. Very little data are available for the springs in the Outlet Las Animas Creek Drainage Basin (Figure 8-2). In March of 1967, Davie and Spiegel measured NWS, also known as Warm Spring, to have a flow rate of 0.81 cfs (Davie and Spiegel, 1967). No other historical flow data were available for this spring or any others along or within the Outlet Las Animas Creek Basin.

Baseline Data

One spring, NWS, along Las Animas Creek (Figure 8-3) was identified for measurement from August 2010 to April 2011. The flow rate at NWS ranged from 0.731 cfs in November to 1.1 cfs in August (Appendix 8-A).

Seasonal Patterns

The flow rates recorded from the spring at NWS did not appear to be affected by the seasonal pattern impacting the in-stream flow rates along Las Animas Creek (Figure 8-3).

Water Quality

Historical Data

No historical water quality data were available for any springs or seeps in the Outlet Las Animas Creek Basin.

Baseline Data

Water quality samples were collected in August 2010, November 2010, January 2011, and April 2011. In general, the concentrations of arsenic, chloride, fluoride, magnesium, potassium, total residue, sodium, specific conductance, sulfate, and TDS were higher in samples collected from NWS than they were in samples collected from Las Animas Creek (Appendix 8-C). The pH level of the spring at NWS was lower than pH levels recorded for the creek, and the spring had lower concentrations of silicon as well.

Seasonal Patterns

The water quality parameters collected at NWS do not appear to follow a seasonal pattern and remained relatively constant from August 2010 to April 2011 (Appendix 8-C).

8.1.2.1.4 Modifications to the SAP

As NMCC executed the SAP, adjustments to the proposed SAP were necessary based on the actual site conditions encountered in the field. When making adjustments based on field conditions, NMCC strived to find equivalent or improved alternatives, where possible. Due to the ephemeral and intermittent nature of many of the reaches along Las Animas Creek, modifications occurred related to the surface water monitoring locations and sampling frequency proposed in the SAP (INTERA, 2010). In addition, many of the springs and seeps originally identified for quarterly monitoring and sampling, also identified as ephemeral in nature, were dry or had very little flow during the quarterly monitoring.

The quarterly flow measurement of one spring in the Outlet Las Animas Creek Drainage Basin was proposed in the SAP (INTERA, 2010); however, the spring, MAS, was not located in the Las Animas Creek stream bed and may have been masked by the stream flow. This spring location was replaced with NWS, further upstream, and its flow was measured in each quarter and sampled three times. Additional stream locations were sampled along Percha Creek due to the inability to sample from dry locations in other streams (Section 8.1.2.2).

In April 2011, NMCC discussed the sediment sampling plan from the SAP with the New Mexico Energy, Minerals, and Natural Resources Department, Mining and Minerals Division (MMD) (Eustice, 2011). MMD stated it would require a minimum of one sediment sample per drainage. The sediment sample was required to be from the same location as one of the surface water sample locations and downstream of sites which may affect water quality. In April, 2011 one sediment sample was collected from the Outlet Las Animas Creek Drainage Basin (near LAC-E) (Figure 8-2).

8.1.2.2 Percha Creek Drainage Basin

8.1.2.2.1 Drainage Basin Description

Percha Creek originates in the Black Range, approximately 30 miles west of the Mine Permit Area, and has ephemeral, intermittent, and perennial reaches (Appendix 8-B). In 2000, the NMOSE published a hydrographic survey report for the outlying areas of the Lower Rio Grande Basin, which included Percha Creek. This report compiled water rights information and aerial photography for each region in outlying areas of the Lower Rio Grande (NMOSE, 2000). Davie and Spiegel (1967) reported the depth of the alluvium in Percha Creek at the Interstate-25 bridge to be 40-ft thick.

Streamflow in Percha Creek is intermittent in the Hillsboro reach and perennial in the area known as the Percha Box, a steep-walled reach of the drainage that has incised into Paleozoic bedrock approximately 3 miles south of the Mine Permit Area (BLM, 1996) (Figure 8-4). Downstream of the Percha Box, the Percha Creek flows onto the Santa Fe Group, and flows are ephemeral. Though Percha Creek has perennial reaches, the creek does not contribute perennial flow to the Lower Rio Grande Basin.

The upper portion of the Percha Creek Drainage Basin contains a number of residences in the town of Hillsboro. A number of landowners have shallow alluvial wells, and surface water is used for irrigation when available in some areas. Downstream from Hillsboro there are a few ranches in the Percha Creek Drainage Basin. Some of the ranches utilize shallow wells in the creek alluvium to supply stock wells, and a few diversion ditches feed stock ponds when water is available.

8.1.2.2.2 Percha Creek

Flow

Historical Data

Streamflow in Percha Creek is intermittent throughout most of the reach in the Percha Creek Drainage Basin (Figure 8-4). Downstream of Hillsboro in the reach known as Percha Box, the flow is perennial. SRK (1995) reported that measurable stream flows averaged 0.44 to 0.55 cfs within and just east of Percha Box, with a range of 0.39 to 1.01 cfs. This was the only reach of Percha Creek with measurable flows during the SRK sampling period. Volumetric flow in Percha Creek was measured at 13 locations by Adrian Brown Consultants (1996a) from approximately ¼-mile upstream of the entry to Percha Box to approximately 5 miles downstream of the exit from Percha Box. Flow was found to be localized, occurring within and immediately to the east of Percha Box, and ranging from 1.02 cfs to 0.265 cfs, with many reaches dry or with standing water only.

A USGS stream-gauging station located on Percha Creek near Hillsboro has been recording peak flow data in Percha Creek since 1957 (USGS, 2011). Flow rates measured at this location have ranged from 0 (zero) up to 20,000 cfs (Figure 8-5). Peak flows are related to storm flows, and some years do not have significant storm flow events given variability in precipitation. NMED SWQB has collected flow measurements at select locations along Percha Creek. However, these data are not available in published reports.

Baseline Data

In August 2010, November 2010, January 2011, and April 2011, flow measurements were collected from various measurement locations along accessible perennial and intermittent reaches of Percha Creek (Figure 8-4). The flow measurements were collected to characterize the volumetric flow of the springs and streams within the Percha Creek Drainage Basin (INTERA, 2010). Perennial stream reaches and springs were sampled four times, while ephemeral and intermittent reaches and springs were sampled opportunistically after precipitation events. To aid in the opportunistic sampling, one auto-sampler was installed along an intermittent reach of Percha Creek. This auto-sampler, installed near PC-E (Figure 8-4), did not collect a sample due to dry conditions in this stretch of the creek during the baseline sampling period.

Flow rates ranged from 0.002 to 7.45 cfs along Percha Creek from August 2010 to April 2011 (Appendix 8-A). Location PC-C had the greatest flow during the high-volume measurements in August. Seasonal trends show that the summer month of August exhibited the greatest flow rates at all measurement locations, and that among all locations, PC-C had the greatest flow rate. The spring at PCS-A displayed less fluctuation in flow, ranging from 0.64 cfs in August to 0.41 cfs in November.

In addition to the baseline flow measurements collected from August 2010 to April 2011, flow measurements were collected at 16 locations along Percha Creek on June 29 and 30, 2011 (Figure 8-4). The measurement locations are identified as PC-1 through PC-16 and are summarized in Table 8-5. Calculated discharge rates were lower at each location along the creek relative to previously observed values measured from August 2010 to April 2011 (Appendix 8-A). Three perennial reaches were observed along Percha Creek from Hillsboro downstream (inset, Figure 8-4). The maximum flow rate of the first reach was 0.66 cfs at PC-7, approximately 150 ft downstream of the spring inflow at PCS-A (Figure 8-4). The maximum flow rate in the second measurable reach was 0.16 cfs at PC-9, and the maximum flow rate in the third measurable reach was 0.34 cfs at PC-15.

During the June 2011 measurement event, Percha Creek had both losing and gaining reaches. Flow started approximately 400 ft upstream from PC-1 with a rate of 0.24 cfs. The rate decreased at PC-2, approximately 1,395 ft downstream of the SoF (inset, Figure 8-4). The rate varied slightly until the inflow from the springs at PC-6, approximately 4,220 ft downstream of the SoF and close to the end of Percha Box. Downstream of the springs at PC-6 and PC-7 is a facies change from the Paleozoic carbonates, which compose the bedrock in the Percha Box, to Tertiary volcanic rocks and then the Upper Santa Fe Group sediments. Flow in Percha Creek decreased significantly downstream of the Percha Box, and all surface flow disappeared for approximately 995 ft between PC-8 and PC-9. Surface flow also ceased along an approximately 4,500-ft interval downstream of PC-10. Approximately 500 ft upstream of PC-11, flow began again in Percha Creek and continued for approximately 10,700 ft (almost 2 miles) before disappearing into the sandy alluvium (Table 8-6; inset, Figure 8-4).

Seasonal Patterns

The greatest flow rates measured in Percha Creek from August 2010 to April 2011 were recorded in the summer quarter in August (Figure 8-6). With the exception of an increase in volume in January for two locations, all of the stream flow measurements decreased with time except PCS-A (Figure 8-6). The flow rates in November were substantially lower than those recorded in August, and PC-A and PC-D had a small increase in flow in January which then decreased again in April. In addition, the in-stream flow rates measured in June 2011 (Appendix 8-B) were considerably lower than all previously measured rates (Appendix 8-A). The June 2011 measurements were conducted prior to any late-summer rain events to determine low-flow conditions. The seepage rates determined from the June 2011 flow measurements are provided in Table 8-5.

Water Quality

Historical Data

Percha Creek water quality was examined by Adrian Brown Consultants (1996a) and for the PFEIS (BLM, 1999). Adrian Brown Consultants sampled Percha Creek at the entry and exit to Percha Box, and 5,000 ft downstream from the exit from Percha Box, and measured field parameters at all seven locations in which water was found (Table 8-1). For the three samples submitted for laboratory analysis, pH ranged from 7.62 to 7.82, sulfate ranged from 63 to 71 mg/L, and TDS ranged from 336 to 406 mg/L. The PFEIS (BLM, 1999) reports that surface water flowing in Percha Creek has a chemistry dominated by calcium bicarbonate, with pH in the range of 7.0 to 8.0, sulfate in the range of 20 to 70 mg/L, and TDS in the range of 300 to 400 mg/L. Complete analytical results for Percha Creek are compiled in Appendix 8-C.

Following the assessments in the 1990s, NMED SWQB collected water quality data from Percha Creek at the Box in support of a water quality survey of the Lower Rio Grande tributaries. Water quality monitoring included analysis of total nutrients, total and dissolved metals, major anions and cations, and field parameters. Biological surveys, which included the monitoring of fecal coliform and E. coli as well as the collection of macroinvertebrates and physical habitat characteristics, were conducted at select stations (NMED SWQB, 2009). As summarized by NMED SWQB (2009), results from water quality found no exceedances of water quality criteria for total nutrients, total and dissolved metals, major anions and cations, bacteria, and field parameters such as dissolved oxygen, pH, and temperature (NMED SWQB, 2009). The results of this analysis indicated that the low DO values documented in Percha Creek are likely the result of a significant groundwater input and therefore these sites were determined by NMED to be fully supporting its aquatic life use with respect to DO. In addition, stream bottom deposits collected in 2007 showed that Percha Creek was fully supporting its aquatic life uses with respect to sedimentation/siltation; a change from when the stream was found to be only partially supporting on the 1998 §303(d) list, which attributed stream bottom deposits as the cause. Consequently, NMED/SWQB intends to remove the sedimentation/siltation impairment listing for Percha Creek in the 2010-

2012 State of New Mexico CWA §303(d)/§305(b) Integrated Report. Those data are summarized in NMED SWQB (2009).

Baseline Data

In August 2010, November 2010, January 2011, and April 2011, field parameters and water quality samples were collected from various measurement locations along accessible perennial and intermittent reaches of Percha Creek (Figure 8-4). In April 2011, one sediment sample was collected along Percha Creek. Field parameters are presented in Appendix 8-A. Analytical results are presented in Appendix 8-C.

Water quality data for Percha Creek (Appendix 8-C) were similar to historical water quality data collected by Adrian Brown Consultants (1996a) and BLM (1999). In samples collected from August 2010 to April 2011, the pH was slightly higher than the historical data, in the range of 8.23 to 8.51, and the sulfate and TDS concentrations were very similar, in the range 49 to 74 mg/L for sulfate and 298 to 378 mg/L for TDS. The sodium concentrations measured in Percha Creek range from 14 to 60 mg/L, and the chloride concentrations range from 6 to 11 mg/L.

In April 2011, a sediment sample was collected from PC-C in addition to the water sample. The results of both the water quality analysis (Appendix 8-C) and the sediment analysis were similar. Calcium, magnesium, silicon, and uranium concentrations were lower in the sediment sample (Appendix 8-D) than in the water sample, while aluminum, barium, copper, and iron concentrations were slightly higher in the sediment sample (Appendix 8-D).

Seasonal Patterns

The water quality samples collected from Percha Creek from August 2010 to April 2011 do not display a strong seasonal pattern. The concentrations of sulfate, sodium, and chloride increased as flow rates throughout the year decreased for sample locations PC-B, PC-C, and PC-D. The pH measured at PC-B, PC-C, and PC-D decreased as flow rates decreased. The concentrations and pH from sample location PC-A remained fairly constant even with a large decrease in flow volume from the August sample event to the November sample event. The TDS concentrations remained fairly similar throughout the season, increasing slightly at PC-B and PC-C, and decreasing slightly at PC-A and PC-D.

8.1.2.2.3 Springs

Several springs in the Percha Creek Basin have been identified (Figure 8-4). The SAP identified seven springs in the Percha Creek Basin for quarterly flow monitoring and two for quarterly water quality sampling. Two springs identified in the SAP for planning purposes were not identified in the field: CSCS-A and WSCS-B. In addition, three springs were identified in the field, but were dry or had minimal stagnant water in each quarter: WSC-A, CSC-A, and PWS. Five springs were identified and sampled and/or measured for flow rates: CSCS-C, CSCS-B, PCS-A, WS, and WSCS-A (Figure 8-4).

Flow

Historical Data

Spring and seep flow rates are infrequently reported in the available literature for the Mine Permit Area and surrounding areas. No historical data were available on the flow rates of springs and seeps within the Percha Creek Basin.

Baseline Data

Flow rate measurements range from less than 0.001 to 0.64 cfs in springs within the Percha Creek Basin from August 2010 to April 2011 (Appendix 8-A). Measurement location PCS-A (Figure 8-4) had the greatest flow, ranging from 0.41 to 0.64 cfs. The springs WS, WSCS-A, CSCS-B and CSCS-C, in Warm Spring Canyon and Cold Spring Canyon (Figure 8-4), had much lower flows, ranging from 0 (zero) to 0.748 cfs.

Seasonal Patterns

The summer measurements in August 2010 consisted of the greatest flow volumes for the springs and seeps in the Percha Creek Basin. The springs in Warm Spring Canyon and Cold Spring Canyon had very little flow, ranging from 0 (zero) to 0.748 cfs in January and April (Appendix 8-A). The flow measurements taken at PCS-A in August were more than 0.22 cfs higher than the flow rates in November, January, and April; however, the flow rate did increase again to 0.66 cfs in June 2011 (Appendix 8-A).

Water Quality

Historical Data

No historical data were available on the water quality of springs and seeps within the Percha Creek Basin.

Baseline Data

Water quality samples were collected from five springs in the Percha Creek Basin from August 2010 to April 2011 (Figure 8-4, Appendix 8-C). WS and CSCS-B were sampled four times each in August 2010, November 2010, January 2011, and April 2011. Samples collected from the springs WS, WSCS-A, CSCS-B, and CSCS-C had pH values ranging from 7.37 to 8.38, sulfate concentrations in the range of 3.5 to 300 mg/L, TDS concentrations in the range of 445 to 1,000 mg/L, sodium concentrations in the range of 4.7 to 290 mg/L, and chloride concentrations in the range of 1 to 50 mg/L. The spring at PCS-A along Percha Creek had concentrations that fell within the range of values measured at the springs upstream in Warm Spring Canyon and Cold Spring Canyon. The concentrations at PCS-A in August 2010 were 56 mg/L sulfate, 353 mg/L TDS, 33 mg/L sodium, 8.5 mg/L chloride, and a pH of 8.04.

Seasonal Patterns

The springs in Percha Creek Basin did not display a strong seasonal trend in the water quality data collected from August 2010 to April 2011. The sulfate and chloride concentrations increased as flow rates decreased.

8.1.2.2.4 Modifications to the SAP

As NMCC executed the SAP, adjustments to the proposed SAP were necessary based on the actual site conditions encountered in the field. When making adjustments based on field conditions, NMCC strived to find equivalent or improved alternatives, where possible. Modifications from the surface water monitoring locations and sampling frequency proposed in the SAP were due to the ephemeral and intermittent nature of many of the reaches along Percha Creek (INTERA, 2010). In addition, many of the springs and seeps originally identified for quarterly monitoring and sampling were dry or had very little flow during the quarterly monitoring events and alterations were made to the proposed SAP locations and sampling frequency.

Additional stream locations were sampled along Percha Creek due to the inability to sample from dry locations in other streams. Quarterly flow measurements of five springs and seeps in Percha Creek Drainage Basin were proposed in the SAP (INTERA, 2010). Only one proposed spring, WS, had enough flow in each quarter to measure flow. The spring at WSCS-A was flowing at an estimated rate of less than 2.22×10^{-3} cfs in August 2010 and January 2011, and was dry in November 2010 and April 2011. Two springs, PCS-A and CSCS-B, were added to the monitoring, and flow was measured at both of these locations in each quarter. In addition, the spring at

CSCS-C was monitored, though flow was estimated to be less than 2.22 x 10^{-3} cfs in August 2010 and the spring was dry the remainder of the monitoring period.

Per guidance from Chris Eustice of MMD (2011), one sediment sample was collected in April 2011 from Percha Creek Drainage Basin near PC-C (Figure 8-4).

8.1.2.3 Greenhorn Arroyo Drainage Basin

8.1.2.3.1 Drainage Basin Description

The Mine Permit Area is drained by ephemeral streams (arroyos) within the Greenhorn Arroyo Drainage Basin, a sixth-level sub-watershed defined by the Hydrologic Unit classification system (Seaber et al., 1987), that drains 29,414 acres of land on the eastern slope of the Animas Uplift to a single outlet into the Rio Grande (Figure 8-1). Flows within the Greenhorn Arroyo Drainage Basin are ephemeral; they only occur in direct response to precipitation. As a result, this drainage, similar to others in the region, does not contribute any perennial surface water flow to the Rio Grande.

Numerous arroyos contribute to the trunk channel of Greenhorn Arroyo. Of these, Grayback Arroyo is the primary drainage through the Mine Permit Area. Grayback Arroyo originates west of the Mine Permit Area, is diverted around the mine pit, and drains eastward until it converges with the trunk channel of Greenhorn Arroyo, approximately 8 miles east of the Mine Permit Area boundary (Figure 8-1). In pre-mining times, Grayback Arroyo drained directly through the mine area, but was later re-routed around the southern perimeter of the mine area for flood control purposes (Raugust, 2003). Grayback Arroyo is an ephemeral stream and flows only during periods of snow melt or rain events.

8.1.2.3.2 Greenhorn and Grayback Arroyos

Flow

Historical Data

Flow rates in Grayback Arroyo at SWQ-3 (Figure 8-7) were measured by Newcomer et al. (1993) to be 0.028 cfs in March of 1993.

Baseline Data

Flow rates in the Grayback Arroyo were minimal during the quarterly sampling time period. Three sampling locations were identified along the Grayback Arroyo (Figure 8-7). Sampling locations SWQ-2 and SWQ-3 had standing water and not enough flow to measure in August and November. SWQ-2 was dry in January and April, while SWQ-3 had standing water in January but was dry in April. Sampling location SWQ-1 was dry during each quarter of sampling.

Seasonal Patterns

Grayback Arroyo did not exhibit any seasonal patterns.

Water Quality

Historical Data

The surface water chemistry of Grayback Arroyo was initially investigated in 1977 at three locations as part of an environmental assessment prepared by the BLM in response to an application by Quintana Minerals Corporation for an open pit copper mine at the Mine Permit Area (BLM, 1978). The three locations sampled in 1977 generally correspond to the sampling locations identified in Figure 8-7, with one location upstream of the permit boundary, one within the Mine Permit Area approximately 300 yards from the mine rim, and a third located where the arroyo leaves the Mine Permit Area (BLM, 1978). Water samples were collected in January, March, and July of 1977.

WQCC standards for metals were not exceeded at any location in any of the 1977 sampling events (BLM, 1978). Results for pH (7.6–8.1) were in the same range as samples collected later at these three locations. TDS results upstream of the Mine Permit Area (720-1000 mg/L) were comparable to those of samples collected later, but samples taken at locations within and downstream of the Mine Permit Area were comparatively lower (800-1,320 mg/L) than the results for later sampling events, such as those conducted by Newcomer et al. (1993) at SWQ-1 (upgradient of the pit lake), SWQ-2 (downgradient of the pit lake but within the area of mining disturbance), and SWQ-3 (approximately 1 mile downgradient of the pit lake) (Figure 8-7). Field parameters measured by Newcomer et al. (1993) are shown in Table 8-1 and complete analytical results are presented in Appendix 8-C. Results from the 1990s (Appendix 8-C) generally show, with a few exceptions, that concentrations of TDS, sulfate, and chloride increase from SWQ-1 to SWQ-3, or from west to east as surface water flows through the Mine Permit Area.

All three sample locations in Grayback Arroyo, SWQ-1, SWQ-2, and SWQ-3 (Figure 8-7), were neutral to alkaline between 1982 and 1998 (Appendix 8-C). Results for all three locations indicated a trend of increasing TDS concentrations over time. Samples from SWQ-1 were all less than 1,000 mg/L TDS, samples from SWQ-2 had a TDS range from 990 mg/L in 1983 to 4,464 mg/L in 1996, and samples from SWQ-3 ranged from 1,866 mg/L in 1992 to 4,432 mg/L in 1993 (Appendix 8-C). Sulfate results for all three sample locations also indicated increasing concentrations over time. Samples from SWQ-1 had a range of sulfate concentrations from 68 mg/L in 1982 to 323.1 mg/L in 1993, samples from SWQ-2 had a sulfate range from 271.2 mg/L in 1995 to 2,566.3 mg/L in 1996, and samples from SWQ-3 ranged from 952.2 mg/L in 1992 to 2,382 mg/L in 1995 (Appendix 8-C). The chloride results from SWQ-1 had a range of concentrations from 10 mg/L in 1982 to 47.2 mg/L in 1992, chloride results from SWQ-2 had a range of concentrations from 46 mg/L in 1981 to 223 mg/L in 1996, and chloride results from SWQ-3 had a range of concentrations from 96.7 mg/L in 1996 to 238 mg/L in 1995 (Appendix 8-C).

Baseline Data

The water quality of Grayback Arroyo at sites SWQ-2 and SWQ-3 was investigated from August 2010 to April 2011. The concentrations of TDS, sulfate, and chloride have decreased significantly from historical concentrations at sampling location SWQ-2 within the Mine Permit Area (Appendix 8-C). In the sample collected at SWQ-2 in August 2010, the concentrations were as follows: TDS was 78 mg/L, sulfate was 11 mg/L, and chloride was 0.71 mg/L. The pH measured at SWQ-2 in August 2010 was 7.42. The copper concentration at SWQ-2 was 0.085 mg/L in August 2010 (Appendix 8-C).

The concentrations of TDS and sulfate measured at SWQ-3, east of the Mine Permit Area, have increased from historical concentrations, while chloride concentrations have decreased slightly (Appendix 8-C). In August 2010, the TDS concentration was 4,500 mg/L and the sulfate concentration was 2,900 mg/L. Chloride concentrations measured in August 2010 were 130 mg/L and in April 2011 were 74 mg/L. The pH values measured at SWQ-3 range from 7.92 to 8. Copper concentrations measured at SWQ-3 were 0.062 mg/L in August 2010 and 0.011 mg/L in April 2011 (Appendix 8-C). Compared to the August 2010 sample collected from SWQ-2, concentrations of analytical parameters are generally higher at SWQ-3 than at SWQ-2.

In April 2011, sediment samples were collected from SWQ-2 and SWQ-3. The results do not show that concentrations are generally higher at one location versus another (Appendix 8-D). For example, concentrations of carbonate, copper, magnesium, selenium, silicon, and sodium are higher or slightly higher in sediment sampled from SWQ-2, whereas concentrations of aluminum, barium, iron, molybdenum, and uranium are higher or slightly higher in sediment sampled from SWQ-3.

Seasonal Patterns

The water quality in Grayback Arroyo does not display any seasonal patterns.

8.1.2.3.3 Springs

Three seeps were identified in BLM (1999) along Grayback Arroyo. One seep with riparian vegetation was identified as being located near a buried storm water collection pond. A second seep was identified downstream from the first seep and supports a small cottonwood/willow stand. The third seep is located south of the operations area. These seeps were not flowing during the baseline data collection program and are considered historical seeps.

Two springs are located within the Greenhorn Arroyo Drainage Basin to the north (BG-2) and west (BG) of the Mine Permit Area (Figure 8-7). Other unnamed seeps can occur in the pit walls surrounding the pit lake after precipitation events; these are likely the result of fractured flow through the bedrock exposed in the pit wall.

Flow

Historical Data

Spring and seep flow rates are infrequently reported in the available literature for the Mine Permit Area and surrounding areas. Several springs and seeps have been identified within the Greenhorn Arroyo Drainage Basin. Two springs, identified as BG and BG-2, are located to the north and west of the Mine Permit Area (Figure 8-7) and several unnamed seeps occur in the walls surrounding the pit lake. BG and BG-2 were judged by Newcomer et al. (1993) to be ephemeral. The seeps along the pit walls are observed to flow in response to precipitation events, and as mentioned above, are likely the result of fractured flow through the bedrock exposed in the pit wall. All known springs and seeps in the Greenhorn Arroyo Drainage Basin are upgradient of the proposed mine water discharge location.

Baseline Data

The springs identified in the Greenhorn Arroyo Drainage Basin, BG and BG-2, were dry during the baseline quarterly monitoring program. The pit wall seep, PWS-1, on the northwest corner of the pit wall (Figure 8-7) was measured for flow rate in August 2010. A timed fill of a known volume was conducted to estimate a flow rate of less than 2.22×10^{-5} cfs. The rate of flow at PWS-1 was too low or dry in the subsequent quarters and, as a result, flow was not measured (Figure 8-7).

Seasonal Patterns

PWS-1 and other seeps along the pit wall that were dry, flow in direct response to precipitation and are therefore likely to flow more in the late summer months after monsoon storms. The springs, BG and BG-2, upgradient of the Mine Permit Area, are also ephemeral. However, flow was not observed at either location from August 2010 to April 2011.

Water Quality

Historical Data

Newcomer et al. (1993) sampled the BG and BG-2 springs in April 1993, and SRK observed and sampled seeps in the pit wall in 1997 (SRK, 1997b). Field parameters and water chemistry analytical data for these locations are presented in Table 8-1 and Appendix 8-C, respectively. SRK (1997b) reported concentrations in the pit wall seep from May 1993 as follows: pH of 1.9, sulfate of 10,000 mg/L, and chloride of 35 mg/L. Samples from BG and BG-2 had pH ranging from 8.0 to 8.2, sodium ranging from 90 to 124 mg/L, bicarbonate ranging from 411 to 535 mg/L, sulfate ranging from 184 to 228 mg/L, and TDS ranging from 680 to 690 mg/L. On the basis of these results, ABC (1996a) judged BG and BG-2 to be qualitatively similar to the Grayback Arroyo sample location SWQ-1, while the pit wall location appears to have been subject to a similar process as the locations at SWQ-2 and SWQ-3.

Baseline Data

The sample collected from PWS-1 in August 2010 had a pH of 2. The sulfate concentration was 11,000 mg/L, and the TDS concentration was 13,900 mg/L. The sample also had high concentrations of aluminum at 540 mg/L, calcium at 470 mg/L, copper at 80 mg/L, iron at 1,600 mg/L, and a number of other analytes (Appendix 8-C).

Seasonal Patterns

One sample was collected from PWS-1 and no samples were collected from BG and BG-2, so a seasonal pattern in the water quality from seeps and springs in the Greenhorn Arroyo Drainage Basin was not observed.

8.1.2.3.4 Pit Lake

The open pit that was mined during the early 1980s now contains a lake that is located within the Mine Permit Area (inset, Figure 8-7). Since 1989, the pit lake has been sampled for water quality at various locations and depths, including samples collected by past operators of the mine, state regulatory agencies, and academic researchers studying the mine (BLM, 1999).

Historical Water Levels

During the late 1980s and early 1990s, a 12.8-acre lake formed in the existing pit. The pit lake was estimated to be about 40-ft deep, based on a pit bottom elevation of 5,380 ft amsl and a water level elevation of 5,420 ft amsl as measured in 1986 (SRK, 2010).

Baseline Water Levels

The deepest point in the pit lake was determined during the bathymetric survey in September 2010 and was used as a single gauging station to measure water depth. Water depth was measured four times from this location during the baseline sampling program: (1) 34.6 ft in September 2010, (2) 35.8 ft in January 2011, (3) 31.6 ft in April 2011, and (4) 28.9 ft in July 2011 (Table 8-7).

A gauge to record water level elevation was set on the southern end of the pit lake in April 2011 with the zero point of the gauge set at an elevation of 5,440 ft amsl. Three water level elevation readings were recorded during the baseline program and show the following elevations: (1) 5,444.44 ft amsl on May 12, 2011, (2) 5,443.425 ft amsl on July 1, 2011, and (3) 5,443.15 ft amsl on July 20, 2011. As summarized in a recent evaluation (JSAI, 2011a), the pit lake currently covers an area of approximately 5.2 acres and contains about 60 acre-ft of water.

Seasonal Patterns

Based on the four measurements of water depth, water level was highest in the winter month of January and lowest in the summer month of July. As shown by the gauge readings, water levels decreased from May 2011 to late July 2011 by 1.29 ft. Water levels in the pit lake appear to drop in the summer months when there is increased evaporation.

Water Quality

Historical Data

The water quality of the pit lake has been sampled over 65 times at various depths and locations since the initial samples were collected on April 13, 1989, by the New Mexico Environment Improvement Board (Raugust, 2003). Raugust (2003) concluded that the collective data show several trends in the variability of water quality over time, mainly that evapoconcentration and buffering processes are influencing the quality of the lake water. Pit water has historically exceeded the WQCC groundwater standards for sulfate, chloride, TDS, manganese, and uranium (20.6.2.3103 of the New Mexico Administrative Code [NMAC]) and has, at times, dropped below the acceptable pH range of 6 to 9.

Analytical results of samples collected from 1989 to 1998 indicate that sulfate, chloride, TDS, manganese, and pH all increased over this period. For example, sulfate increased from a range of 2,250 to 3,000 mg/L to a range of 3,500 to 4,300 mg/L over this time period. Chloride increased from an average of around 100 mg/L to around 250 mg/L, which may be attributed to lower average annual precipitation and higher annual temperatures during this period (BLM, 1999). However, the sulfate-to-chloride ratio dropped during this time period, suggesting that sulfate rose at a slower rate than chloride due to the formation of gypsum and the subsequent buffering of the sulfate concentration in pit lake water by gypsum (gypsum is observed along the margins of the pit lake during the summer months when the pit lake level has dropped). TDS ranged from 2,700 mg/L in 1991 (Newcomer et al., 1993) to about 6,000 mg/L in 1998 (Raugust, 2003). Manganese ranged from 1.8 to 4.3 mg/L (BLM, 1999). The measured pH values have generally increased over time to about 8.0. However, in 1992 and again in 2008, pH decreased to 4.4 and 4.5 (NMED GWQB, 2008), respectively, deviating from the overall trend of elevated pH values. The overall rise in the pH may be due to buffering by wall rock. There are no historical data available for uranium, other than a sample collected in 2004 that showed the uranium concentration from this sample exceeded the WQCC standard (NMED GWQB, 2008).

Other key studies that present the water quality are summarized in SRK (1997a) and include hydrogeologic and hydrogeochemical studies (SRK, 1995), post-closure pit water balance model calculations (SRK, 1997b), water quality and host rock geochemical studies (SRK, 1997c), and post-hearing submittals that followed the 1997 New Mexico Mine Permit public hearing.

Baseline Data

The pit lake was sampled at its deepest point in September 2010, January 2011, April 2011, and July 2011 (Figure 8-7 and Figure 8-8). Analytical results of samples collected from September 2010 to July 2011 generally show that sulfate, chloride, TDS, manganese, magnesium, cobalt, fluoride, sodium, and potassium have all increased from historical sampling events and some have increased from the January 2010 sample (Appendix 8-E). From January 2010, sulfate increased from 5,200 mg/L to a range of 5,500 to 6,400 mg/L, TDS increased from 7,770 mg/L to a range of 7,780 to 9,680 mg/L, magnesium increased from 570 mg/L to a range of 590 to 780 mg/L, sodium increased from 690 mg/L to a range of 730 to 920 mg/L, and potassium increased from a concentration of 25 mg/L to a range of 26 to 35 mg/L. A few constituents decreased from January 2010 to July 2011, including aluminum, which decreased from 5.5 mg/L to a range of <0.02 to 1.7 mg/L, iron, which decreased from 1.3 mg/L to a range of <0.02 to 0.032 mg/L, and copper, which decreased from 11 mg/L to a range of <0.006 to 2 mg/L. The measured pH values increased from 6 in January 2010 to a range of 6.67 to 7.86, within the acceptable range of 6 to 9. Uranium concentrations in all discrete-depth and composite water quality samples were either 0.11 or 0.12 mg/L.

In September 2010, a sediment core was collected from the deepest point in the pit lake (Figure 8-8). One sediment sample (PL-C2-WI) was taken from the core by homogenizing the sediment from 0 (zero) to 10 inches below the sediment-water interface. This uppermost interval from 0 (zero) to 10 inches was chosen purely based on the minimum sample volume required by the laboratory to run the suite of analytical parameters. This interval was selected in place of homogenizing the entire interval of the core because isolating the upper unit better characterizes the sediment that interacts with the water column and is of more interest for geochemical analysis of the pit lake system. The analytical result for sulfate concentration was 26,000 mg/Kg, chloride was 890 mg/Kg, manganese was 380 mg/Kg, magnesium was 610 mg/Kg, aluminum was 6,100 mg/Kg, iron was 9,300 mg/Kg, copper was 1,400 mg/Kg, and lead was 4.1 mg/Kg. The concentration of uranium in the sediment was <500 mg/Kg. All results are presented in Appendix 8-F.

Seasonal Patterns

As water levels in the pit lake dropped from increased evaporation in the warmer months, the concentrations of sulfate, chloride, TDS, calcium, sodium, and fluoride increased. The analytical results do not indicate the presence of a chemocline, or the chemical stratification in the lake, during any of the four sampling seasons (Appendix 8-E). The pit lake did display limited thermal stratification during the winter and summer sampling, with greater stratification in the summer (Figure 8-9). The temperature profiles for the winter and summer sampling showed a greater than 1^{o}C per meter change indicating the presence of a thermocline, as defined by NMED SWQB protocols for lake sampling (NMED SWQB, 2011).

8.1.2.3.5 Modifications to the SAP

As NMCC executed the SAP, adjustments to the proposed SAP were necessary based on the actual site conditions encountered in the field. When making adjustments based on field conditions, NMCC strived to find equivalent or improved alternatives, where possible. Due to the ephemeral nature of the Greenhorn Arroyo Drainage Basin, modifications occurred based on field conditions from the surface water monitoring locations and sampling frequency proposed in the SAP (INTERA, 2010). Many of the springs and seeps originally identified for quarterly monitoring and sampling were also identified as ephemeral in nature and were dry or had very little flow during quarterly monitoring.

Flow measurements were not collected from the three auto-sampler locations along Grayback Arroyo (SWQ-1, SWQ-2, and SWQ-3) (Figure 8-7). In August 2010, the flow at SWQ-3 was estimated to be less than 0.002 cfs, SWQ-2 had standing water with no movement, and SWQ-1 was dry. SWQ-2 was sampled in August 2010 from standing water, and in April 2011, the sediment at SWQ-2 was sampled. Water samples were collected from SWQ-3 in August 2010, November 2010, and April 2011. In addition, one sediment sample was collected from SWQ-3 in April 2011.

Quarterly flow measurements of two springs in the Greenhorn Arroyo Drainage Basin were proposed in the SAP (INTERA, 2010). Both springs, BG and BG-2, were dry during the quarterly monitoring. One seep was identified within the Greenhorn Arroyo Drainage Basin, PWS-1, located on the northwest side of the pit wall. This seep was successfully sampled in August 2010; however, flow was insufficient during the remainder of the monitoring to collect a sample. The flow in August 2010 was estimated to be less than 2.2×10^{-5} cfs by monitoring the time it took to fill a known volume. Based on a communication with Chris Eustice of MMD (2011), two sediment samples were collected from Greenhorn Arroyo Drainage Basin near SWQ-2 and SWQ-3 in place of water quality samples (Figure 8-7).

The locations surveyed during the pit lake bathymetry survey in September 2010 deviate from the survey lines proposed in the SAP (INTERA, 2010). Severe wind on the day of the survey made it difficult for the survey crew to keep the boat on the proposed survey lines; however, the crew increased the number of lines traversed across the lake to provide adequate coverage of the depth measurements (Figure 8-8). The deepest point in the pit was marked with a buoy that marked the location for the pit lake water quality samples and the sediment sample (Figure 8-8).

On September 10, 2010, two discrete samples were collected due to a lack of stratification in the pit lake as shown in the lake profile for fall 2010 (Figure 8-9). One composite sample was also collected in September. During the sampling in the remaining quarters, three discrete samples and one composite sample were collected in accordance with the SAP (INTERA, 2010). Although the pit lake did not display a thermocline or chemocline during the April 2011 sampling event, three discrete depth samples were collected, as well as one composite, due to the depth of light penetration estimated by secchi disk transparency (Table 8-7 and Figure 8-9). The SAP (INTERA, 2010) proposed that two discrete samples should be collected in the absence of lake stratification, one in the euphotic zone and one below. During the April 2011 sampling event, light penetrated to within 1 ft of the pit lake bottom and any discrete depth sampling within that 1-ft interval would have been altered by stirring up the lake bottom sediments.

The SAP (INTERA, 2010) called for NMCC to homogenize the entire sediment core and then sample the homogenized sediment for laboratory analysis. Given the stratigraphy of the core observed in the field before homogenization, NMCC instead homogenized only the uppermost 10 inches of sediment to better characterize the sediment that interacts with the water column above. The decision to isolate the interval of 0 (zero) to 10 inches below the sediment-water interface was made solely based on the minimum sample volume required by the laboratory.

8.2 Groundwater

8.2.1 Objective of Baseline Data Collection Program

Pursuant the requirements of Part 13 of 19.10.6.602 NMAC, the objective of the baseline data characterization program for groundwater resources is to describe the water quality and water quantity of the groundwater within the proposed Mine Permit Area and, to the extent practicable, the potentially affected area. These data serve as site-specific and regional background level information to identify reclamation standards and gauge reclamation performance prior to mining operations. There were some modifications to the baseline characterization program described in the SAP; however, the baseline data set includes significant historical data and is more than adequate to achieve the ultimate goal of the program. This robust data-gathering program provides the basis for moving forward with mine permitting and for groundwater and surface water impact assessments.

8.2.2 Regional Hydrogeology

Regional geology (Figure 8-10) includes bedrock units along the western side of the Rio Grande Rift and sediments that filled the rift zone. The Baseline Study Area consists of three major hydrogeologic zones (shown conceptually on Figure 8-11 and in plan view as Figure 8-12):

1. The graben east of the Black Range and west of the Animas Uplift.

2. The Animas Uplift, in which the ore body is located.
3. The Palomas Basin, a sediment-filled basin east of the Animas Uplift in which the mine water supply wells are located. The Palomas Basin lies within the Lower Rio Grande Underground Water (NMOSE administrative) Basin.

The Animas Uplift contains the Copper Flat Mine open pit, excavated in 1982 by Quintana Minerals, which the NMCC proposes to expand. The Project water supply wells are located within the basin on a mesa adjacent to Animas Creek (Figure 8-13). Parts of the waste rock and tailing storage facilities would also be located overlying the western margin of the Palomas Basin within the Mine Permit Area.

The geologic description is adapted from Shomaker (1993), who cites Harley (1934), Hedlund (1975), Dunn (1982), and Seager et al. (1982). Locations of wells and water level measurements are presented with potentiometric surface contours on Figure 8-14. Interpreted contours are shown for (1) bedrock of the Animas Uplift and the pit area, (2) the Santa Fe Group aquifer, and (3) the shallow alluvium along Las Animas Creek. Groundwater levels range from above 5,800 ft amsl at the western edge of the graben to about 4,200 ft amsl at Caballo Lake. Descriptions of each hydrogeologic zone, from west to east, are as follows.

8.2.2.1 Graben West of Animas Uplift

West of the Animas Uplift, between the Uplift and the Black Range, lies a half-graben in which Tertiary-age alluvial fan deposits of the Santa Fe Group overlie Tertiary-age volcanic rocks and Paleozoic-age sedimentary rocks. Dips are eastward, and the half-graben is bounded on the east by normal faults (Figure 8-13). The Santa Fe beds may reach a thickness of 1,000 ft on the east side of the half-graben (Seager et al., 1982).

Local precipitation and runoff from the Black Range provide groundwater recharge to the graben. Discharge occurs mainly as springflow and possibly also as subsurface discharge to the Animas Uplift. Springflow in the Warm Springs drainage discharges as baseflow to Percha Creek. The emergence of water at Warm Springs, at the eastern edge of the graben, demonstrates that the andesite of the Animas Uplift acts as a barrier to flow at depth from the graben. Groundwater in the graben generally flows west to east, but also flows around the low-permeability andesite south toward Percha Creek and north toward Las Animas Creek (Figure 8-14).

The graben (half graben) west of the Animas Uplift is composed of Santa Fe Group sediments and is recharged by runoff from the Black Range. The half graben is bound on the east by normal faults, and the beds dip eastward. Near the eastern edge of the Animas Uplift, groundwater discharges at Warm Springs. The contrast between the chemical makeup of Warm Springs water and that of wells and springs within the Animas Uplift indicates that the source of Warm Springs water is not within the Uplift, as might otherwise be inferred from the relative heads at the spring, and at wells and springs within the Uplift (Newcomer and Finch, 1993). The direction of groundwater flow in the graben is generally west to east, but the low permeability crystalline bedrock aquifer acts as a barrier to groundwater flow from the graben west of the Animas Uplift to the Palomas Basin and forces groundwater flow around the crystalline bedrock through preferential pathways in the carbonate bedrock units of the uplift toward Percha and Animas Creeks.

8.2.2.2 Animas Uplift

The Animas Uplift is an upthrown block bounded by north-to-south-trending faults, ranging from less than 2 to about 4 miles wide (Figure 8-12). The Copper Flat Mine ore body is located within a nearly circular remnant of a Cretaceous-age andesite volcano about 4 miles in diameter that is part of the Animas Uplift. Drilling has shown that the andesite is present to a depth of more than 3,000 ft (Dunn, 1982, p. 314). The andesite is bounded on the north and south by Paleozoic-age limestone, and on the east by the Santa Fe Group sediments of the Palomas Basin. On the west, the andesite body is in fault contact with Paleozoic-age limestones, Tertiary-age volcanic rocks, and overlying Santa Fe Group sediments of the half-graben between the Animas Uplift and the Black Range (Figure 8-13).

The ore body itself is in the Copper Flat Mine quartz monzonite stock, within the andesite. The quartz monzonite porphyry intruded the vent of the volcano, and then dikes and mineralized veins intruded the monzonite porphyry and radiated outwards from the porphyry into fault and fracture zones in the andesite. The porphyry copper deposit is concentrated within a breccia pipe in the quartz monzonite stock.

Recharge to the quartz monzonite and andesite is limited by low hydraulic conductivity. Recharge to the limestone north and south of the andesite is likely greater (Shomaker, 1993), including infiltration of runoff from Las Animas and Percha Creeks that was generated at higher elevations in the Black Range and in the half-graben between the Black Range and Animas Uplift.

In the limestone, groundwater discharges as springflow and baseflow to Percha and Las Animas Creeks. In the andesite, groundwater discharges as subsurface flow across fault contacts between the andesite and the Palomas Basin, and as evaporation from the open pit.

The low hydraulic conductivity of the quartz monzonite and andesite is reflected in the low pumping rates required in 1982 to dewater the Quintana pit. The dewatering rate required to maintain the greater than 45-ft drawdown in an excavation about 100 ft by 200 ft in area at maximum depth was estimated at 22 gallons per minute (gpm) (Shomaker, 1993). SRK (1997b) reports pumping rates up to 50 gpm. The range in dewatering rates is likely influenced by precipitation and localized recharge.

It can be expected that the hydraulic conductivity of rock deeper in the andesite and quartz monzonite will have still lower hydraulic conductivity because of the decrease in weathering and the lithostatic pressure resulting in closing of fractures with depth. The andesite acts as a hydrologic containment vessel for the existing and proposed open pit.

Detailed geologic mapping by Hedlund (1975) and Dunn (1982) identified radiating dikes and veins that are expected to be the most permeable features in the southwest, southeast, and northeast quadrants of the roughly circular andesite body. The radiating dikes and veins may be inferred to have relatively low conductivity as well. Several mine shafts in Wicks Gulch were examined and found to be almost full of water; if there were significant hydraulic conductivity, either along fractures or through the rock matrix, water levels would be closer to the elevation of nearby surface channels.

Away from the andesite body, where the Animas Uplift consists of fractured, predominantly limestone and dolomite bedrock, it is likely that significant permeability has developed by the combination of fracturing and enlargement of fracture openings by dissolution of carbonate minerals. This hypothesis is supported by groundwater elevation contours and the account of an air-drilled exploration hole in the vicinity of the windmill well in the SW ¼ SE ¼ Sec. 3, T. 16 S., R. 7 W., which was abandoned because large water production overcame the capacity of the compressor to continue circulation (Shomaker, 1993). The well is close to the fault which offsets the andesite against the predominantly limestone Paleozoic-age section.

8.2.2.3 Palomas Basin

The Palomas Basin, part of the Rio Grande Rift system, is a sediment-filled structural trough (Figure 7-3, Section 7). The principal water-bearing sediments of the Palomas Basin are (1) alluvial fan deposits and fluvial sands and gravels of the Santa Fe Group, and (2) alluvium in the inner valleys of the Rio Grande and principal tributaries.

Davie and Spiegel (1967, p. 9) describe the Santa Fe Group in Las Animas Creek area as consisting of (a) an alluvial fan facies, interfingering eastward with (b) a clay facies, possibly representing the distal or deltaic beds of the alluvial fan facies, which in turn interfingers with (c) an axial river facies consisting of well-sorted sand and gravel containing well-rounded quartzite pebbles. The sediments are stratified and in general dip to the east. This description of the distribution of fine-grained sand and clay, and of coarser sand and gravel, is reflected in the logs of wells and shown in the cross section on Figure 8-13. In general, the sediments become finer grained to the east from the western margin to the center of the basin.

Water recharges the Palomas Basin at its western edge through alluvial fans at the edge of the Animas Uplift, including infiltration of runoff from Greenhorn and Grayback Arroyos and as infiltration of baseflow and runoff from the upper catchments of Las Animas and Percha Creeks. As inferred by the contours shown on Figure 8-14, groundwater flows east toward the Rio Grande and Caballo Lake. Besides discharging to the Rio Grande and Caballo, groundwater discharges as evapotranspiration from irrigated and riparian areas along Las Animas and Percha Creeks.

Stratification and heterogeneity of the Santa Fe Group sediments create confined conditions at depth in the lower Palomas Basin. Seepage along Percha Creek, Grayback and Greenhorn Arroyos, and Las Animas Creek alluvial systems recharges the Santa Fe Group sediments in the upper basin, and the recharge hydraulically loads the more permeable zones down-dip. Overlying clay beds create artesian well conditions in the basin down-dip of recharge zones (Figure 8-11).

8.2.3 Hydrogeology of the Permit Area Locality

There are three aquifers within the Copper Flat Mine Permit Area:

1. Crystalline bedrock aquifer
2. Santa Fe Group aquifer system
3. Quaternary alluvial aquifer

A summary of the aquifers and their characteristics is presented in Table 8-8. The distribution of geologic units is shown on Figure 8-15, and the subsurface conditions are illustrated on the hydrogeologic cross sections presented as Figures 8-16, 8-17, and 8-18.

Crystalline Bedrock Aquifer: The hills surrounding Copper Flat Mine, referred to as Hillsboro Hills, consist of Cretaceous-age andesite flows, breccias, and volcaniclastic rocks that were erupted from an andesite volcano (McLemore, 2001; Raugust and McLemore, 2004). The andesite is a near-circular body approximately 4 miles in diameter and over 3,000 ft in depth (Dunn, 1982). The Copper Flat Mine quartz monzonite porphyry intruded the vent of the volcano, and then dikes and mineralized veins intruded the monzonite porphyry and radiate outwards from the porphyry into fault and fracture zones in the andesite. Distribution of the monzonite can be referenced from the geologic map (Figure 8-15) and pit lake cross sections (Figure 8-16). The permeability of the andesite is extremely low, whereas the permeability of the monzonite rocks averages 0.1 ft/day due to localized secondary porosity from fracturing.

Santa Fe Group Aquifer: The sediments of the Santa Fe Group are stratified, contain a wide variety of grain sizes, and, in general, dip to the east. This distribution of fine-grained sand and clay, and of coarser sand and gravel, is reflected in the logs of wells in the tailing facility area. North-to-south and east-to-west hydrogeologic cross sections of the tailing facility area were constructed (Figures 8-17 and 8-18). The Santa Fe Group sediments are over 500-ft thick beneath the tailing facility.

Hydrogeologic conditions beneath the tailing dam are complicated by varying thicknesses of colluvium, thick clay layers in the Santa Fe Group sediments, and basalt and volcaniclastics interbedded in the Santa Fe Group sediments (Figures 8-17 and 8-18). These varying lithologies and sediment grain sizes create preferential flow paths and barriers to groundwater flow. The preferential flow paths are primarily related to coarser-grained colluvium and Santa Fe Group sediments. There appears to be a north-to-south-trending fault that acts as a barrier to groundwater flow east of the tailing impoundment dam (Figures 8-17 and 8-18).

The direction of groundwater flow is from west to east, except in the vicinity of the Copper Flat Mine pit lake where a hydrologic sink exists due to evaporative losses. Regional groundwater elevation contours are shown on Figure 8-14, and a close-up of groundwater contours around the pit lake is illustrated in Figure 8-19. The groundwater elevation contours indicate groundwater flows from the andesite to the alluvium and Santa Fe Group sediments.

<u>Quaternary Alluvial Aquifer</u>: Within the Mine Permit Area, the principal water-bearing sediments east of the andesite are (1) alluvial fan deposits and fluvial sands and gravels of the Santa Fe Group, and (2) saturated alluvium in the principal drainages. Alluvium is found east of the Copper Flat Mine in Grayback Arroyo and primarily consists of sand and gravel. Thickness of the alluvium ranges between 5 and 50 ft. Alluvium may be locally and seasonally saturated north of the tailing impoundment and downgradient of the waste rock piles along Grayback Arroyo.

8.2.4 Groundwater Data

Groundwater data described in this section are organized according to the three primary aquifers present within the Mine Permit Area and surrounding Baseline Study Area. For each aquifer, water quality, water level, and aquifer characteristics are described using those data collected on behalf of NMCC according to the SAP (INTERA, 2010), and existing data collected by previous operators that either mined the Mine Permit Area or worked on permit applications to mine the Mine Permit Area.

8.2.4.1 Crystalline Bedrock Aquifer

Groundwater is present within the crystalline rocks that constitute much of the western portion of the Mine Permit Area (Figure 8-12). Though the rocks themselves have practically no inter-granular permeability, faulting and jointing of the monzonite have created locally permeable zones through which water can move. Several groundwater wells within the crystalline rocks were studied as part of NMCC's baseline program that provide information used to characterize the water quality and water levels within the crystalline rocks (Figure 8-20). Water level elevations were measured in nine wells (Table 8-9) and water quality samples were collected from six wells within this aquifer (Table 8-10). In addition, an open pit partially filled with water, excavated in 1982 by Quintana Minerals Corp. (a previous operator of the Mine Permit Area), exists within the crystalline rocks and provides another observation point for water quality and water level elevations. The pit lake is described further in this section with respect to the lake's effects on groundwater quality and containment.

8.2.4.1.1 Historical Data

Groundwater levels have been measured in wells or piezometers screened in the crystalline bedrock since the early 1980s in support of previous mine permitting efforts. The oldest groundwater quality sample of water quality conditions for the crystalline bedrock aquifer comes from the Pague well (Figure 8-21), a 3.4' x 5', rock-lined, hand-dug well with a windmill that is currently non-operational. A sample collected on August 20, 1946, approximately ten years after the well was constructed, was analyzed for nine chemical constituents. These data provide a historical baseline for select constituents prior to implementation of formal sampling programs in the 1980s and 1990s that were part of mine permitting activities. Historical data from wells screened in the crystalline bedrock aquifer come from water supply and monitoring wells available at the time (see Table 8-11 for historical water quality results). Historical groundwater level and water quality data from crystalline bedrock are summarized in SRK (1995) and BLM (1999).

During the preparation of the PFEIS by Alta Gold (BLM, 1999), the last attempt to permit the mine property, the historical data were used to construct groundwater elevation contour maps that showed a general flow of groundwater from west/northwest to east/southeast (Figure 3-12 in BLM, 1999). As summarized in BLM (1999), there appeared to be a difference in the groundwater geochemistry in wells upgradient of the pit versus those wells located downgradient of the pit. Using data from wells GWQ-4 and GWQ96-22 A and B (Figure 8-21), the authors described water upgradient of the pit as sodium-sulfate dominated at shallow depths and sodium-calcium-bicarbonate dominated at greater depths (BLM, 1999).

Data collected in 1981 from wells downgradient of the ore body by Sergent, Hauskins, and Beckwith (SHB) showed that groundwater in the GWQ-5 (Table 8-11; Figure 8-21), a well located east-southeast of the pit lake in Grayback Arroyo, had a pH value of 7.3, a TDS of 1,260 mg/L, sulfate of 575 mg/L, and bicarbonate of 398 mg/L. GWQ-6, which is located approximately 2,000 ft farther to the southeast of GWQ-5 (Figure 8-21), was more calcium-sodium-magnesium-bicarbonate dominated with a pH of 7.3 and concentrations as follows: 420 mg/L TDS, <50 mg/L sulfate, and about 300 mg/L bicarbonate (Table 8-11). GWQ-5 was a 20-ft deep rock-lined hand dug well (SHB, 1981) that was buried during the Quintana mining operations. When compared to data from the 1990s from another set of nested wells downgradient of the pit lake, GWQ96-23A (shallow) and GWQ96-23B (deep), water chemistry also showed that sulfate exceeded bicarbonate in both the shallow and deep wells. Groundwater chemistry from GWQ-5 likely represented shallow groundwater originating from the Copper Flat area that was influenced by the oxidation of the ore body prior to open pit mining, where the other crystalline bedrock wells (GWQ-6 and GWQ96-23[A,B]) exhibit groundwater chemistry not affected by oxidation of sulfides in the ore body.

Water quality data from two wells, GWQ96-22A and GWQ96-23A, were used to statistically evaluate and compare historical water quality data with baseline water quality data collected for the NMCC baseline program. Summary statistics for historical data (pre 2010) for a given well and a selected constituent were compared to summary statistics of populations for a given constituent and a well that represent data collected from January 2010 through May 2011 as part of the NMCC baseline program. Wells GWQ96-22A and GWQ96-23A were selected for the comparison of data sets representing historical and present baseline conditions for the crystalline bedrock aquifer because these wells have the most observations (Table 8-11).

Using Statistica ProUCL, descriptive statistics for GWQ96-22A and GWQ96-23A were generated for chloride, copper, sulfate, and TDS. These constituents were selected because they were most consistently collected throughout the history of the mine for all studied wells (Table 8-11). Descriptive statistics for historical data are presented in Table 8-12. The results of identical statistics and tests for baseline data collected as part of the NMCC baseline program are presented in Table 8-13. A comparison of summary statistics for historical and baseline data collected for the NMCC program is presented in Table 8-14. The comparison of the means, upper confidence levels, and distribution of data sets (Table 8-14) shows that the addition of baseline data to the historical data set does not significantly change the data set. Therefore, these historical data can be used in conjunction with baseline data to characterize water quality conditions of the crystalline bedrock aquifer.

In addition to evaluating historical water quality, water level measurements from wells GWQ96-22(A and B) and GWQ96-23(A and B) were used to examine the effects of the pit lake on the groundwater flow. As summarized in BLM (1999), the authors conclude that the pit lake behaves as an evaporative sump (see Section 8.1.2.3.4 for additional discussion of current conditions).

8.2.4.1.2 Data Gaps Addressed

The absence of comparable water level measurements from groundwater monitoring wells in the area of the pit lake coupled with contemporaneous pit lake water level measurements prevented previous operators and applicants from clearly and defensibly demonstrating the pit lake water balance and hydraulic regime. Without these synchronous data from a sufficient number of wells that were positioned to evaluate the pit lake hydraulic behavior, the groundwater flow direction in the area of the pit lake could not be definitively determined.

To address this data gap, NMCC installed two additional nested piezometers in 2011, GWQ11-24(A,B) located south of the pit lake and GWQ11-25(A,B) located north of the pit lake (Figure 8-19). The four nested piezometers around the pit provide the data needed to prove the pit lake is a hydrologic sink (Figure 19, Tables 8-9 and 8-17).

8.2.4.1.3 Well Selection Rationale

Wells screened in the crystalline bedrock aquifer were selected based on the availability of well construction details and geographic distribution. Though several wells draw water from the crystalline bedrock aquifer on the Mine Permit Area and adjacent to the Mine Permit Area, the absence of construction details for many of the wells eliminated them from use in the baseline program. Wells GWQ96-22A and GWQ96-23A were selected for the program because well construction details were available; the wells draw water from only the crystalline bedrock aquifer. One is located upgradient of the pit lake (GWQ96-22 A), and one is located downgradient of the pit lake (GWQ96 23 A). In addition to these wells that were originally proposed as part of the SAP (INTERA, 2010), samples or water level measurements from private wells owned by Pitchfork Ranch (GWQ-4, LRG-04153, LRG-04158, and LRG-04159) were collected to help characterize regional conditions as these wells are located within the crystalline bedrock aquifer upgradient of the Mine Permit Area. If the wellhead construction permitted the opportunity for collecting water level measurements or water quality samples, then those data were collected from these existing wells.

Wells EIW, Pague, Delores, GWQ-5, and GWQ-6 were not included in the NMCC baseline characterization program because of the absence of well construction details, and, in the case of GWQ-5, because it was abandoned and covered. EIW is an injection well and its construction does not permit gauging or sampling. Well logs are not available for GWQ-5 and GWQ-6, which introduced some uncertainty about whether the wells could be rehabilitated and whether a representative sample could be collected to characterize water chemistry conditions. Similarly, the absence of well construction details and the poor condition of the Pague and Delores wells, both located to the north of the pit lake, presented concern regarding the ability to collect representative samples. As a result, these wells were not adopted as part of the monitoring program. NMCC has replaced GWQ-5 with a new well (GWQ-5R) located approximately 500 ft to the east of GWQ-5.

The rationale for the locations and depths for drilling additional nested piezometers on the north and south sides of the pit lake were based on proximity to the pit lake, land owned by NMCC, and geologic observations. Nested piezometers GWQ11-24(A,B) and GWQ11-25(A,B) were drilled, constructed, and tested for aquifer properties in 2011. The placement of screen intervals was based on observed fracture density and groundwater during the drilling process. Additional details can be referenced from the NMCC Stage 1 Abatement Plan Amendment (JSAI, 2011).

8.2.4.1.4 Modifications to the SAP

As NMCC executed the SAP, adjustments to the proposed SAP were necessary based on the actual site conditions encountered in the field. When making adjustments based on field conditions, NMCC strived to find equivalent or improved alternatives, where possible. Overall, more wells screened in the crystalline bedrock aquifer were included in the baseline characterization program than were proposed in the SAP (GWQ96-22A and GWQ96-23A) (INTERA, 2010; Table 8-15). The owners of Pitchfork Ranch permitted NMCC to collect groundwater data from several of their wells (GWQ-4, LRG-04153, LRG-04158, and LRG-04159) screened in the crystalline bedrock aquifer (Table 8-9). These wells are useful for characterizing regional groundwater quality and geochemistry beyond the Mine Permit Area. Access ports for measuring water levels did not exist on many of the wells located on the Pitchfork Ranch, which prevented water level measurements from GWQ-4, LRG-04153, and LRG-04159. However, one water level from LRG-04159 was collected during a day when the landowner had pulled the pump for service. See Table 8-9 for water level measurements and Table 8-11 for water quality results.

In addition to the data collected for the baseline program, wells installed by NMCC in support of the Stage I Abatement Plan process for the NMED in the vicinity of the pit lake provide useful water level and water quality data within the Mine Permit Area. Data from these NMCC-installed wells serve as good indicators of aquifer properties, water quality, and groundwater levels within the proposed Mine Permit Area. See Section 8.2.7 for further information on these additional wells.

8.2.4.1.5 Results

Figures 8-19 and 8-20 show the locations of groundwater monitoring wells in the vicinity of the pit lake which provide information for the water-bearing crystalline bedrock. Well construction details for these observation points, along with water level measurements recorded during the baseline program, are presented in Table 8-9. Water quality results are presented in Table 8-11. The results show that groundwater flow in the crystalline bedrock aquifer is generally from west to east (Figure 8-14), with the exception of the area surrounding the pit lake, which behaves as an evaporative sink (Figure 8-19).

For well GWQ96-22A, trends in sulfate and TDS are shown in Figure 8-22 and trends in selected metals are shown in Figure 8-23. For well GWQ96-23A, trends in sulfate and TDS are shown in Figure 8-24 and trends in selected metals are shown in Figure 8-25. In both wells, concentrations of sulfate and TDS generally decrease over time. With the exception of manganese, the selected constituents of concern are below the WQCC standards.

Time-series water level data for the crystalline bedrock aquifer come from monitoring wells drilled around the Copper Flat mine pit (GWQ96-22[A,B], GWQ96-23[A,B], GWQ11-24[A,B], and GWQ11-25[A,B]). A location map and hydrographs can be referenced from Appendix 8-G. The wells surrounding the pit lake have a higher groundwater elevation than the pit lake (Appendix 8-G, Figure B). Water levels in GWQ96-22(A) and GWQ96-23(A) have been relatively the same for the last few years.

8.2.4.2 Santa Fe Group Aquifer System

Overview

Overlying and adjacent to the crystalline bedrock aquifer within the Mine Permit Area and surrounding Baseline Study Area is the Santa Fe Group aquifer system, a system that is locally represented by two hydrostratigraphic units (HSUs): (1) the Upper Santa Fe Group hydrostratigraphic unit (USF), and (2) the Middle Santa Fe Group hydrostratigraphic unit (MSF). Informally, these HSUs comprise the Santa Fe Group aquifer system, and correspond roughly to the upper (Palomas) and middle (Rincon valley) lithostratigraphic subdivisions of the Santa Fe Group used in local and regional geologic mapping (Hawley and Kennedy, 2004).

The Santa Fe Group is composed chiefly of coalescing alluvial fan deposits that are discontinuous and locally heterogeneous with inter-bedded sandstones, silts, and clays of varying percentages. The Upper Santa Fe Group Palomas Formation (Lozinsky and Hawley, 1986) represents the USF. This formation grades eastward from the

Animas Uplift from coarse alluvial fan material to braided stream and deltaic sands and silts to clays near the Rio Grande. The inter-fingering with clays begins approximately 3 to 5 miles west of the current position of the Rio Grande and is responsible for the flowing wells common in this part of the Baseline Study Area (Murray, 1959; Figure 8-13). A basalt flow dated at 4.2 million years before present caps the Palomas Formation gravels near Copper Flat (Seager et al., 1984). The majority of the Santa Fe Group aquifer water supply and monitoring wells in the Baseline Study Area are completed in the USF.

The Middle Santa Fe Group Rincon Valley Formation (Seager and Hawley, 1973) is exposed near Hillsboro, New Mexico, where the reddish-brown clays and clayey silts characteristic of this basal unit are interbedded with basalts dated at 28 million years before present (Seager et al., 1984). The Rincon Valley Formation lacustrine red clays underlie the Palomas Formation and thicken southward toward Hatch, New Mexico, and the Rincon Basin (Wilson et al., 1981).

Tailing Dam Vicinity

The present tailing impoundment facility overlies the old placer workings between Grayback Arroyo and Hunkidori Gulch. Geologic cross sections from west-east and north-south are presented in Figures 8-17 and Figure 8-18, respectively. A study of these placer workings by Segerstrom and Antweiler (1975) showed that the placers were found in paleo-stream terrace alluvium approximately 25- to 30-ft thick that is underlain by a petrocalcic horizon and reddish-brown clay. SRK (1995) and SHB (1980) investigated the areal extent of this reddish-brown clay layer. According to the studies completed by SRK and SHB, the clay layer and the 25 to 30 ft of alluvium that lie above the clay have acted to impede downward migration of water draining from the eastern half of the existing tailings. A groundwater mound was created by seepage from the tailings, as evidenced in some tailing dam monitor wells completed above the clay layer. East of the inferred location of a fault (Figure 8-17) that was described by Seager et al. (1982), the USF thins. The hydraulic gradient in this area ranges from about 250 ft/mile immediately east of the tailing facility to about 100 ft/mile farther to the east (Figure 8-14). An investigation of the eastward extent of the groundwater mound is proposed for the Stage 1 Abatement Plan.

Production Wellfield Vicinity

Farther to the east, the hydraulic gradient decreases from 250 ft/mile to less than 50 ft/mile in the vicinity of the production wellfield (identified as PW wells on Figure 8-26), located about 8 miles from the Mine Permit boundary. This suggests a progressive increase in transmissivity toward the area of the production wellfield. The transmissivity of the USF in the production wellfield area ranges from about 17,000 to 20,000 ft^2/day. Farther to the east, towards Caballo Reservoir, sands and gravels in the Santa Fe Group are interbedded with clays of the ancient Rio Grande. As a consequence, the transmissivity likely decreases slightly and the hydraulic gradient slightly increases (Figure 8-14). In this area just west of Caballo Reservoir, the USF appears to be confined, leading to artesian flow in wells along the lower reaches of both Las Animas Creek and Percha Creek (Figure 8-14). See Section 8.2.4.4 for additional information on artesian wells.

Groundwater gradients strongly suggest that water flows from the Santa Fe Group aquifer system to the floodplain alluvium of the Rio Grande.

8.2.4.2.1 Historical Data

Historical water quality data for chloride, copper, sulfate, and TDS from wells in the area of the tailing impoundment (IW-2, MW-6, NP-1, and NP-3) were used to statistically evaluate and compare historical water quality data with baseline water quality data collected for the NMCC baseline program. These constituents have been analyzed most continuously over the period of study (Table 8-11). Of the numerous wells in the Santa Fe

Group aquifer system, these wells represent the only observation points which contained sufficient data to calculate meaningful statistics (Table 8-11). Following the same method described in Section 8.2.4.1.1, summary statistics were prepared for historical data collected before 2010 (Table 8-12) and baseline data collected between July 2010 through May 2011 (Table 8-13). These two data sets were compared (Table 8-14) to determine whether the addition of historical data to the baseline data significantly changed the overall data set. The comparison of the means, upper confidence levels, and distribution of data sets which contained sufficient data to calculate meaningful statistics (Table 8-14) shows that the addition of baseline data to the historical data set does not significantly change the data set. As a result, these historical data are used to characterize water quality conditions of the Santa Fe Group aquifer system, helping to extend the data set for the aquifer in the area of both the tailing dam facility to the 1980s and in the vicinity of the Production well field to 1975. Hydrographs for wells in the Santa Fe Group aquifer that are monitored by the USGS are provided in Appendix 8-G.

Pumping and specific capacity tests were performed on mine supply wells MW-4 (Water Development Corporation, 1975), GWQ-1 (Water Development Corporation, 1980), GWQ-7 (W.K. Summers & Associates, 1981), and GWQ-9 (Water Development Corporation, 1980). All of these wells are in the vicinity of the tailing impoundment. A summary of the hydraulic properties derived from the wells tested in the tailing impoundment area is listed in Table 8-16.

In 1994, Adrian Brown Consultants performed a 76-hour, constant rate pumping test on GWQ94-17 (inset, Figure 8-21), which is located below the tailing impoundment (ABC, 1996d). Neighboring monitoring wells were used as observation wells during the pumping test. The pumping well, GWQ94-17, was pumped at a rate of 23 gpm. The water levels in the pumping and observation wells never fully recovered to the pre-pumping level, indicating possible boundary effects from dewatering the groundwater mound observed beneath the tailing dam (JSAI, 2011).

Transmissivity of the Santa Fe Group aquifer derived from pumping tests of the NMCC water supply wells PW-1, 2, 3, and 4 (Figure 8-21)(Green and Halpenny, 1976) averages about 20,000 ft^2/day. PW-2 was pumped at 2,020 gpm for 72 hours in January 1976. Water level drawdown and recovery were measured at observation wells PW-1 and MW-5 (Figure 8-27). Aquifer transmissivity was estimated at about 20,000 ft^2/day by matching the solution of Theis (1938) to measured drawdown and recovery at PW-1 and MW-5, and to measured recovery at the pumping well PW-2. PW-1 was pumped at 1,500 gpm for 70 hours in December 1975, and water level drawdown and recovery were measured at observation well MW-5. Aquifer transmissivity of about 17,000 ft^2/day was estimated by matching the solution of Theis (1938) to measured drawdown and recovery at MW-5, and to measured recovery at the pumping well PW-1.

8.2.4.2.2 Data Gaps Addressed

The need for water level measurements from wells located to the east of the Mine Permit Area (Figure 8-20) was identified as a data gap during the previous mine-permitting attempt made by Alta Gold in the 1990s (DBS&A, 1998). These data are useful for evaluating a pre-mining potentiometric surface for the Santa Fe Group aquifer system. As the basis for evaluating potential impacts from mine dewatering and pumping from the production well field, these water level data are critical to the baseline characterization program. Where access was permitted, wells screened in the Santa Fe Group aquifer system located to the east of the Mine Permit Area were included in the baseline data program for measuring water levels to fill data gaps identified in previous permitting attempts for the Mine Permit Area (DBS&A, 1998). Table 8-9 presents those water levels collected during the baseline data program. The distribution of these wells is presented in Figure 8-20. In December 2011, NMCC conducted regional groundwater level measurements in 22 wells to support the regional groundwater model. Table 8-17 presents the water level data and Figure 8-14 presents a regional potentiometric surface map based on the December 2011 regional water level measurements.

An aquifer test is planned in the production well field to further characterize aquifer properties and hydraulic boundaries of the Santa Fe Group aquifer system. NMCC is in the process of working through the permitting process with the BLM, the land manager for the lands where the production wells are located. Those results will be provided to MMD upon completion of the aquifer test report.

8.2.4.2.3 Well Selection Rationale

An inventory of existing wells was completed using existing information available in the NMOSE WATERS database, NMOSE hydrographic survey data, and historical well records reviewed in previous permitting efforts (summarized in ABC, 1996b). Based on this inventory, NMCC identified 18 wells screened in the Santa Fe Group aquifer system for water level measurement or water quality sampling. The following criteria were used to select each well:

- Ownership – Those wells on public land or lands under option to NMCC ranked higher. Those wells that had been sampled in the past also ranked higher, under the assumption that the landowners would still be agreeable to granting NMCC permission to study their well.
- Construction details – Those wells with details on construction, especially the depth of the screened interval, were proposed for water level measurement and sampling. Those wells without details on construction were not proposed for water level measurements.
- Previous samples – Wells from which water quality samples were collected in Q1 or Q2 that exceeded water quality standards received a higher ranking than those wells from the same aquifer and region that did not exceed water quality standards.
- Previous reviewer comments – In response to comments and requests made during the public and regulatory review of the New Mexico Mining Act permit application from Alta Gold Corporation (SRK, 1996) and the Draft Environmental Impact Statement (BLM, 1996), SRK (1997a) developed a sampling program that identified on-site and regional wells to help characterize baseline conditions. As this plan was developed in response to previous public and regulatory comments, those wells included in the SRK (1997a) program ranked higher than those not included in the program.
- Geographic distribution – A good geographical distribution of wells is needed to provide adequate characterization and data for the groundwater impact assessment. Therefore, wells should be located throughout the Baseline Study Area. Ideally, existing wells selected for monitoring should be both upgradient and downgradient of the Mine Permit Area and draw water from all three aquifers to characterize the chemistry of each aquifer.

The combination of these criteria guided the selection of groundwater monitoring wells proposed in the SAP.

8.2.4.2.4 Modifications to the SAP

As NMCC executed the SAP, adjustments to the proposed SAP were necessary based on the actual site conditions encountered in the field. When making adjustments based on field conditions, NMCC strived to find equivalent or improved alternatives, where possible. Water level measurements or water quality samples were not collected from 5 of the original 18 wells located in the Santa Fe Group aquifer system that were proposed in the SAP for various reasons associated with land or well access (Table 8-15). The assumption made during the preparation of the SAP was that those wells proposed to supplement the previous Alta Gold permitting effort described in SRK (1997a) were accessible for monitoring. Though 5 of the original 18 were not studied as planned (Table 8-15), water level measurements were collected from 22 wells and 37 water quality samples were collected from 15 wells screened in the Santa Fe Group aquifer system. The water level results are shown in

Table 8-9 and water quality results are shown in Table 8-11. The wells studied in addition to those wells identified in the SAP were selected based on the criteria identified in the previous section.

8.2.4.2.5 Results

Water level measurements are presented in Table 8-9. Based on these water level data, groundwater flow in the Santa Fe Group aquifer is generally from west to east (Figure 8-14). Results from water quality analyses are presented in Table 8-11. Trends in concentrations in sulfate and TDS, two constituents of concern to the NMED, generally increase over time for wells NP-2 (Figure 8-28), NP-3 (Figure 8-29), and NP-4 (Figure 8-30). Additional analyses of these data are provided in the Stage 1 Abatement Plan.

Time series water level data for the Santa Fe Group aquifer can be divided into (1) the tailing impoundment area, and (2) the Palomas Basin region between Animas and Percha Creeks. A description of the time series water level data sources, table of data for wells with time series water level data, a location map, and hydrographs can be referenced from Appendix 8-G and Figure 8-31.

Water levels beneath the Copper Flat tailing impoundment significantly rose during Quintana Minerals operation in 1983 (see the hydrograph for monitoring wells NP-1 through NP-5 and GWQ-12 presented as Appendix 8-G, Figures C and D). The water level rise beneath the tailings impoundment is the result of a groundwater mound created by infiltration at the tailings dam, low-permeability sediments in the Santa Fe Group aquifer, and the north-to-south-trending fault approximately 800 ft east of the tailing impoundment. The fault acts as a barrier to groundwater flow. Groundwater elevations in the tailing impoundment area have not significantly changed over the last 20 years (1990 to 2010).

Water level data from Copper Flat Mine production well PW-1 and neighboring monitoring wells MW-5, MW-9, and MW-10 provide good information for assessing water level trends in the vicinity of the production wells proposed for New Mexico Copper operations. Monitoring wells MW-9, MW-10, and MW-11 are in Animas Creek Valley and the production wells and MW-5 are located on the mesa between Animas Creek Valley and Grayback Arroyo. Since the early 1990s, a water level decline of approximately 0.5 ft/year is observed from PW-1, MW-9, and MW-10 (Appendix 8-G, Figure E). In Las Animas Creek, downstream of MW-9 and MW-10, well 15S5W29 has not shown a defined water level trend (Appendix 8-G, Figure F).

The USGS has maintained several Santa Fe Group aquifer water level data monitoring points in the baseline data study area (Appendix 8-G, Figure A). Mine wells MW-2, MW-5, MW-6, and MW-8 have data points that span several decades. Each of these monitoring points shows a different water level trend (Appendix 8-G, Figures G through J), suggesting the aquifer system is highly dynamic and influenced by climate and geologic complexity rather than groundwater diversions. For example, MW-2 has shown a groundwater elevation decline of 50 ft over the last 20 years (Appendix 8-G, Figure G) in an area where there is no significant pumping, and MW-6 has shown a groundwater elevation rise of 150 ft over the last 30 years (Appendix 8-G, Figure I). MW-6 is located next to a fault mapped in the Santa Fe Group aquifer. Well 16S6W24 is located in Percha Creek upstream of the artesian zone (Appendix 8-G, Figure A) and exhibits an over 30-ft change in groundwater elevation with no particular trend (Appendix 8-G, Figure K).

8.2.4.3 Quaternary Alluvium

The uppermost aquifer in the Baseline Study Area is the Quaternary alluvial aquifer, which is composed of channel and floodplain gravels, sands, and silts. Minton (1961) describes exploratory drilling from shallow water resources in area of Ladder Ranch. Later, Davie and Spiegel (1967) summarized their early work on understanding the shallow wells that develop groundwater of the alluvial aquifer within Las Animas Creek Drainage Basin. The authors provide water level contour maps that delineate water levels in the alluvium for the fall of 1966 as well as a cross section of the alluvial aquifer in and along Las Animas Creek. Logs from wells drilled along Las Animas and Percha Creeks indicate that upper alluvial gravels extend from the surface to a depth of approximately 20 to 60 ft depending on the location along the creek (BLM, 1999; NMOSE files). There are fewer data available for the thickness of these deposits in the lower portion of Greenhorn Arroyo.

The alluvial aquifer in Las Animas Creek Drainage Basin consists of local alluvial deposits adjacent to and underlying Las Animas Creek. Groundwater in this narrow, sinuous aquifer is in direct hydraulic communication with Las Animas Creek surface water. Surface water in the creek and groundwater in the aquifer form a single surface-to-groundwater flow system. Surface water flow from one location to the next may be related, in part, to the proportion of total system flow being carried by the aquifer at each location. Along its course, Las Animas alluvial aquifer receives recharge by rainfall infiltration. Discharge from the aquifer occurs through evaporation and evapotranspiration from riparian vegetation and existing well pumping. A detailed seepage investigation of the drainage was conducted in June 2011 (Appendix 8-B), which characterizes the complexity of the gaining and loosing reaches of Las Animas Creek. Based on this information coupled with a survey of artesian wells described in Section 8.2.4.4., a cross section along the axis of the creek (Figure 8-32) is presented in Figure 8-33 that shows groundwater elevations, including a zone where the alluvial aquifer is perched above the Santa Fe Group aquifer system. At Caballo Reservoir, all water in Las Animas surface/groundwater system discharges to the reservoir.

Similar to the Las Animas Drainage Basin, the alluvial aquifer in both the Percha Creek and Greenhorn Arroyo Drainage Basins consists of local alluvial deposits adjacent to and underlying drainage channels that are stratigraphically above or adjacent to Santa Fe Group sedimentary rocks and sediments. The extent of the alluvial aquifer is shown in Figure 8-12. Flowing wells identified in NMOSE (2000) and in Figure 8-32 also exist within the vicinity of Caballo Reservoir. Further information on the artesian well survey is presented in Section 8.2.4.4.

8.2.4.3.1 Historical Data

During a previous effort by Alta Gold Co. to permit the Mine Permit Area in the 1990s, MW-11 was drilled as an observation point into the Quaternary alluvial aquifer. Historical water level (Table 8-9) and water quality data are available for this well (Table 8-11).

At the location of monitoring wells MW-9, MW-10, and MW-11 (Figure 8-20), north of the production well field, the groundwater level in the USF is some 58 ft lower than the water level in the overlying Quaternary alluvial aquifer (ABC, 1996c). As a result, the Quaternary alluvial aquifer is perched above the USF in the vicinity of MW-11. Such conditions are interpreted to occur along a substantial length of Las Animas Creek (ABC, 1996c). In spite of these gradients, the amount of surface water loss from the Quaternary alluvial aquifer in Las Animas Creek Drainage Basin is not significant, suggesting that vertical hydraulic conductivity in the USF is relatively low.

8.2.4.3.2 Data Gaps Addressed

The MMD (1997) noted gaps in the adequacy of historical data collected as part of the Alta Gold Co. permit application and EIS process (BLM, 1996). These gaps were largely focused on concerns about the sufficiency of baseline data used to evaluate the impact of groundwater pumping on local wells and riparian habitats in Las Animas and Percha Creek Drainage Basins as well as the assumptions about aquifer properties. In addition, concerns regarding the impact of proposed mine dewatering and groundwater pumping on flowing wells were identified as another data gap (MMD, 1997). These concerns have been addressed by data and information presented in this Baseline Data Report.

NMCC has an observation well (MW-11) in the alluvial aquifer along Las Animas Creek (Figure 8-27). MW-11 will be used as an observation well for a proposed large-scale pumping test that will characterize aquifer properties, including the hydraulic communication between the Santa Fe Group aquifer system, in which the production wells are screened, and the Quaternary alluvial aquifer. Water level monitoring will include pre-pumping, pumping, and recovery conditions. In addition to this pumping test, a detailed survey of artesian wells was completed to better characterize the flowing wells and understand how the artesian system is connected to adjacent and underlying aquifers and stream discharge into those aquifers (Appendix 8-H). Additional data collected from the USGS, NMOSE files, and wells drilled by others in the Baseline Study Area have helped develop an understanding of the aquifer systems, particularly the alluvial aquifer and underlying USF artesian zone.

8.2.4.3.3 Well Selection Rationale

MW-11 and Animas Station 8 wells were two alluvial groundwater wells gauged or sampled as part of the baseline program as access was granted by private landowners. Because MW-11 was installed as part of a previous permitting effort for the purposes of groundwater monitoring, the well construction details were available and permitted groundwater samples to be collected and water levels to be measured. The Animas Station 8 well is also located on private property about 2.9 miles upstream of MW-11. Spatially, it provides an upstream observation point for water levels farther from the location for proposed production well pumping.

The Upper Percha and Lower Percha Artesian wells (Figure 8-21) were also included as part of the original baseline study, as they too could provide useful observation points for the Quaternary alluvial aquifer in the Percha Creek Drainage Basin. NMCC requested permission from the well owners to gain access to both wells. However, because these wells were not constructed for groundwater monitoring purposes, modifications to the well head would have been necessary to incorporate the wells into the baseline program. Arrangements to modify the well heads were not in place during the course of the baseline program, and therefore the wells were not studied as part of the baseline program. However, as of May, 2011, NMCC has installed water level measurement ports in wells LRG-10948 and Upper Percha (Figure 8-21) and has permission to collect water level data for future hydrology studies as needed. Further information on flowing wells in the area of the Lower Percha Artesian well is presented in Section 8.2.4.4.

8.2.4.3.4 Modifications to the SAP

As NMCC executed the SAP, adjustments to the proposed SAP were necessary based on the actual site conditions encountered in the field. When making adjustments based on field conditions, NMCC strived to find equivalent or improved alternatives, where possible. The Saladone well, which was first studied by Minton (1961) and later used as part of an aquifer test (Atkins, 1992), was proposed in the SAP as a water level observation point upstream in Las Animas Creek drainage with the objective of characterizing water levels in the Quaternary aquifer to the northeast of the location for proposed mine dewatering. However, additional data were not collected from the Saladone well because the well was destroyed due to flooding (DoBrott, 2010) prior to the commencement of the baseline study program. In addition, the following wells were initially identified in the SAP as being wells that develop water from the Quaternary alluvial aquifer: GWQ-11, GWQ94-16, GWQ94-19, IW-1, and IW-2. However, after further review of available well logs, it was determined that these wells develop water from the sediments and sedimentary rocks of the USF. GWQ-11, GWQ94-16, GWQ94-19, IW-1, and IW-2 were studied, but are described in the previous discussion on the Santa Fe Group aquifer system. GWQ94-18 was dry during each visit (Table 8-9). Therefore, a water quality sample could not be collected from the well, as proposed in the SAP (Table 8-15).

8.2.4.3.5 Results

Water level measurements for the Animas Station 8 and MW-11 wells are presented in Table 8-9. Results for water quality analysis of three samples collected from MW-11 during the baseline program are presented in Table 8-11.

Time series water level data for the Quaternary alluvial aquifer were compiled for the Baseline Study Area. A location map and hydrographs can be referenced from Appendix 8-G and Figure 8-31. With the exception of Well 15S5W24, all of the hydrographs for the Quaternary alluvial aquifer are in Las Animas Creek Valley. Groundwater elevation data from MW-11 demonstrates the Quaternary alluvial aquifer is perched above the Santa Fe Group aquifer (Appendix 8-G, Figure E). Downstream of MW-11, USGS-monitored wells 15S5W26 and 15S5W27 show annual groundwater elevation changes of about 10 ft (Appendix 8-G, Figures L and M). Well 15S5W24 is located directly north of Las Animas Creek Valley in Seco Creek Valley near I-25, and has over 166 data points. This well has a long-term water level decline with seasonal peaks related to precipitation events (Appendix 8-G, Figure N).

8.2.4.4 Artesian Well Inventory

The artesian wells within the Baseline Study Area are constructed in the Santa Fe Group sediments, and artesian conditions occur where there is a low permeability confining layer, such as clay, overlying a permeable layer of silt, sand, and gravel. Figure 8-32 is a regional map showing the locations of artesian wells in the inventory area, and Figure 8-34 is a map detailing artesian wells in the lower Las Animas Creek valley where density of wells is greatest. A west-to-east cross section down Las Animas Creek is presented as Figure 8-33. Las Animas Creek hydrogeologic cross section is based on available well logs and regional geology described by Seager et al. (1982) and Hawley and Kennedy (2004). See Appendix 8-H for an inventory of artesian wells in Las Animas Creek valley and vicinity.

As shown on Figure 8-32, all of the known artesian wells are found east of the mapped north-to-south fault zones identified by Seager et al. (1982). East of a series of north-to-south-trending faults, the beds of the Santa Fe Group sediments dip to the east (Figure 8-33). The artesian aquifer exists because the eastward dipping sand beds are recharged near the water table, and confined by clay beds down-dip to the east of the zone of recharge. There are three distinct hydrogeologic zones identified on Figure 8-33:

1. Hydrogeologic Zone 1 is where Las Animas Creek alluvial aquifer is perched above the Santa Fe Group aquifer by a horizontal clay layer in the Santa Fe Group sediments. This zone occurs where the Santa Fe Group sediments are down-dropped between two north-to-south-trending faults. The hydrograph presented as Figure 8-35 illustrates the vertical water level elevation difference between the alluvium and underlying Santa Fe Group sediments.
2. Hydrogeologic Zone 2 is where the Santa Fe Group consists of predominantly coarse-grained sediments, and the overlying Las Animas Creek and alluvium can readily recharge the regional aquifer. Zone 2 is labeled as a potential recharge zone for artesian wells. Zone 2 occurs directly east of the north-to-south-trending faults shown on Figures 8-32 and 8-33. Water level elevations in the alluvium are similar to water level elevations in the underlying Santa Fe Group sediments.
3. Hydrogeologic Zone 3 is where the Santa Fe Group sediments are highly stratified and dipping to the east. In Zone 3, wells typically deeper than 100 to 200 ft are artesian (Figure 8-33).

8.2.4.4.1 Historical Data

The first artesian wells in the Baseline Study Area were drilled in the late 1930s, after the construction of Caballo Reservoir in 1938. Most all of the artesian wells were drilled prior to the NMOSE declaration of Las Animas Creek and Lower Rio Grande Underground Water Basins.

Most of the artesian wells are located in Las Animas Creek valley and Percha Creek valley, with a few artesian wells in the Oasis area along Highway I-25. Murray (1959) identified 26 artesian wells throughout the investigation area, the 1966 NMOSE Las Animas Creek Hydrographic Survey Sheet 1 identifies 26 artesian wells, and Davie and Spiegel (1967) identified 27 wells in Las Animas Creek area and two artesian wells in the Oasis area. Flow from selected artesian wells has been measured by Murray (1959), Davie and Speigel (1967), and JSAI (1995 unpublished field survey).

8.2.4.4.2 Data Gaps Addressed

Data gaps regarding the artesian wells have included (1) a current inventory of artesian wells in the Baseline Study Area, (2) artesian well construction details, (3) the hydrogeologic setting for artesian wells, and (4) quantified diversion rates from artesian wells.

Construction details on the artesian wells are limited, but it appears a number of artesian wells were drilled without proper annular seals to prevent flow of water from the artesian zone into the overlying alluvium and stream channels. Furthermore, many of the artesian wells were never valved and are therefore left open to flow continuously to the land surface. Since the area was declared by the NMOSE, valves to regulate artesian flow and metering have been conditions attached to many of the water right permits granted since that time.

An updated inventory of artesian wells in Las Animas Creek valley and vicinity was conducted in 2011. The primary purpose of the updated inventory was to address the data gaps listed in this section. The inventory region was divided into three areas: (1) Las Animas Creek valley, (2) Oasis (between Las Animas Creek valley and Percha Creek), and (3) Percha Creek valley.

Data sources included the following:

1. Groundwater report by Murray (1959)
2. Las Animas Creek Hydrographic Survey Report by Davie and Spiegel (1967)
3. NMOSE online WATERS database
4. NMOSE files
5. JSAI 1995 field survey

Well information from the data sources listed above was combined and verified. NMOSE files consisted of water right declarations, well records, proof of completion of works, NMOSE field check reports, and other available documents attached to water rights applications and permits. An attempt was made to match data from different sources to the correct well, and to reconcile apparent discrepancies. A list of inventoried wells is presented as Appendix 8-H.

Currently there are over 61 artesian wells identified in the investigation area. Well depths range between 120 and 505 ft below land surface. Over the last 50 years, significant changes in flow rates have been observed in the few artesian wells that have time series data. Figure 8-36 is a graph of artesian flow rates versus time. It is apparent that artesian flow rates have significantly declined in both Percha and Las Animas Creek valleys. There are many factors that affect artesian flow, including climate conditions and recharge, and Caballo Reservoir stage. Dewatering by artesian well upward leakage and open flow, however, appears to be mainly responsible for the long-term decline in artesian flow rates (Appendix 8-H).

8.2.5 Baseline Hydrologic Consequences from Existing Operations and Reclamation

With the exception of the water supply wells, the existing mine facilities are located within the Copper Flat Mine Permit Area (Figures 8-26 and 8-37). For the Copper Flat Mine property, potential areas of impact include the tailing impoundment, waste rock piles, and the pit lake.

The mine permit facilities can be divided into two hydrogeologic segments: (1) waste rock piles and pit areas underlain by low permeability andesite and monzonite rocks, and (2) the tailing impoundment area underlain by alluvium and Santa Fe Group sediments. The baseline hydrologic consequences from existing operations and reclamation are currently being evaluated under the NMCC Stage 1 Abatement Plan proposal (INTERA, 2011), as amended (JSAI, 2011).

8.2.5.1 Pit Lake

The Quintana pit was excavated to a maximum depth corresponding to elevation 5,400 ft amsl. The current water level in the pit is about 5,440 ft (Table 8-18). The pre-mining groundwater level (without lake evaporation) was about 5,450 ft. The pit lake is a hydrologic sink with no discharges to groundwater (JSAI, 2011). The andesite rocks act as a hydraulic container for the more fractured monzonite rocks. Prior to the pit lake, groundwater discharged from the andesite and monzonite rocks to the alluvium along Grayback Arroyo. Between June and September 2011, evaporative effects decreased the pit lake elevation from 5,443.80 to 5,442.74 ft amsl.

The pit lake quality has been affected by minor influxes of pit wall seepage and concentration of dissolved constituents from evaporation. The pit lake has buffering capacity to maintain neutral pH (6.00 to 7.72), although high-precipitation periods and subsequent pit wall seepage can temporarily exceed the pit lake buffering capacity (Newcomer and Finch, 1993). Table 8-19 lists the constituents of concern (COC) identified from the pit lake chemistry data. The primary COCs are TDS, sulfate, and pH. Pit lake chemistry data from 2010 and 2011 demonstrate that the pit lake is not stratified, and that depth sampling is not necessary.

Piezometer nests GWQ96-22(A,B) and GWQ96-23(A,B) provide adequate monitoring of upgradient (GWQ96-22(A,B)) and downgradient (GWQ96-23(A,B)) groundwater quality conditions. Recently constructed nested piezometers GWQ11-24(A,B) and GWQ11-25(A,B) have not been sampled; however, they are proposed to be sampled in ongoing monitoring described in Section 8.2.7.

8.2.5.2 Waste Reclamation Pile

The waste rock piles are more permeable than the underlying rock, and infiltrated precipitation will drain off at the waste rock-bedrock interface. The runoff from the waste rock piles and the mill site fill will be intercepted by the existing mine pit and Grayback Arroyo. As a result, the waste rock and mill site fill may be contributing to increased TDS in downgradient surface water quality. Observed groundwater impacts are being addressed though the ongoing Stage 1 Abatement program (INTERA, 2011) as amended (JSAI, 2011).

Surface water quality sampling points SWQ-2 and SWQ-3 may provide an indication of water quality impacts from the waste rock piles. The primary COCs are sulfate and TDS. Metal concentrations in surface water samples have been low or not detectable, and pH has been above neutral in the 7 to 8 range (see Section 8.1.2.3.2).

Discharges to groundwater from potential waste rock pile leachate would occur via storm water runoff. The pit footprint will capture runoff from nearby waste rock piles to the north and northwest, and Grayback Arroyo will receive runoff from the waste rock piles east of the pit capture area. GWQ-3 is located in Grayback Arroyo and is the best location downstream of the waste rock pile for detecting discharges to groundwater from the waste rock piles.

The environmental geochemistry program described in Section 7, Geology, will be utilized to predict the geochemistry and acid rock drainage potential of the waste rock types reporting to the waste rock piles. The geochemical sample results along with the geochemical modeling will be coupled with the unsaturated flow modeling to evaluate the potential impact, if any. The baseline geochemistry program as described in Section 7.5 and the ongoing geochemical program currently underway to support the NMED groundwater discharge permit application will guide the engineering and monitoring requirements to ensure any potential impacts are detected, monitored, and mitigated.

8.2.5.3 Tailing Dam

The construction and operation of the tailing impoundment in the early 1980s created a groundwater mound and discharges of increased sulfate and TDS to groundwater. Preferential pathways for the seepage include the alluvium, fractured basalt, and coarser-grained Santa Fe Group sediments. Clay layers in the Santa Fe Group sediments act as vertical barriers to groundwater flow. The sulfate plume appears to be stable (the groundwater mound has not subsided) and downgradient migration is limited by a barrier boundary fault. The Stage 1 Abatement Plan (INTERA, 2011), as amended (JSAI, 2011) discusses this known groundwater impact and describes the activities to further characterize the extent of the limited sulfate plume.

8.2.5.4 Summary of Impacts

The existing pit lake has elevated constituents (Table 8-19), but the pit lake is a hydrologic sink because evaporative losses are greater than surface water and groundwater inflow (JSAI, 2011a). No impacts to groundwater from the pit lake have been observed. A groundwater TDS plume primarily composed of sulfate is observed below the tailing impoundment. The tailing impoundment sulfate plume appears to be stationary, and monitoring has not indicated significant migration. Evaluating the extent of potential impacts along Grayback Arroyo and directly downgradient of the tailing impoundment sulfate plume is proposed for the NMCC Stage 1 Abatement Plan.

8.2.6 Probable Hydrologic Consequences from Proposed Operations and Reclamation

Probable hydrologic consequences (PHCs) from the proposed Copper Flat Mine operations may occur from the proposed facilities within the Mine Permit Area and from pumping the water supply wells. The proposed mine pit, waste rock storage facilities, and part of the tailing storage facility would be located on the Animas Uplift. Figure 8-38 is a map showing the proposed mine facilities within the Mine Permit Area. For future mining operations, the surface runoff from the waste rock piles will be controlled as shown in the Mine Plan of Operations submitted to the BLM in June 2011 and currently under review by the NMED.

The PHCs from the proposed operations and reclamation will be evaluated using a groundwater flow model that represents the baseline study area. Historical and baseline data will be used for model calibration and verification. A summary of the groundwater modeling task is as follows:

- Develop the conceptual hydrogeologic framework as the basis for model design.
- Simulate the local flow system including groundwater units, surface channels, and the flow of recharge from the mountains to the Rio Grande.

- Calibrate the groundwater flow model to steady state and historical transient data sets and available pumping test data.
- Project pit dewatering rates.
- Simulate realistic well field pumping rates based on projected dewatering rates and process water balance (for evaluation of operational needs and environmental impacts).
- Project groundwater drawdown and streamflow depletion resulting from dewatering and water supply pumping.
- Project post-mining recovery of pit water level and pit lake water balance.
- Produce a detailed pit lake water balance for use in geochemical evaluation.
- Project long-term and permanent drawdown and changes to basin water balance, due to pit lake evaporation.
- Track any outflows from the pit and groundwater flows downgradient of the tailing impoundment, waste rock facilities, and low-grade stockpile for potential water quality evaluation.

PHCs will be evaluated using a regional groundwater flow model that encompasses the area of potential impacts from the proposed mine facilities and supply wells. The groundwater flow model extent and grid are shown on Figure 8-39.

8.2.6.1 Crystalline Bedrock Aquifer

The PHC to the crystalline bedrock aquifer from the proposed mining operation would be related to the expansion of the mine pit to the configuration shown on Figure 8-38 and subsequent dewatering of the pit area.

Hydraulic conductivity values were derived from slug tests performed on wells GWQ96-22 and GWQ96-23 (SRK, 1997b). The slug test analysis estimated an extremely low range in hydraulic conductivity of 0.00003 to 0.003 ft/day for the unfractured andesite and quartz monzonite rocks. NMCC (in progress) has evaluated injection tests performed on GWQ-5R, GWQ11-24, and GWQ11-25. A summary of the hydraulic conductivity estimates is presented as Table 8-20.

A representative range of effective bulk hydraulic conductivity for the fractured rock surrounding the pit lake is about 0.05 to 0.1 ft/day. The andesite rocks appear to have an order of magnitude lower hydraulic conductivity than the fractured monzonite as evidenced by the slow recovery of GWQ-5R, which was dry upon well completion on September 6, 2011, but has recovered to an elevation of 5,311 ft amsl on September 29, 2011 (or approximately 23 ft of recovery).

The low permeability andesite rocks will limit dewatering rates and limit the expansion of the drawdown cone to where the majority of the aquifer dewatering will occur within the Mine Permit Area. The environmental geochemistry program described in Section 7, Geology, will be utilized to determine the impacts to the pit lake water quality. The geochemical sample results along with the geochemical modeling will be coupled with the groundwater flow modeling to evaluate the potential impact, if any, to the future pit lake water quality (Section 7.5)

8.2.6.2 Santa Fe Group Aquifer System

The PHC to the Santa Fe Group aquifer from the proposed mining operation would be related to the design of the tailing facility (NMCC, 2010) and its potential for seepage, as well as potential aquifer dewatering from pumping the water supply wells. The proposed tailing facility will be designed using modern technology that limits the potential for seepage and maximizes the recycling of water (conservation).

Pumping and specific capacity tests were performed on mine supply wells MW-4 (Water Development Corporation, 1975), GWQ-1 (Water Development Corporation, 1980), GWQ-7 (W.K. Summers & Associates, 1981), and GWQ-9 (Water Development Corporation, 1980). All of these wells are in the vicinity of the tailing impoundment. A summary of the hydraulic properties derived from the wells tested in the tailing impoundment area is listed in Table 8-16.

Adrian Brown Consultants (1996d) performed a 76-hour constant rate pumping test on GWQ94-17 located below the tailing impoundment. Neighboring monitoring wells were used as observation wells during the pumping test. The pumping well GWQ94-17 was pumped at a rate of 23 gpm. The water levels in the pumping and observation wells never fully recovered to the pre-pumping level, indicating boundary effects from dewatering the groundwater mound observed beneath the tailing dam. Furthermore, the pumping test data confirmed the clay zones observed in the upper Santa Fe Group sediments (Figures 8-17 and 8-18) act as vertical barriers to groundwater flow.

Transmissivity of the Santa Fe Group aquifer derived from pumping tests of the NMCC water supply wells (Green and Halpenny, 1976) averages about 20,000 ft^2/day. PW-2 was pumped at 2,020 gpm for 72 hours in January 1976, and water level drawdown and recovery was measured at observation wells PW-1 and MW-5 (Figure 8-27). Aquifer transmissivity is estimated at about 20,000 ft^2/day by matching the solution of Theis (1938) to measured drawdown and recovery at PW-1 and MW-5, and to measured recovery at the pumping well PW-2. PW-1 was pumped at 1,500 gpm for 70 hours in December 1975, and water level drawdown and recovery was measured at observation well MW-5. Aquifer transmissivity of about 17,000 ft^2/day is estimated by matching the solution of Theis (1938) to measured drawdown and recovery at MW-5, and to measured recovery at the pumping well PW-1.

The amount of potential aquifer dewatering from pumping the proposed water supply wells will depend on mining operation water demand, distribution of pumping, success with water reuse, and duration of pumping. In addition to the primary water supply wells shown on Figure 8-26, NMCC has several supply wells located in the Mine Permit Area. Nevertheless, groundwater from aquifer storage will be required for proposed mine operations and aquifer drawdown is expected to occur. However, in contrast to other water users, pumping for mine operations is for a relatively short time period. The potential effects from groundwater pumping will be evaluated by using the calibrated groundwater flow model. Data from pumping tests performed on the production wells will be used for model calibration.

8.2.6.3 Quaternary Alluvial Aquifer System

The PHC to the alluvial aquifer from the proposed mining operation would be related to pumping water supply wells. In places, the alluvial aquifer is perched above the Santa Fe Group aquifer. No hydrologic impacts are expected where the two aquifers are hydraulically disconnected. The degree of aquifer drawdown in the alluvial aquifer from proposed mining operations will be evaluated using a regional groundwater flow model calibrated to available data representative of the alluvial aquifer and surrounding regional groundwater system. Historical and baseline data are sufficient for model calibration of the alluvial aquifer system.

8.2.7 Ongoing Groundwater Monitoring

Ongoing groundwater monitoring, beyond baseline data collection requirements, will occur as part of the development of the regional groundwater flow model in support of the mine-permitting process and for the Stage 1 Abatement Plan. Pumping and observation wells for the proposed production well pumping test are shown on Figure 8-40. A summary of the proposed monitoring for the Stage 1 Abatement Plan is provided in Table 8-21, and monitoring points are shown on Figure 8-41. One to two additional monitoring wells below the tailing impoundment are proposed for defining the downgradient extent of the sulfate plume.

8.2.7.1 Crystalline Bedrock Aquifer

Proposed groundwater monitoring for the crystalline bedrock aquifer includes collection of water level and water quality data in the Mine Permit Area for the Stage 1 Abatement Plan (Table 8-21).

8.2.7.2 Santa Fe Group Aquifer System

Proposed groundwater monitoring for the Santa Fe Group aquifer includes collection of water level and water quality data in the Mine Permit Area for the Stage 1 Abatement Plan (Table 8-21), and possibly water level monitoring .

NMCC is planning a large-scale pumping test on the mine supply wells. The proposed pumping and observation wells are shown on Figure 8-40. In January 2012, NMCC drilled and installed another well screened the artesian aquifer in Las Animas Creek as an observation well for the production well test. The new artesian well is named GWQ11-27 and is screened from 220 to 320 ft below ground surface. Its location is presented on Figure 8-40. The assessment of aquifer properties will be further refined based on (1) hydrogeologic investigations and aquifer testing planned to more fully characterize hydraulic properties of the bedrock around the existing and proposed pit, and (2) aquifer testing planned to more fully characterize hydraulic properties around the existing production wells, including vertical resistance to flow. General plans and objectives for the planned hydrogeological investigations and aquifer testing were presented by NMCC on September 19, 2011 to the State Agencies including representatives of the Mines and Minerals Division; New Mexico Environment Department, Groundwater Bureau, Mining Compliance Section; and Office of the State Engineer. The evaluation of aquifer properties will be further refined during development of the numerical groundwater flow model shown on Figure 8-39.

8.2.7.3 Quaternary Alluvial Aquifer

NMCC has an observation well (MW-11) in the alluvial aquifer along Las Animas Creek (Figure 8-27). MW-11 will be used as an observation well for the proposed large-scale pumping test. Water level monitoring would include pre-pumping, pumping, and recovery conditions.

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Tables

Table 8-1
Historical Flow and Water Quality Parameters

Location	Date	Description	Flow (cfs)	pH	Conductivity (µS/cm)	Temperature (°C)
Las Animas Creek	1967	Upper Reach	1.0 – 2.0	NM	NM	NM
Las Animas Creek	1967	Middle Reach	1.0 – 1.5	NM	NM	NM
Las Animas Creek	1996	LAC-E	0.546	8.2	400	17
Percha Box	1996	1200’ u/s of Box entry	Dry	NA	NA	NA
Percha Box	1996	700’ u/s of Box entry	0	8.1	600	32
Percha Box	1996	400’ u/s of Box entry	Dry	NA	NA	NA
Percha Box	1996	Box entry	0.265	7.7	500	23
Percha Box	1996	1500’ d/s of Box entry	0.446	8.2	500	23
Percha Box	1996	Box exit	1.02	8.4	400	25
Percha Box	1996	2400’ d/s of Box exit	0	9.3	400	32
Percha Box	1996	2500’ d/s of Box exit	Dry	NA	NA	NA
Percha Box	1996	5000’ d/s of Box exit	0.394	9.0	400	28
Percha Box	1996	5400’ d/s of Box exit	0	9.0	400	32
Percha Box	1996	5500’ d/s of Box exit	Dry	NA	NA	NA
Percha Box	1996	3 miles d/s of Box exit	Dry	NA	NA	NA
Percha Box	1996	5 miles d/s of Box exit	Dry	NA	NA	NA
Grayback Arroyo	4/1/93	SWQ-1	1 – 2	8.3	1150	NM
Grayback Arroyo	5/7/93	SWQ-1	Dry	NA	NA	NA
Grayback Arroyo	3/31/93	SWQ-2	< 1	7.7	3150	NM
Grayback Arroyo	3/31/93	SWQ-3	12.5	8.1	3330	NM
Spring/Seep	4/1/93	BG	1 – 2	8.2	1090	NM

Location	**Date**	**Description**	**Flow (cfs)**	**pH**	**Conductivity (µS/cm)**	**Temperature (°C)**
Spring/Seep	5/7/93	BG	Dry	NA	NA	NA
Spring/Seep	4/1/93	BG-2	< 1	8.2	1030	NM
Spring/Seep	5/7/93	BG-2	< 1	NM	NM	NM
Spring/Seep	1997	PW-2	NM	8.16	NM	NM
Spring/Seep	1967	WS	0.8	NM	NM	81.5
Spring/Seep	4/2/93	WS	0.00735	8.5	1980	NM

Notes:

Box = Percha Box
u/s = upstream
d/s = downstream
NA = no water present for sampling
NM = parameter not measured or not available

Table 8-2

Las Animas Creek Stream Flow Calculations from 1996 through 1998 near LAC-E (ABC, 1998)

Date	Flow Rate Cubic Feet per Second (cfs)
4/10/1996	No Flow
5/30/1996	No Flow
7/3/1996	No Flow
9/5/1996	No Flow
10/2/1996	No Flow
12/17/1996	No Flow
1/15/1997	11.2
2/12/1997	13.9
3/18/1997	37.7
4/21/1997	20.6
5/19/1997	8.3
6/9/1997	0.9
7/1/1997	No Flow
8/15/1997	22.7
9/16/1997	No Flow
10/30/1997	No Flow
1/12/1998	60.3
2/19/1998	12.7
3/19/1998	51.8

Table 8-3

Las Animas Creek Stream Flow Calculations Collected on June 28, 2011

Site Name	Discharge (cfs)	Approximate Distance Downstream from Start of Flow (ft)
LAC-1	0.21	450
LAC-2	0.37	920
LAC-3	0.05	2,300
LAC-4	0.02	3,030
End of Flow	0	3,530
Start of Flow	0	5,200
LAC-5	0.02	5,830
LAC-6	0.02	6,580
End of Flow	0	6,680

Table 8-4

Seepage Rates for the Measured Reaches of Las Animas Creek (June 2011)

Reach	Seepage Rate (cfs)	Gaining or Losing Reach
SoF to LAC-1	0.21	Gaining
LAC-1 to LAC-2	0.16	Gaining
LAC-2 to LAC-3	-0.32	Losing
LAC-3 to LAC-4	-0.03	Losing
LAC-4 to Dry	-0.02	Losing
Dry to LAC-5	0.02	Gaining
LAC-5 to LAC-6	0.002	Gaining
LAC-6 to End	-0.02	Losing

Table 8-5

Percha Creek Stream Flow Calculations Collected on June 29 and 30, 2011

Site Name	Discharge (cfs)	Approximate Distance Downstream from Start of Flow (ft)
PC-1	0.24	400
PC-2	0.18	1,395
PC-3	0.13	2,080
PC-4	0.19	3,235
PC-5	0.01	4,010
PC-6	0.66	4,220
PC-7	0.88	4,370
PC-8	0.06	7,140
End of Flow	0	7,940
Start of Flow	0	8,835
PC-9	0.16	8,935
PC-10	0.04	9,220
End of Flow	0	9,420
Start of Flow	0	13,885
PC-11	0.15	14,385
PC-12	0.23	17,800
PC-13	0.08	19,365
PC-14	0.33	20,765
PC-15	0.34	21,875
PC-16	0.03	24,105
End of Flow	0	24,605

Table 8-6

Seepage Rates for the Measured Reaches of Percha Creek (June 2011)

Reach	Seepage Rate (cfs)	Gaining or Losing Reach
SoF to PC-1	0.24	Gaining
PC-1 to PC-2	-0.06	Losing
PC-2 to PC-3	-0.05	Losing
PC-3 to PC-4	0.05	Gaining
PC-4 to PC-5	-0.18	Losing
PC-6	0.66	Inflow
PC-5 to PC-7	0.87	Gaining
PC-7 to PC-8	-0.82	Losing
PC-8 to Dry	-0.06	Losing
Dry to PC-9	0.16	Gaining
PC-9 to PC-10	-0.12	Losing
PC-10 to Dry	-0.04	Losing
Dry to PC-11	0.15	Gaining
PC-11 to PC-12	0.08	Gaining
PC-12 to PC-13	-0.15	Losing
PC-13 to PC-14	0.25	Gaining
PC-14 to PC-15	0.01	Gaining
PC-15 to PC-16	<0	Losing
PC-16 to End	-0.02	Losing

Table 8-7
Pit Lake Water Depths

Season	Depth of Water (ft)
September 2010	34.6
January 2011	35.8
April 2011	31.6
July 2011	28.9

Table 8-8

Geologic Units and Their Characteristics

Geologic Unit	Description	Thickness (ft)	Range in Estimated Hydraulic Conductivity (ft/day)
Alluvium [1]	Sand and Gravel in Grayback Arroyo	< 50	10 to 100
Colluvium [2]	Fan Deposits of Poorly Sorted Angular Sand and Gravel	< 50	1 to 10
Santa Fe Group Sediments [3]	Highly Stratified Gravel, Sand, Silt, and Clay	1 to 2,000	0.01 to 10
Andesite [4]	Fine-Grained Porphyritic Rock with Plagioclase Phenocrysts	> 3,000	<0.01
Monzonite [4]	Quartz Monzonite with Fracture Controlled Sulfide Mineralization; Other Common Minerals Include Magnetite, Fluorite, Calcite, and Apatite	> 3,000	0.01 to 0.1

[1] - Dunn (1982); Finch et al. (2008)
[2] - Hedlund (1975)
[3] - Seager et al. (1982); Hawley and Kennedy (2004)
[4] - Dunn (1982); SRK (1997); JSAI (work in progress)

Table 8-9

Summary of Water Level Measurements

Well Name	Year Drilled	Diameter (inches)	Total Depth (ft bmp)	Top of Screen (ft bgl)	Bottom of Screen (ft bgl)	Elevation of Measuring Point (ft amsl)	Aquifer	Date of Water Level Measurement	Depth to Water (ft bmp)	Water Level Elevation (ft amsl)
Animas Station 8	NA	NA	NA	NA	NA	4614.8	Qal	5/4/2011	12.67	4602.13
Animas Station 8	NA	NA	NA	NA	NA	4614.8	Qal	9/27/2010	10.78	4604.02
Evans	NA	6.625	193	NA	NA	5,192.0	Other	9/29/2010	170.18	5021.82
GWQ-5R*	2011	4.0	120	80	120	5412.178	CB	9/29/2011	98.91	5313.27
GWQ-5R*	2011	4.0	120	80	120	5412.178	CB	10/20/2011	82.12	5330.06
GWQ-5R*	2011	4.0	120	80	120	5412.178	CB	11/1/2011	73.36	5338.82
GWQ-5R*	2011	4.0	120	80	120	5412.178	CB	12/8/2011	54.07	5358.11
GWQ-10	1981	3.0	121	NA	NA	5213.285	SF	1/27/2010	22.18	5191.11
GWQ-10	1981	3.0	121	NA	NA	5213.285	SF	6/24/2010	22.98	5190.31
GWQ-10	1981	3.0	121	NA	NA	5213.285	SF	9/27/2010	23.19	5190.10
GWQ-11	1981	3.0	80	52.00	72.00	5196.42	SF	6/24/2010	19.68	5176.74
GWQ-11	1981	3.0	80	52.00	72.00	5196.42	SF	1/27/2010	19.49	5176.93
GWQ-11	1981	3.0	80	52.00	72.00	5196.42	SF	9/27/2010	19.91	5176.51
GWQ-11	1981	3.0	80	52.00	72.00	5196.42	SF	5/4/2011	20.02	5176.40
GWQ-12	1981	3.0	130	NA	NA	5237.075	SF	9/28/2010	79.51	5157.57
GWQ-12	1981	3.0	130	NA	NA	5237.075	SF	6/24/2010	79.98	5157.10
GWQ-12	1981	3.0	130	NA	NA	5237.075	SF	1/27/2010	79.3	5157.78
GWQ-12	1981	3.0	130	NA	NA	5237.075	SF	5/4/2011	79.71	5157.37
GWQ-12	1981	3.0	130	NA	NA	5237.075	SF	12/8/2011	79.83	5157.25
GWQ94-13	1994	4.0	112	73.95	104.50	5200.47	SF	9/27/2010	12.43	5188.04
GWQ94-13	1994	4.0	112	73.95	104.50	5200.47	SF	6/24/2010	12.33	5188.14
GWQ94-13	1994	4.0	112	73.95	104.50	5200.47	SF	1/27/2010	11.63	5188.84
GWQ94-13	1994	4.0	112	73.95	104.50	5200.47	SF	5/4/2011	13.02	5187.45
GWQ94-14	1994	4.0	158.8	127.50	157.50	5192.69	SF	9/27/2010	5.77	5186.92
GWQ94-14	1994	4.0	158.8	127.50	157.50	5192.69	SF	1/27/2010	5.04	5187.65
GWQ94-14	1994	4.0	158.8	127.50	157.50	5192.69	SF	6/24/2010	5.46	5187.23

Well Name	Year Drilled	Diameter (inches)	Total Depth (ft bmp)	Top of Screen (ft bgl)	Bottom of Screen (ft bgl)	Elevation of Measuring Point (ft amsl)	Aquifer	Date of Water Level Measurement	Depth to Water (ft bmp)	Water Level Elevation (ft amsl)
GWQ94-14	1994	4.0	158.8	127.50	157.50	5192.69	SF	10/5/2010	5.77	5186.92
GWQ94-14	1994	4.0	158.8	127.50	157.50	5192.69	SF	5/4/2011	6.42	5186.27
GWQ94-15	1994	4.0	148.5	112.00	142.00	5183.07	SF	6/24/2010	4.48	5178.59
GWQ94-15	1994	4.0	148.5	112.00	142.00	5183.07	SF	9/27/2010	4	5179.07
GWQ94-15	1994	4.0	148.5	112.00	142.00	5183.07	SF	1/27/2010	3.73	5179.34
GWQ94-15	1994	4.0	148.5	112.00	142.00	5183.07	SF	5/4/2011	4.92	5178.15
GWQ94-16	1994	4.0	45.75	25.00	45.00	5197.41	SF	5/4/2011	21.26	5176.15
GWQ94-16	1994	4.0	45.75	25.00	45.00	5197.41	SF	1/29/2010	20.71	5176.70
GWQ94-16	1994	4.0	45.75	25.00	45.00	5197.41	SF	9/27/2010	21.13	5176.28
GWQ94-16	1994	4.0	45.75	25.00	45.00	5197.41	SF	6/24/2010	20.9	5176.51
GWQ94-17	1994	4.0	150.68	120.00	150.00	5198.13	SF	1/27/2010	9.35	5188.78
GWQ94-17	1994	4.0	150.68	120.00	150.00	5198.13	SF	6/24/2010	10.04	5188.09
GWQ94-17	1994	4.0	150.68	120.00	150.00	5198.13	SF	9/27/2010	10.11	5188.02
GWQ94-18	1994	4.0	60	10.00	50.00	5194.83	SF	6/24/2010	Dry	Dry
GWQ94-18	1994	4.0	60	10.00	50.00	5194.83	SF	9/27/2010	Dry	Dry
GWQ94-18	1994	4.0	60	10.00	50.00	5194.83	SF	1/27/2010	Dry	Dry
GWQ94-19	1994	4.0	54	10.00	50.00	5203.36	SF	6/24/2010	52.26	5151.10
GWQ94-19	1994	4.0	54	10.00	50.00	5203.36	SF	9/27/2010	52.22	5151.14
GWQ94-19	1994	4.0	54	10.00	50.00	5203.36	SF	1/27/2010	52.27	5151.09
GWQ94-20	1994	4.0	340	288.00	338.00	5203.49	SF	1/27/2010	18.05	5185.44
GWQ94-21A*	1994	2.0	263	213.00	263.00	5192.71	SF	12/8/2011	8.36	5184.35
GWQ94-21B*	1994	2.0	315	285.00	315.00	5192.22	SF	12/8/2011	8.05	5184.17
GWQ96-22A	1996	2.0	231.71	174.00	244.00	5596.17	CB	9/27/2010	48.59	5547.58
GWQ96-22A	1996	2.0	231.71	174.00	244.00	5596.17	CB	6/24/2010	48.52	5547.65
GWQ96-22A	1996	2.0	231.71	174.00	244.00	5596.17	CB	1/28/2010	53.69	5542.48
GWQ96-22A*	1996	2.0	231.71	174.00	244.00	5596.17	CB	6/30/2011	53.62	5542.55
GWQ96-22A*	1996	2.0	231.71	174.00	244.00	5596.17	CB	8/28/2011	54.63	5541.54
GWQ96-22A*	1996	2.0	231.71	174.00	244.00	5596.17	CB	9/8/2011	54.9	5541.27
GWQ96-22B	1996	2.0	420	340.00	380.00	5595.95	CB	10/7/2010	48.3	5547.65
GWQ96-22B*	1996	2.0	420	340.00	380.00	5595.95	CB	6/30/2011	52.95	5543.00

Well Name	Year Drilled	Diameter (inches)	Total Depth (ft bmp)	Top of Screen (ft bgl)	Bottom of Screen (ft bgl)	Elevation of Measuring Point (ft amsl)	Aquifer	Date of Water Level Measurement	Depth to Water (ft bmp)	Water Level Elevation (ft amsl)
GWQ96-22B*	1996	2.0	420	340.00	380.00	5595.95	CB	8/28/2011	54.59	5541.36
GWQ96-22B*	1996	2.0	420	340.00	380.00	5595.95	CB	9/8/2011	54.76	5541.19
GWQ96-23A	1996	2.0	102.24	50.00	100.00	5489.84	CB	6/24/2010	41.97	5447.87
GWQ96-23A	1996	2.0	102.24	50.00	100.00	5489.84	CB	10/6/2010	41.8	5448.04
GWQ96-23A	1996	2.0	102.24	50.00	100.00	5489.84	CB	1/28/2010	42.15	5447.69
GWQ96-23A	1996	2.0	102.24	50.00	100.00	5489.84	CB	5/4/2011	42.02	5447.82
GWQ96-23A	1996	2.0	102.24	50.00	100.00	5489.84	CB	9/27/2010	41.8	5448.04
GWQ96-23A*	1996	2.0	102.24	50.00	100.00	5489.84	CB	6/30/2011	40.32	5449.52
GWQ96-23A*	1996	2.0	102.24	50.00	100.00	5489.84	CB	8/28/2011	40.71	5449.13
GWQ96-23A*	1996	2.0	102.24	50.00	100.00	5489.84	CB	9/8/2011	40.74	5449.10
GWQ96-23B	1996	2.0	250.9	150.00	250.00	5489.70	CB	5/4/2011	41.99	5447.71
GWQ96-23B	1996	2.0	250.9	150.00	250.00	5489.70	CB	10/6/2010	41.72	5447.98
GWQ96-23B*	1996	2.0	250.9	150.00	250.00	5489.70	CB	6/30/2011	40.37	5449.33
GWQ96-23B*	1996	2.0	250.9	150.00	250.00	5489.70	CB	8/28/2011	40.87	5448.83
GWQ96-23B*	1996	2.0	250.9	150.00	250.00	5489.70	CB	9/8/2011	41.06	5448.64
GWQ11-24A*	2011	2.0	90	60.00	90.00	5517.37	CB	8/28/2011	52.74	5464.63
GWQ11-24A*	2011	2.0	90	60.00	90.00	5517.37	CB	9/7/2011	58.8	5458.57
GWQ11-24A*	2011	2.0	90	60.00	90.00	5517.37	CB	10/20/2011	55.92	5461.45
GWQ11-24A*	2011	2.0	90	60.00	90.00	5517.37	CB	11/1/2011	55.91	5461.46
GWQ11-24B*	2011	2.0	250	230.00	250.00	5517.26	CB	8/28/2011	59.57	5457.69
GWQ11-24B*	2011	2.0	250	230.00	250.00	5517.26	CB	9/7/2011	60.15	5457.11
GWQ11-24B*	2011	2.0	250	230.00	250.00	5517.26	CB	10/20/2011	59.99	5457.27
GWQ11-24B*	2011	2.0	250	230.00	250.00	5517.26	CB	11/1/2011	59.95	5457.31
GWQ11-25A*	2011	2.0	100	70.00	100.00	5533.60	CB	8/28/2011	50.91	5482.69
GWQ11-25A*	2011	2.0	100	70.00	100.00	5533.60	CB	9/7/2011	57.41	5476.19
GWQ11-25A*	2011	2.0	100	70.00	100.00	5533.60	CB	10/20/2011	62.15	5471.45
GWQ11-25A*	2011	2.0	100	70.00	100.00	5533.60	CB	11/1/2011	63.12	5470.48
GWQ11-25B*	2011	2.0	242	222.00	242.00	5533.41	CB	8/28/2011	62.9	5470.51
GWQ11-25B*	2011	2.0	242	222.00	242.00	5533.41	CB	9/7/2011	66.22	5467.19
GWQ11-25B*	2011	2.0	242	222.00	242.00	5533.41	CB	10/20/2011	67.25	5466.16

Well Name	Year Drilled	Diameter (inches)	Total Depth (ft bmp)	Top of Screen (ft bgl)	Bottom of Screen (ft bgl)	Elevation of Measuring Point (ft amsl)	Aquifer	Date of Water Level Measurement	Depth to Water (ft bmp)	Water Level Elevation (ft amsl)
GWQ11-25B*	2011	2.0	242	222.00	242.00	5533.41	CB	11/1/2011	67.7	5465.71
Highway Well	1934	0.0	NA	NA	NA	5210.962	SF	1/27/2010	22.1	5188.86
Highway Well	1934	0.0	NA	NA	NA	5210.962	SF	5/4/2011	22.88	5188.08
Highway Well West	NA	NA	NA	NA	NA	5210.624	SF	5/4/2011	98.74	5111.88
IW-1	1982	4.0	49	NA	49.00	5198.99	SF	6/24/2010	36.11	5162.88
IW-1	1982	4.0	49	NA	49.00	5198.99	SF	9/27/2010	Dry	Dry
IW-2	1982	4.0	46.45	NA	45.00	5208.01	SF	5/4/2011	39.01	5169.00
IW-2	1982	4.0	46.45	NA	45.00	5208.01	SF	1/31/2010	37.41	5170.60
IW-2	1982	4.0	46.45	NA	45.00	5208.01	SF	9/27/2010	38.63	5169.38
IW-2	1982	4.0	46.45	NA	45.00	5208.01	SF	6/24/2010	37.82	5170.19
IW-3	1982	4.0	45	NA	45.00	5213.17	SF	9/27/2010	Dry	Dry
IW-3	1982	4.0	45	NA	45.00	5213.17	SF	1/31/2010	Dry	Dry
IW-3	1982	4.0	45	NA	45.00	5213.17	SF	6/24/2010	Dry	Dry
Ladder Airstrip	NA	NA	NA	NA	NA	4998.231	SF	9/29/2010	285.31	4712.92
LRG 04158	1955	NA	150	NA	NA	5533.066	CB	11/11/2010	47.01	5486.06
LRG 04159	2002	NA	200	160.00	200.00	5719.69	CB	11/4/2010	13.56	5706.13
MW-2	1975	8.0	1500	133	1500	5007.39	SF	5/12/2011	154.73	4852.66
MW-4	1975	6.0	2000	123	1500	5125.0	SF	5/13/2011	77.14	5047.86
MW-6	1975	6.0	1112	310.00	1000.00	4768.33	SF	12/9/2011	214.45	4553.88
MW-8	1975	6.0	1004	366.00	1000.00	5023.65	SF	10/5/2010	357.8	4665.85
MW-9	1994	4.0	252.2	200.00	250.00	4454.32	SF	9/27/2010	74.6	4379.72
MW-9	1994	4.0	252.2	200.00	250.00	4454.32	SF	5/4/2011	74.64	4379.68
MW-9	1994	4.0	252.2	200.00	250.00	4454.32	SF	7/7/2010	74.88	4379.44
MW-9*	1994	4.0	252.2	200.00	250.00	4454.32	SF	12/8/2011	75.1	4379.22
MW-10	1994	4.0	125	80	120	4453.672	SF	5/4/2011	72.56	4381.11
MW-10*	1994	4.0	125	80	120	4453.672	SF	6/28/2011	73.30	4380.37
MW-10*	1994	4.0	125	80	120	4453.672	SF	12/8/2011	73.31	4380.36
MW-11	1994	4.0	65	12.00	32.00	4454.00	Qal	9/27/2010	12.06	4441.94
MW-11	1994	4.0	65	12.00	32.00	4454.00	Qal	7/7/2010	11.77	4442.23
MW-11	1994	4.0	65	12.00	32.00	4454.00	Qal	5/4/2011	12.46	4441.54

Well Name	Year Drilled	Diameter (inches)	Total Depth (ft bmp)	Top of Screen (ft bgl)	Bottom of Screen (ft bgl)	Elevation of Measuring Point (ft amsl)	Aquifer	Date of Water Level Measurement	Depth to Water (ft bmp)	Water Level Elevation (ft amsl)
MW-11*	1994	4.0	65	12.00	32.00	4454.00	Qal	6/28/2011	13.95	4440.05
MW-11*	1994	4.0	65	12.00	32.00	4454.00	Qal	12/8/2011	14.17	4439.83
NP-1	1981	2.0	105.99	NA	106.00	5188.75	SF	5/4/2011	30.8	5157.95
NP-1	1981	2.0	105.99	NA	106.00	5188.75	SF	6/24/2010	31.15	5157.60
NP-1	1981	2.0	105.99	NA	106.00	5188.75	SF	9/27/2010	29.7	5159.05
NP-1	1981	2.0	105.99	NA	106.00	5188.75	SF	1/31/2010	30.36	5158.39
NP-2	1981	2.0	98.25	NA	110.00	5192.54	SF	5/4/2011	32.92	5159.62
NP-2	1981	2.0	98.25	NA	110.00	5192.54	SF	6/24/2010	33.23	5159.31
NP-2	1981	2.0	98.25	NA	110.00	5192.54	SF	1/31/2010	32.27	5160.27
NP-2	1981	2.0	98.25	NA	110.00	5192.54	SF	9/27/2010	31.49	5161.05
NP-3	1981	4.0	79.38	80.00	95.00	5199.73	SF	6/24/2010	11.4	5188.33
NP-3	1981	4.0	79.38	80.00	95.00	5199.73	SF	5/4/2011	12.02	5187.71
NP-3	1981	4.0	79.38	80.00	95.00	5199.73	SF	9/27/2010	11.45	5188.28
NP-4	1981	4.0	102.2	97.00	112.00	5225.73	SF	5/4/2011	35.22	5190.51
NP-4	1981	4.0	102.2	97.00	112.00	5225.73	SF	6/24/2010	34.35	5191.38
NP-4	1981	4.0	102.2	97.00	112.00	5225.73	SF	9/27/2010	34.61	5191.12
NP-4	1981	4.0	102.2	97.00	112.00	5225.73	SF	1/31/2010	33.51	5192.22
NP-5	1981	2.0	44	24.00	39.00	5198.81	Qb	5/4/2011	22.63	5176.18
NP-5	1981	2.0	44	24.00	39.00	5198.81	Qb	9/27/2010	22.56	5176.25
NP-5	1981	2.0	44	24.00	39.00	5198.81	Qb	6/24/2010	22.28	5176.53
Pague	1936	NA	26	NA	NA	5550.814	CB	5/4/2011	11.69	5539.12
PW-1*	1975	16.0	960	368	951	4707.673	SF	12/8/2011	328.25	4379.42
PW-2*	1976	16.0	1005	367	995	4685.703	SF	12/8/2011	306.8	4378.90
PW-3*	1976	16.0	970	380	965	4731.053	SF	12/8/2011	350.6	4380.45
PW-4*	1980	16.0	957	354	954	4668.966	SF	12/8/2011	289.38	4379.59
UNKNOWN	NA	4.0	61.32	NA	NA	5100.584	Qal	5/4/2011	32.76	5067.82

Notes:
Qal = Quaternary aquifer; Qb = Quaternary basalt; SF = Santa Fe Group aquifer system; CB = Crystalline bedrock aquifer
NA = not available; Dry = well was dry
*Well gauged by NMCC after fourth quarter of baseline monitoring (May 2011).

Table 8-10

Summary of Quarterly Groundwater Quality Samples Collected by Well

Quarter	Collection Date	Well Name	Aquifer
Q1	1/29/2010	GWQ94-14	SF
	1/29/2010	GWQ94-15	SF
	1/30/2010	GWQ96-22A	CB
	1/30/2010	GWQ96-23A	CB
	1/31/2010	IW-2	SF
	1/31/2010	NP-1	SF
	1/31/2010	NP-2	SF
	1/31/2010	NP-4	SF
		Number of Water Quality Samples Collected in Q1	***8***
Q2	7/2/2010	GWQ94-13	SF
	6/29/2010	GWQ94-14	SF
	6/29/2010	GWQ94-15	SF
	6/29/2010	GWQ94-16	SF
	7/6/2010	GWQ94-17	SF
	7/1/2010	GWQ96-22A	CB
	7/1/2010	GWQ96-23A	CB
	6/29/2010	IW-2	SF
	7/8/2010	MW-6	SF
	7/7/2010	MW-9	SF
	7/7/2010	MW-11	Qal
	6/28/2010	NP-1	SF
	6/28/2010	NP-2	SF
	7/8/2010	NP-3	SF
	7/2/2010	NP-4	SF
	6/28/2010	NP-5	Qb
		Number of Water Quality Samples Collected in Q2	***16***
Q3	11/5/2010	GWQ-4	CB
	10/5/2010	GWQ94-13	SF
	10/5/2010	GWQ94-14	SF
	10/1/2010	GWQ94-15	SF
	9/30/2010	GWQ94-16	SF
	10/7/2010	GWQ96-22A	CB
	10/7/2010	GWQ96-22B	CB
	10/6/2010	GWQ96-23A	CB
	10/6/2010	GWQ96-23B	CB
	9/30/2010	IW-2	SF
	11/4/2010	LRG 04159	CB
	9/28/2010	MW-1	SF
	9/28/2010	MW-2	SF
	9/27/2010	MW-6	SF
	10/12/2010	MW-8	SF

Quarter	Collection Date	Well Name	Aquifer
	10/4/2010	MW-9	SF
	10/4/2010	MW-11	Qal
	10/5/2010	NP-1	SF
	10/7/2010	NP-3	SF
	9/30/2010	NP-5	Qb
		Number of Water Quality Samples Collected in Q3	***20***
Q4	5/11/2011	GWQ94-13	SF
	5/13/2011	GWQ94-14	SF
	5/13/2011	GWQ94-15	SF
	5/10/2011	GWQ94-16	SF
	5/12/2011	GWQ96-23A	CB
	5/12/2011	GWQ96-23B	CB
	5/9/2011	IW-2	SF
	5/11/2011	MW-9	SF
	5/10/2011	MW-11	Qal
	5/11/2011	NP-3	SF
	5/10/2011	NP-5	Qb
		Number of Water Quality Samples Collected in Q4	***11***
		Total Number of Wells Sampled	**55**

Notes:

Qal = Quaternary aquifer
Qb = Quaternary basalt
SF = Santa Fe Group aquifer system
CB = Crystalline bedrock aquifer

Table 8-11
Groundwater Quality Analytical Results

Well Name	Collection Date	Alkalinity, Total (As CaCO3) (mg/L CaCO3)	Aluminum (mg/L)	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Bicarbonate (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Calcium (mg/L)	Carbonate (mg/L)	Chloride (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Cyanide (mg/L)	Fluoride (mg/L)	Iron (mg/L)	Lead (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)	Nickel (mg/L)
15.6.31.431	6/4/1976							228	<0.1		117		14.3					0.52	0.002		25.6	0.003			
	4/9/1981		<0.1		<0.005	<0.1		285.7	0.025	<0.001			22	<0.005		0.7		0.58	<0.25	<0.005		<0.05		0.005	<0.01
GWQ-1	1/20/1981							280.6			84	0	200						0.05		14.6				
	2/2/1981							276			74	0	20						1.7		20				
	3/27/1981				<0.01											<0.05	<0.01	0.6		<0.02					
	6/11/1981		<0.05	<0.005	<0.005	<0.1	<0.002		<0.1	<0.0005				<0.025	<0.05	<0.025			<0.05	<0.005		<0.03	<0.001	<0.05	<0.05
	6/15/1981		<0.25		<0.002	<1		251	0.076	<0.01	81	0	22	<0.05	<0.05	<0.02	<0.05	0.51	<0.05	<0.05	12	<0.02	<0.001	<0.1	<0.05
	2/25/1982									<0.005			22			<0.05	<0.01	0.3	0.14			0.063	<0.001	<0.05	
	3/30/1989		<0.1			<0.1	<0.1	280	<0.1	<0.1	84		20	<0.1	<0.05	<0.1			<0.1	<0.1	16	<0.05		<0.1	<0.1
	7/19/1991				0.003	0.01		262.4		<0.005	88	0	21.1	<0.02		<0.02		0.58	<0.05	<0.005	18	<0.02	<0.0002		
	3/31/1993		<0.01		<0.005	<0.5		297	0.03	<0.002	82	0	22	<0.02	<0.05	<0.01	<0.01	0.54	<0.05	<0.02	21	<0.02	<0.001	<0.02	<0.01
	5/25/1994		0.025	<0.005	<0.005	<0.1		270		<0.0005	80	0	22	<0.025		<0.025		0.52	<0.05	<0.005	18	<0.03	<0.001		<0.05
	7/21/1994		<0.05	0.0052	<0.005	<0.1	<0.002	278	<0.1	<0.0005	95	0	25	<0.025	<0.05	<0.025		0.52	<0.05	<0.005	19	<0.03	<0.001	<0.05	<0.05
GWQ-2	6/15/1981		<0.01		<0.01	<0.2		242	<0.1	<0.005	102	0	20	<0.01	<0.1	<0.05	<0.01	0.5	<0.1	<0.02	16	<0.05	0.0013	<0.05	<0.05
	6/25/1981		<0.025		<0.002	<1		261	0.162	<0.01	98	<1	24.8	<0.05	<0.05	<0.02	<0.05	0.48	0.1	<0.05	11.4	<0.02	<0.001	<0.1	<0.05
GWQ-3	3/27/1981				<0.01											<0.05	<0.01	0.6		<0.02					
	6/15/1981		<0.25		0.004	<1		354	0.108	<0.01	138	<1	40.1	<0.05	<0.05	<0.02	<0.05	0.72	<0.05	<0.05	25.8	0.02	<0.001	<0.1	<0.05
	2/25/1982									<0.005			56			<0.05	<0.01	0.6	<0.1			<0.05	<0.001	<0.05	
	5/12/1982									<0.005			56			<0.05	<0.01	0.7	<0.1			<0.05	<0.001	<0.05	
	6/30/1982									<0.005			48			<0.05	<0.01	0.7	<0.1			<0.05	<0.001	<0.05	
	12/23/1982									<0.005			64			<0.05	<0.01	0.7	<0.1			<0.05	<0.001	<0.05	
	2/21/1983									<0.005			68			<0.05	<0.01	0.7	<0.1			<0.05	<0.001	<0.05	
	5/13/1983									<0.005			82			<0.05	<0.01	0.6	<0.1			<0.05	<0.001	0.11	
	8/9/1983									<0.005			78			<0.05	<0.01	0.7	0.11			<0.05	<0.001	<0.05	
	11/1/1983									<0.005			90			<0.05	<0.01	0.7	<0.1			<0.05	<0.001	<0.05	
	3/16/1984									<0.005			74			<0.05	<0.01	0.3	<0.1			<0.05	<0.001	<0.05	
GWQ-4	6/10/1981		<0.01		<0.01	<0.2		376	<0.1	<0.005	137	0	30	<0.01	<0.05	<0.05	<0.01	0.6	<0.1	<0.02	27	<0.05	<0.001	<0.05	<0.05
	11/6/1981		<0.01		<0.01	<0.2			<0.1	<0.005	72		22	<0.01	<0.02	<0.05	<0.01	0.7	<0.1	<0.02		<0.05	<0.001	<0.05	<0.05
	4/1/1993		<0.1		<0.005	1		404	0.02	<0.002	125	0	27	<0.02	<0.05	<0.01	<0.01	0.73	0.2	<0.02	23	<0.02	<0.001	<0.02	<0.01
	5/26/1994		<0.025	<0.005	<0.005	<0.1		316	<0.1	<0.0005	93	0	30	<0.025	<0.05	<0.025		0.63	0.13	<0.005	22	<0.03	<0.001	<0.05	<0.05
	11/5/2010	310	<0.02	<0.001	<0.001	0.057	<0.002	310	<0.04	<0.002	120	<2	72	<0.006	<0.006	0.0075	<0.01	0.73	0.059	<0.005	25	0.029	<0.0002	<0.008	<0.01
GWQ-5	6/15/1981		<0.01		<0.01	<0.2		398	<0.1	<0.005	200	0	42	<0.01	<0.05	<0.05	<0.01	1	<0.1	<0.02	49	<0.05	<0.001	<0.05	<0.05
GWQ-6	6/15/1981		<0.25		<0.002	<1		309	0.135	<0.01	68	<0.1	32.6	<0.05	<0.05	<0.02	<0.05	1.09	<0.05	<0.05	11.1	0.076	0.00235	<0.1	<0.05
	2/25/1982									<0.005			102			<0.05	<0.01	1.1	<0.1			<0.05	<0.001	<0.05	
	4/1/1993		<0.1		<0.005	0.6		322	0.09	<0.002	49	0	22	<0.02	<0.05	0.03	<0.01	0.84	5.05	<0.02	14	0.36	<0.001	<0.02	<0.01
GWQ-7	1/20/1981							341.6			96	0	200						0.03		14.6				
	2/2/1981							278			74	0	20						3.8		27				
	3/27/1981				<0.01											<0.05	<0.01	0.6		<0.02					
	4/6/1981				0.003											<0.05	0.36	0.59		<0.01					
	6/15/1981		<0.25		<0.002	<1		285	0.065	<0.01	88	<1	24.5	<0.05	<0.05	<0.02	<0.05	0.53	<0.05	<0.05	15.7	<0.02	<0.001	<0.1	<0.05
	8/7/1981							268.4			80		100						0.02		19.4				

Table 8-11

Groundwater Quality Analytical Results

Well Name	Collection Date	Nitrate (As N)+Nitrite (As N) (mg/L)	Nitrate as N (NO3) (mg/L)	Nitrogen, Nitrate (As N) (mg/L)	Nitrogen, Nitrite (As N) (mg/L)	pH	Potassium (mg/L)	Selenium (mg/L)	Silicon (mg/L)	Silver (mg/L)	Sodium (mg/L)	Specific Conductance (µmhos/cm)	Sulfate (mg/L)	Suspended Solids (mg/L)	Thallium (mg/L)	Total Dissolved Solids (mg/L)	Uranium (mg/L)	Vanadium (mg/L)	Zinc (mg/L)
15.6.31.431	6/4/1976		1.39			7.78	1.78				50.4	720	137			520			
	4/9/1981		1.14					<0.005					144.5						0.14
GWQ-1	1/20/1981					7.3					632		250			450			
	2/2/1981					7.9					60		156			520			
	3/27/1981		5.5																0.16
	6/11/1981							<0.005		<0.025					<0.005				<0.05
	6/15/1981		3.75			7.4	3.06	0.0022		<0.02	49.1	700	117		<0.005	500			0.078
	2/25/1982		0.2			7.9		<0.005					84			410			
	3/30/1989						3			<0.1	61		133			512			<0.1
	7/19/1991		5.19			7.34	2.7	<0.002		<0.02	39.6	799	136.4			543			
	3/31/1993		4.9			7.7	2.1	<0.005		<0.01	67	822	160			536			<0.01
	5/25/1994		4.3			7.9	2.7	<0.005		<0.025	55	760	150			614			<0.05
	7/21/1994		4.2			7.97	2.7	<0.005		<0.025	66	861	162		<0.005	558			<0.05
GWQ-2	6/15/1981		5.6			7.3	2.3	<0.005		<0.02	42	700	140			530			0.16
	6/25/1981		4.3				2.96	0.0022		<0.02	41.2		111			448			0.11
GWQ-3	3/27/1981		5.5																0.16
	6/15/1981		0.25			7	2.66	0.0037		<0.02	86	1100	335			868			0.061
	2/25/1982		0.4			7.9		<0.005					490			1040			
	5/12/1982		0.2			7.9		<0.005					410			930			
	6/30/1982		0.4			7.6		<0.005					365			860			
	12/23/1982		0.2			8.5		<0.005					340			990			
	2/21/1983		0.2			7.7		<0.005					428			970			
	5/13/1983		0.3			8		<0.005					437			980			
	8/9/1983		<0.2			7.8		<0.005					385			1060			
	11/1/1983		0.3			8		<0.005					529			1240			
	3/16/1984		3.4			8.2		<0.005					530			1190			
GWQ-4	6/10/1981		1.1			7.2	1.2	<0.005		<0.02	91	1000	270			770			0.056
	11/6/1981		2			7.9		<0.005		<0.02			162			500			0.28
	4/1/1993		0.1			7.6	1	<0.005		<0.01	86	1060	235			702			0.38
	5/26/1994		<1			8.08	1.8	<0.005		<0.025	74	1010	220			926			0.56
	11/5/2010			1.8	<0.1	7.53	1.2	0.0059	11	<0.005	110	1200	230	11	<0.001	798	0.0037	<0.05	0.14
GWQ-5	6/15/1981		0.6			7.3	1.1	<0.005		<0.02	173	1500	575			1260			0.064
GWQ-6	6/15/1981		3.3			7.3	2.4	0.0046		<0.02	57	600	40.5			400			<0.025
	2/25/1982		0.5			8.3		<0.005					220			810			
	4/1/1993		1.1			7.7	3.1	<0.005		<0.01	53	597	10			304			0.03
GWQ-7	1/20/1981					7.2					781		350			500			
	2/2/1981					7.9					51		156			530			
	3/27/1981		1.4																0.28
	4/6/1981		0.9																0.24
	6/15/1981		0.54			7.2	2.33	<0.0005		<0.02	47.9	700	110			496			0.278
	8/7/1981					7.4					138.9		150			475			

Table 8-11
Groundwater Quality Analytical Results

Well Name	Collection Date	Alkalinity, Total (As CaCO3) (mg/L CaCO3)	Aluminum (mg/L)	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Bicarbonate (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Calcium (mg/L)	Carbonate (mg/L)	Chloride (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Cyanide (mg/L)	Fluoride (mg/L)	Iron (mg/L)	Lead (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)	Nickel (mg/L)
GWQ-7	8/10/1981				<0.01			229			68		24			<0.05	<0.01	0.6	1.7	<0.02	21				
	10/23/1981		<0.01		<0.01	<0.02			<0.1	<0.005	71		26	<0.01	<0.02	<0.05	<0.01	0.5	0.14	<0.02		<0.05	<0.001	<0.05	<0.05
	11/6/1981		<0.01		<0.01	<0.2			<0.1	<0.005	71		24	<0.01	<0.02	<0.05	<0.01	0.8	<0.1	<0.02		<0.05	<0.001	<0.05	<0.05
	2/25/1982									<0.005			26			<0.05	<0.01	0.5	0.17			<0.05	<0.001	<0.05	
	12/28/1982									<0.005			20			<0.05	<0.01	0.3	0.26			0.16	<0.001	<0.05	
	2/21/1983									<0.005			22			<0.05	<0.01	0.4	<0.1			0.27	<0.001	<0.05	
	3/16/1983																					<0.05			
	5/13/1983									<0.005			20			<0.05	<0.01	0.6	<0.1			<0.05	<0.001	<0.05	
	8/9/1983									<0.005			22			<0.05	<0.01	0.6	<0.1			<0.05	<0.001	<0.05	
	11/1/1983									<0.005			22			<0.05	<0.01	0.6	<0.1			<0.05	<0.001	<0.05	
	3/16/1984									<0.005			20			<0.05	<0.01	0.8	<0.1			<0.05	<0.001	0.08	
	5/30/1984									<0.005			20			<0.05	0.02	0.6	<0.1			<0.05	<0.001	<0.05	
	9/12/1984									<0.005			20			<0.05	<0.01	0.6	<0.1			<0.05	<0.001	<0.05	
	11/27/1984									<0.005			18			<0.05	<0.01	0.6	<0.1			<0.05	<0.001	<0.05	
	5/17/1985												20												
	11/13/1985												18												
	5/23/1986												22												
	10/8/1986												22												
	3/30/1989		<0.1			<0.1	<0.1	278	<0.1	<0.1	80		15.9	<0.1	<0.05	<0.1			<0.1	<0.1	22	<0.05		<0.1	<0.1
	3/30/1993		<0.1		<0.005	<0.5		298	0.04	<0.002	68	0	21	<0.02	<0.05	<0.01	<0.01	0.56	<0.05	<0.02	31	<0.02	<0.001	<0.02	<0.01
	5/25/1994		0.25	<0.005	<0.005	<0.1		480		0.00058	490	0	20	<0.025		0.11		2.1	0.72	<0.005	51	1.1	<0.001		<0.05
	7/21/1994		<0.05	<0.005	<0.005	<0.1	<0.002	349	<0.1	<0.0005	14	0	22	<0.025	<0.05	<0.025		16	1.2	<0.005	8.2	0.21	<0.001	<0.05	<0.05
GWQ-8	6/4/1976							241	<0.1		122		16.7					0.51	0.002		15.5	0.003			
	2/2/1981							276			74		20						1.7		20				
	8/19/1981		<0.25		<0.004	<1		283	0.076	<0.01	72.9	<1	24	<0.05	<0.05	<0.05	<0.05	0.59	<0.1	<0.05	12.1	0.047	<1	<0.1	<0.05
	2/25/1982									<0.005			38			<0.05	<0.01	1	<0.1			0.17	<0.001	<0.05	
	3/31/1993		<0.05		<0.005	0.042		262	<0.1	<0.0005	149	<1	22	<0.01	<0.01	<0.01	<0.01	0.53	0.038	<0.002	21	<0.01	<0.0002	<0.02	<0.02
	5/25/1994		<0.025	<0.005	<0.005	<0.1		272	<0.1	<0.0005	120	0	41	<0.025	<0.05	<0.025		0.5	0.24	<0.005	20	<0.03	<0.001	<0.05	<0.05
GWQ-9	6/4/1976							188	<0.1		69.2		19.9					0.44	0.004		15.2	0.001			
	1/20/1981							305			92	0	200						0.05		9.7				
	2/2/1981							273			73	0	20						1.8		24				
	3/27/1981				<0.01											<0.05	<0.01	0.6		<0.02					
	4/6/1981				0.002											<0.05	0.15	0.56		<0.01					
	8/7/1981							268.4			80		100						0.06		19.4				
	8/10/1981				<0.01			268			76		22			<0.05	<0.01	0.5	0.49	0.033	20				
	10/8/1981		<0.25		<0.004	<1		302	0.044	<0.01	51.8	<1	22.4	<0.05	<0.05	<0.05	<0.05	0.6	<0.1	<0.05	17.1	<0.02	<1	<0.1	<0.05
	2/25/1982									<0.005			26			<0.05	<0.01	0.5	<0.1			<0.05	<0.001	<0.05	
	12/28/1982									<0.005			20			<0.05	<0.01	0.5	<0.1			<0.05	<0.001	<0.05	
	2/21/1983									<0.005			20			<0.05	<0.01	0.5	<0.1			<0.05	<0.001	<0.05	
	5/13/1983									<0.005			20			<0.05	<0.01	0.5	<0.1			<0.05	<0.001	<0.05	

Table 8-11
Groundwater Quality Analytical Results

Well Name	Collection Date	Nitrate (As N)+Nitrite (As N) (mg/L)	Nitrate as N (NO3) (mg/L)	Nitrogen, Nitrate (As N) (mg/L)	Nitrogen, Nitrite (As N) (mg/L)	pH	Potassium (mg/L)	Selenium (mg/L)	Silicon (mg/L)	Silver (mg/L)	Sodium (mg/L)	Specific Conductance (µmhos/cm)	Sulfate (mg/L)	Suspended Solids (mg/L)	Thallium (mg/L)	Total Dissolved Solids (mg/L)	Uranium (mg/L)	Vanadium (mg/L)	Zinc (mg/L)
GWQ-7	8/10/1981		1.2			7.7					48		162			490			0.63
	10/23/1981		1.1					<0.005		<0.02			160			490			0.41
	11/6/1981		1.2			8.1		<0.005		<0.02			158			480			0.19
	2/25/1982		0.8			8		<0.005					162			510			
	12/28/1982		<0.2			8.1		<0.005					40			250			
	2/21/1983		2.8			8.3		<0.005					47			250			
	3/16/1983																		
	5/13/1983		1.2			8.1		<0.005					158			470			
	8/9/1983		1			8		<0.005					130			490			
	11/1/1983		1.8			8.1		<0.005					137			500			
	3/16/1984		1			8.3		<0.005					140			450			
	5/30/1984		0.9			7.7		<0.005					154			470			
	9/12/1984		1.4			8		<0.005					128			500			
	11/27/1984		1.4			7.7		<0.005					144			490			
	5/17/1985					7.9							144			500			
	11/13/1985					7.8							137			450			
	5/23/1986					7.9							142			490			
	10/8/1986					7.4							116			460			
	3/30/1989						2			<0.1	47		131			492			0.1
	3/30/1993		138			7.8	1.6	<0.005		<0.01	52	752	138			482			0.1
	5/25/1994		<1			7.26	14	<0.005		<0.025	80	2630	1300			2420			<0.05
	7/21/1994		<1			7.72	13	<0.005		<0.025	47	660	<5		<0.005	224			<0.05
GWQ-8	6/4/1976		16.8			7.48	1.72				76.1	780	114			560			
	2/2/1981		60			7.9							156			520			
	8/19/1981		2.8			7.42	4.2	0.004		<0.02	84.1		134			608			0.69
	2/25/1982		0.3			7.6		<0.005					220			380			
	3/31/1993		5.7			7.7	3.5	<0.005		<0.01	94	1110	260			290			0.075
	5/25/1994		5.3			7.97	2.4	<0.005		<0.025	76	1060	290			792			<0.05
GWQ-9	6/4/1976		4			8.6	1.56				30	480	34			350			
	1/20/1981					7.4					703		300			450			
	2/2/1981					7.9					49		156			510			
	3/27/1981		1.4																0.16
	4/6/1981		1.2																0.13
	8/7/1981					7.4					128.9		140			450			
	8/10/1981		1.4			8					47		148			470			0.96
	10/8/1981		0.96			7.22	3.3	<0.002		<0.02	71		133			476			0.35
	2/25/1982		0.9			8.3		<0.005					160			430			
	12/28/1982		1			7.8		<0.005					150			480			
	2/21/1983		1.4			8		<0.005					161			480			
	5/13/1983		1.1			8.2		<0.005					158			460			

Table 8-11
Groundwater Quality Analytical Results

Well Name	Collection Date	Alkalinity, Total (As CaCO3) (mg/L CaCO3)	Aluminum (mg/L)	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Bicarbonate (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Calcium (mg/L)	Carbonate (mg/L)	Chloride (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Cyanide (mg/L)	Fluoride (mg/L)	Iron (mg/L)	Lead (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)	Nickel (mg/L)
GWQ-9	8/9/1983									<0.005			20			<0.05	<0.01	0.5	<0.1			<0.05	<0.001	<0.05	
	11/1/1983									<0.005			18			<0.05	<0.01	0.5	<0.1			<0.05	<0.001	<0.05	
	3/16/1984									<0.005			18			<0.05	<0.01	0.7	<0.1			<0.05	<0.001	<0.05	
	5/30/1984									<0.005			18			<0.05	<0.01	0.5	<0.1			<0.05	<0.001	<0.05	
	9/12/1984									<0.005			20			<0.05	<0.01	0.5	<0.1			<0.05	<0.001	<0.05	
	11/27/1984									<0.005			16			<0.05	<0.01	0.5	<0.1			<0.05	<0.001	<0.05	
	5/17/1985												20												
	11/13/1985												20												
	5/23/1986												36												
	10/8/1986												20												
GWQ-10	4/6/1981				0.002					<0.01						<0.05	0.02	0.53		<0.01			<1		
	8/10/1981		10.2		<0.004	<1		219	0.016	<0.01	74	<1	23.5	<0.05	<0.05	<0.05	<0.05	1.14	2.31	<0.05	11.3	1.18	<1	<0.1	<0.05
	10/27/1981		<0.01		<0.01	<0.2			<0.1	<0.005	68		22	<0.01	<0.02	<0.05	<0.01	0.6	<0.01	<0.02		<0.05	<0.001	<0.05	<0.05
	10/30/1981		<0.25		<0.005	<1			0.77	<0.01			22.8	<0.05	<0.05	<0.05	<0.05	0.98	<1	<0.05		<0.02	<0.001	<0.1	<0.02
	11/6/1981		<0.01		<0.01	<0.2			<0.1	<0.005	72		22	<0.01	<0.02	<0.05	<0.01	0.7	<0.1	<0.02		<0.05	<0.001	<0.05	<0.05
	11/13/1981		0.37		<0.005	0.25		275.6	0.037	0.001	84.2		22.85	<0.005			0.001	0.62		<0.005	17.45	0.5	<0.0005	<0.01	<0.05
	11/17/1981		<0.01		<0.01	<0.2			<0.1	<0.005	70		26	<0.01	<0.02	<0.05	<0.01	0.6	<0.1	<0.02		<0.05	<0.001	<0.05	<0.05
	11/23/1981		<0.01		<0.01	<0.2			<0.1	<0.005	70		26	<0.01	<0.02	<0.05	<0.01	0.6	<0.1	<0.02		<0.05	<0.001	<0.05	<0.05
	12/7/1981		<0.01		<0.01	<0.2			<0.1	<0.005	67		24	<0.01	<0.02	<0.05	<0.01	0.5	<0.1	<0.02		<0.05	<0.001	<0.05	<0.05
	12/15/1981		<0.01		<0.01	<0.2			<0.1	<0.005	89		24	<0.01	<0.02	<0.05	<0.01	0.7	<0.1	<0.02		<0.05	<0.001	<0.05	<0.05
	12/22/1981		<0.01		<0.01	<0.2			<0.1	<0.005	85		24	<0.01	<0.02	<0.05	<0.01	0.5	<0.1	<0.02		<0.05	<0.001	<0.05	<0.05
	1/5/1982		<0.01		<0.01	<0.2			<0.1	<0.005	80		22	<0.01	<0.02	<0.05	<0.01	0.6	0.13	<0.02		<0.05	<0.001	<0.05	<0.05
	1/26/1982									<0.005			24			<0.05	<0.01	0.6	<0.1			<0.05	<0.001	<0.1	
	2/22/1982									<0.005			24			<0.05	<0.01	0.6	0.12			<0.05	<0.001	<0.05	
	4/26/1982									<0.005			20			<0.05	<0.01	0.6	0.41			<0.05	<0.001	<0.05	
	5/17/1982									<0.005			28			<0.05	<0.01	0.6	0.1			<0.05	<0.001	<0.05	
	6/8/1982									<0.005			22			<0.05	<0.01	0.5	<0.1			<0.05	<0.001	<0.05	
	6/30/1982									<0.005			20			<0.05	<0.01	0.6	0.62			<0.05	<0.001	<0.05	
	9/2/1982							278		<0.001	82.6		22.3					0.54			17	<0.05		<0.01	
	12/23/1982									<0.005			26			<0.05	<0.01	0.6	<0.1			<0.05	<0.001	<0.05	
	2/21/1983									<0.005			24			<0.05	<0.01	0.6	<0.1			<0.05	<0.001	<0.05	
	5/13/1983									<0.005			32			<0.05	0.02	0.6	<0.1			<0.05	<0.001	<0.05	
	8/9/1983									<0.005			36			<0.05	<0.01	0.6	<0.1			<0.05	<0.001	<0.05	
	11/1/1983									<0.005			34			<0.05	<0.01	0.6	0.17			<0.05	<0.001	<0.05	
	3/16/1984									<0.005			42			<0.05	<0.01	0.5	0.11			<0.05	<0.001	<0.05	
	5/30/1984									<0.005			56			<0.05	<0.01	0.5	<0.1			<0.05	<0.001	<0.05	
	9/12/1984									<0.005			68			<0.05		0.5	<0.1			<0.05	<0.001	<0.05	
	11/27/1984									<0.005			64			<0.05	<0.01	0.6	<0.1			<0.05	<0.001	<0.05	
	5/17/1985												52												
	11/13/1985												42												
	5/23/1986												58												
	10/8/1986												54												

Table 8-11
Groundwater Quality Analytical Results

Well Name	Collection Date	Nitrate (As N)+Nitrite (As N) (mg/L)	Nitrate as N (NO3) (mg/L)	Nitrogen, Nitrate (As N) (mg/L)	Nitrogen, Nitrite (As N) (mg/L)	pH	Potassium (mg/L)	Selenium (mg/L)	Silicon (mg/L)	Silver (mg/L)	Sodium (mg/L)	Specific Conductance (µmhos/cm)	Sulfate (mg/L)	Suspended Solids (mg/L)	Thallium (mg/L)	Total Dissolved Solids (mg/L)	Uranium (mg/L)	Vanadium (mg/L)	Zinc (mg/L)
GWQ-9	8/9/1983		0.9			8		<0.005					135			480			
	11/1/1983		0.8			8.2		<0.005					132			460			
	3/16/1984		1.7			8.1		<0.005					132			460			
	5/30/1984		0.9			7.6		<0.005					154			450			
	9/12/1984		1.3			8		<0.005					132			470			
	11/27/1984		1.5			7.9		<0.005					132			470			
	5/17/1985					8							149			490			
	11/13/1985					7.8							142			450			
	5/23/1986					7.9							137			490			
	10/8/1986					7.6							125			460			
GWQ-10	4/6/1981		4.6				8.25												0.12
	8/10/1981		0.22			7.48	8.32	<0.002		<0.02	58.7		143			528			0.23
	10/27/1981		1.1			8.2		<0.005		<0.02			168			520			0.25
	10/30/1981		0.66			8.1		<0.002		<0.02			122			588			0.24
	11/6/1981		2			7.9		<0.005		<0.02			162			500			0.28
	11/13/1981		1.8			7.75	2.34	0.01		<0.001	39.1	700	140.9		<0.005	509			0.9
	11/17/1981		1.8			7.9		<0.005		<0.02			156			500			0.28
	11/23/1981		1.8			7.7		<0.005		<0.02			161			650			0.37
	12/7/1981		1.8			8.2		<0.005		<0.02			168			490			0.87
	12/15/1981		2.6			7.9		<0.005		<0.02			181			550			0.44
	12/22/1981		2.5			8.1		<0.005		<0.02			168			480			0.35
	1/5/1982		2.9			7.5		<0.005		<0.02			174			430			0.31
	1/26/1982		2.3			7.8		<0.005					162			490			
	2/22/1982		2.1			7.6		<0.005					161			510			
	4/26/1982		2			7.4		<0.005					168			840			
	5/17/1982		2.3			7.7		<0.005					175			490			
	6/8/1982		2.2			8		<0.005					162			500			
	6/30/1982		3.3			8		<0.005					160			510			
	9/2/1982		2.25			7.3	2.73	<0.005			57.5	690	143.4			506			
	12/23/1982		1.7			8.5		<0.005					138			500			
	2/21/1983		2.4			7.9		<0.005					161			470			
	5/13/1983		2.4			8		<0.005					161			480			
	8/9/1983		2.4			7.9		<0.005					142			510			
	11/1/1983		4.8			8.1		<0.005					125			500			
	3/16/1984		3.5			8.2		<0.005					128			500			
	5/30/1984		3.3			7.5		<0.005					161			530			
	9/12/1984		4.2			7.8		<0.005					158			580			
	11/27/1984		4.9			7.7		<0.005					163			580			
	5/17/1985					7.8							163			570			
	11/13/1985					7.7							149			500			
	5/23/1986					7.9							151			560			
	10/8/1986					7.5							137			550			

Table 8-11

Groundwater Quality Analytical Results

Well Name	Collection Date	Alkalinity, Total (As CaCO3) (mg/L CaCO3)	Aluminum (mg/L)	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Bicarbonate (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Calcium (mg/L)	Carbonate (mg/L)	Chloride (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Cyanide (mg/L)	Fluoride (mg/L)	Iron (mg/L)	Lead (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)	Nickel (mg/L)
GWQ-10	3/4/1987		<0.1	0.9		<0.1	<0.1	256	<0.1	<0.1	90		59	<0.1	<0.05	<0.1			<0.1	<0.1	20.7	<0.05		<0.1	<0.1
	5/25/1987																								
	1/12/1988		<0.1			<0.1	<0.1	243	<0.1	<0.1	116		78.8	<0.1	<0.05	<0.1			<0.1	<0.1	24	<0.05		<0.1	<0.1
	4/4/1988												65												
	8/23/1988												63												
	2/9/1989												76.3												
	6/1/1989												67.9												
	11/30/1989												72.1												
	11/14/1990												92.7												
	2/11/1991				<0.001								78.1												
	7/19/1991				0.002	0.02		241.6		<0.005	106.3	0	83.3	<0.02				0.51	0.07	<0.005	24.1	<0.02	<0.0002		
	8/29/1991												84.7												
	11/26/1991												58.2												
	3/15/1992												82.5												
	5/25/1992												83.8												
	7/16/1992												76.3												
	10/8/1992												83.4												
	11/27/1992												80.3												
	12/15/1992												90.9												
	2/25/1993												95.5												
	3/30/1993		<0.1		<0.005	<0.5		254	0.04	<0.002	104	0	94	<0.02	<0.05	<0.01	<0.01	0.52	<0.05	<0.02	27	<0.02	<0.001	<0.02	<0.01
	9/28/1993												96												
	5/26/1994		0.85	<0.005	<0.005	<0.1		232		<0.0005	100	0	92	<0.025		0.026		0.51	1.1	<0.005	25	0.059	<0.001		<0.05
	6/23/1994												103.6												
	7/23/1994		<0.05	<0.005	<0.005	<0.1	<0.002	238	<0.1	<0.0005	110	0	98	<0.025	<0.05	<0.025		0.49	<0.05	<0.005	26	<0.03	<0.001	<0.05	<0.05
	9/22/1994												89.2												
	1/29/1995												87.5												
	3/29/1995												84.9												
	6/27/1995												84.8												
	9/21/1995												91.3												
	1/10/1996												97.7												
	4/3/1996												97.4												
	9/25/1996												86.2												
	1/15/1997												91												
GWQ-11	8/10/1981		<0.25		<0.004	<1		237	0.092	<0.01	68.3	<1	37	<0.05	<0.05	<0.05	<0.05	0.9	1.14	<0.05	13.5	0.45	<1	<0.1	<0.05
	10/27/1981		<0.01		<0.01	<0.2			<0.1	<0.005	72		36	<0.01	<0.02	<0.05	<0.01	1	<0.1	<0.02		<0.05	<0.001	<0.05	<0.05
	10/30/1981		<0.25		<0.005	<1			0.55	<0.01			39.1	<0.05	<0.05	<0.05	<0.05	0.96	<0.1	<0.05		<0.02	<0.001	<0.1	<0.02
	11/6/1981		<0.01		<0.01	<0.2			<0.1	<0.005	67		36	<0.01	<0.02	<0.05	<0.01	1	<0.1	<0.02		<0.05	<0.001	<0.05	<0.05
	11/13/1981		<0.25		<0.005	0.2		241.1	0.041	0.001	82.6		37.64	<0.005			<0.001	0.99		<0.005	17.2	<0.05	<0.0005	0.12	<0.05

Table 8-11
Groundwater Quality Analytical Results

Well Name	Collection Date	Nitrate (As N)+Nitrite (As N) (mg/L)	Nitrate as N (NO3) (mg/L)	Nitrogen, Nitrate (As N) (mg/L)	Nitrogen, Nitrite (As N) (mg/L)	pH	Potassium (mg/L)	Selenium (mg/L)	Silicon (mg/L)	Silver (mg/L)	Sodium (mg/L)	Specific Conductance (µmhos/cm)	Sulfate (mg/L)	Suspended Solids (mg/L)	Thallium (mg/L)	Total Dissolved Solids (mg/L)	Uranium (mg/L)	Vanadium (mg/L)	Zinc (mg/L)
GWQ-10	3/4/1987						2.34			<0.1	73.6	740	150			568			<0.1
	5/25/1987												154.2						
	1/12/1988						3			<0.1	64		173			648			<0.1
	4/4/1988												170.6			552			
	8/23/1988												179.2			692			
	2/9/1989												180.5			618			
	6/1/1989												162.7			604			
	11/30/1989												161.7			620			
	11/14/1990												178			635			
	2/11/1991												213.5			696			
	7/19/1991		3.88			8.05	3.9	0.002		<0.02	46.9	975	166.6			645			
	8/29/1991					7.44							191.7			665			
	11/26/1991					7.46							171.2			648			
	3/15/1992					7.85							191.6			641			
	5/25/1992					7.41							169.2			621			
	7/16/1992					7.51							166.6			626			
	10/8/1992					7.43							161.4			659			
	11/27/1992					7.89							174.4			654			
	12/15/1992					7.48							168.7			582			
	2/25/1993					7.39							175.8			620			
	3/30/1993		3.9			7.8	2.3	<0.005		<0.01	71	1020	183			642			0.11
	9/28/1993					7.7							142.6			693			
	5/26/1994		3.5			7.82	3.1	<0.005		<0.025	56	1050	175			1000			0.55
	6/23/1994					7.97							191.6			671			
	7/23/1994		3.5			7.97	2.8	<0.005		<0.025	66	1050	184		<0.005	696			<0.05
	9/22/1994					7.45							155.8			668			
	1/29/1995					7.52							65.7			672			
	3/29/1995					7.67							176			62			
	6/27/1995					7.29							168.7			677			
	9/21/1995					7.42							187.4			693			
	1/10/1996					7.29							197.5			654			
	4/3/1996					6.95							218.2			628			
	9/25/1996					7.56							190.8			679			
	1/15/1997					7.59							203.67			746			
GWQ-11	8/10/1981		1.02			7.38	7.88	0.006		<0.02	48.1		123			612			<0.05
	10/27/1981		0.7			8.1		<0.005		<0.02			183			550			0.17
	10/30/1981		0.61			8.4		<0.011		<0.02			101			536			0.23
	11/6/1981		1.5			8.1		<0.005		<0.02			168			520			0.29
	11/13/1981		1.33			7.7	3.9	0.023		<0.001	43.7	700	155.6			544			0.79

Table 8-11
Groundwater Quality Analytical Results

Well Name	Collection Date	Alkalinity, Total (As CaCO3) (mg/L CaCO3)	Aluminum (mg/L)	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Bicarbonate (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Calcium (mg/L)	Carbonate (mg/L)	Chloride (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Cyanide (mg/L)	Fluoride (mg/L)	Iron (mg/L)	Lead (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)	Nickel (mg/L)
GWQ-11	11/17/1981		<0.01		<0.01	<0.2			<0.1	<0.005	71		36	<0.01	<0.02	<0.05	<0.01	1	<0.1	<0.02		<0.05	<0.001	<0.05	<0.05
	11/23/1981		<0.01		<0.01	<0.2			<0.1	<0.005	67		36	<0.01	<0.02	<0.05	<0.01	0.9	<0.1	<0.02		<0.05	<0.001	<0.05	<0.05
	12/7/1981		<0.01		<0.01	<0.2			<0.1	<0.005	57		56	<0.01	<0.02	<0.05	<0.01	0.9	<0.1	<0.02		<0.05	0.0064	<0.05	<0.05
	12/15/1981		<0.01		<0.01	<0.2			<0.1	<0.005	85		38	<0.01	<0.02	<0.05	<0.01	1	<0.1	<0.02		<0.05	<0.001	<0.05	<0.05
	12/22/1981		<0.01		<0.01	<0.2			<0.1	<0.005	82		40	<0.01	<0.02	<0.05	<0.01	0.5	0.27	<0.02		0.093	<0.001	<0.05	<0.05
	1/5/1982		<0.01		<0.01	<0.2			<0.1	<0.005	79		40	<0.01	<0.02	<0.05	<0.01	1	0.14	<0.02		<0.05	<0.001	<0.05	<0.05
	1/26/1982									<0.005			40			<0.05	<0.01	1	<0.1			<0.05	<0.001	<0.1	
	2/22/1982									<0.005			38			<0.05	<0.01	0.9	0.11			<0.05	<0.001	<0.05	
	4/26/1982									<0.005			40			<0.05	<0.01	0.8	0.36			<0.05	<0.001	0.05	
	5/17/1982									<0.005			44			<0.05	<0.01	0.8	0.11			<0.05	<0.001	<0.05	
	6/8/1982									<0.005			44			<0.05	<0.01	0.8	<0.1			<0.05	<0.001	<0.05	
	6/30/1982									<0.005			44			<0.05	<0.01	0.8	0.39			<0.05	<0.001	<0.05	
	9/2/1982							226		<0.001	111.2		52.22					0.78			27.6	<0.05		<0.01	
	12/23/1982									<0.005			52			<0.05	<0.01	0.8	<0.1			<0.05	<0.001	<0.05	
	2/21/1983									<0.005			44			<0.05	<0.01	0.8	0.38			<0.05	<0.001	<0.05	
	5/13/1983									<0.005			44			<0.05	0.01	0.8	<0.1			<0.05	<0.001	<0.05	
	8/9/1983									<0.005			46			<0.05	<0.01	0.8	<0.1			<0.05	<0.001	<0.05	
	11/1/1983									<0.005			46			<0.05	<0.01	0.8	<0.1			<0.05	<0.001	<0.05	
	3/16/1984									<0.005			52			<0.05	<0.01	0.6	<0.1			<0.05	<0.001	<0.05	
	5/30/1984									<0.005			58			<0.05	<0.01	0.8	<0.1			<0.05	<0.001	<0.05	
	9/12/1984									<0.005			60			<0.05	<0.01	0.8	<0.1			<0.05	<0.001	<0.05	
	11/27/1984									<0.005			60			<0.05	<0.01	0.8	<0.1			<0.05	<0.001	<0.05	
	5/17/1985												64												
	11/13/1985												62												
	5/23/1986												66												
	10/8/1986												70												
	3/4/1987		<0.1	1.1		<0.1	<0.1	220	<0.1	<0.1	108		69	<0.1	<0.05	<0.1			<0.1	<0.1	26.1	<0.05		<0.1	<0.1
	5/25/1987																								
	1/12/1988		<0.1			<0.1	<0.1	214	<0.1	<0.1	128		77.1	<0.1	<0.05	<0.1			<0.1	<0.1	31	<0.05		<0.1	<0.1
	4/4/1988												74.6												
	8/23/1988												73												
	2/9/1989												77												
	6/1/1989												69.7												
	11/30/1989												79.8												
	11/14/1990												104.4												
	2/11/1991				<0.001								88.9												
	7/19/1991				0.004	0.1		220.9		<0.005	122.5	0	89.7	<0.02				0.74	<0.05	<0.002	33.6	<0.02	<0.0002		
	8/29/1991												92.6												
	11/26/1991												89.3												

Table 8-11
Groundwater Quality Analytical Results

Well Name	Collection Date	Nitrate (As N)+Nitrite (As N) (mg/L)	Nitrate as N (NO3) (mg/L)	Nitrogen, Nitrate (As N) (mg/L)	Nitrogen, Nitrite (As N) (mg/L)	pH	Potassium (mg/L)	Selenium (mg/L)	Silicon (mg/L)	Silver (mg/L)	Sodium (mg/L)	Specific Conductance (µmhos/cm)	Sulfate (mg/L)	Suspended Solids (mg/L)	Thallium (mg/L)	Total Dissolved Solids (mg/L)	Uranium (mg/L)	Vanadium (mg/L)	Zinc (mg/L)
GWQ-11	11/17/1981		1.3			8		<0.005		<0.02			165			520			0.64
	11/23/1981		1.7			7.8		<0.005		<0.02			181			570			0.53
	12/7/1981		1.6			7.9		<0.005		<0.02			184			560			1.6
	12/15/1981		1.5			7.9		<0.005		<0.02			191			570			1.1
	12/22/1981		1.9			8		<0.005		<0.02			185			530			0.42
	1/5/1982		2.5			7.5		<0.005		<0.02			174			480			0.44
	1/26/1982		1.7			7.9		<0.005					168			500			
	2/22/1982		1.4			7.7		<0.005					168			510			
	4/26/1982		1.3			7.6		<0.005					165			510			
	5/17/1982		1.9			7.8		<0.005					185			510			
	6/8/1982		1.7			7.9		<0.005					185			530			
	6/30/1982		2.3			7.9		<0.005					198			590			
	9/2/1982		1.94			7.3	3.51	<0.005			57.5	940	247.6			700			
	12/23/1982		1.6			8.5		<0.005					235			650			
	2/21/1983		1.7			8		<0.005					218			600			
	5/13/1983		1.9			8.1		<0.005					206			570			
	8/9/1983		2			7.9		<0.005					168			580			
	11/1/1983		4.8			8		<0.005					174			580			
	3/16/1984		3.8			8.3		<0.005					184			540			
	5/30/1984		1.9			7.5		<0.005					195			550			
	9/12/1984		2.3			7.9		<0.005					181			590			
	11/27/1984		2.3			7.7		<0.005					165			570			
	5/17/1985					7.8							197			640			
	11/13/1985					7.7							183			600			
	5/23/1986					7.8							210			650			
	10/8/1986					7.6							200			560			
	3/4/1987					6.7	3.51			<0.1	62.1	820	200			696			<0.1
	5/25/1987												230						
	1/12/1988						4			<0.1	63		253			718			<0.1
	4/4/1988												277.7			694			
	8/23/1988												293.8			772			
	2/9/1989												258.4			730			
	6/1/1989												238.2			708			
	11/30/1989												254.3			732			
	11/14/1990												257.4			746			
	2/11/1991												233.4			790			
	7/19/1991		3.93			7.36	3.9	0.002		<0.02	40.1	1100	210.2			785			
	8/29/1991					7.46							278.6			771			
	11/26/1991					7.29							240.7			770			

Table 8-11
Groundwater Quality Analytical Results

Well Name	Collection Date	Alkalinity, Total (As CaCO3) (mg/L CaCO3)	Aluminum (mg/L)	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Bicarbonate (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Calcium (mg/L)	Carbonate (mg/L)	Chloride (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Cyanide (mg/L)	Fluoride (mg/L)	Iron (mg/L)	Lead (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)	Nickel (mg/L)
GWQ-11	3/15/1992												65.1												
	5/25/1992												96.2												
	10/8/1992												96												
	11/27/1992												96												
	12/15/1992												98.1			0.017									
	2/25/1993												104												
	3/30/1993		0.2		<0.005	<0.5		227	0.04	<0.002	126	0	104	<0.02	<0.05	<0.01	<0.01	0.52	0.33	<0.02	34	0.03	<0.001	<0.02	<0.01
	9/28/1993												105.6												
	5/25/1994		0.14	<0.005	<0.005	<0.1		199		<0.0005	120	0	110	<0.025		<0.025		0.72	0.16	<0.005	34	<0.03	<0.001		<0.05
	6/23/1994												117.2												
	7/22/1994		<0.05	0.0055	<0.005	<0.1	<0.002	207	<0.1	<0.0005	140	0	116	<0.025	<0.05	<0.025		0.7	<0.05	<0.005	37	<0.03	<0.001	<0.05	<0.05
	9/22/1994												112.3												
	1/29/1995												199.5												
	3/29/1995												99.4												
	6/27/1995												101.7												
	9/21/1995												112.1												
	1/10/1996												120.8												
	4/3/1996												119.2												
	9/25/1996												116												
	1/15/1997												127												
GWQ-12	2/21/1983									<0.005			18			<0.05	<0.01	1	<0.1			<0.05		<0.05	
	5/13/1983									<0.005			16			<0.05	<0.01	1	<0.1			<0.05	<0.001	<0.05	
	8/9/1983									<0.005			22			<0.05	<0.01	0.6	<0.1			<0.05	<0.001	<0.05	
	11/1/1983									<0.005			14			<0.05	<0.01	1.1	0.32			<0.05	<0.001	<0.05	
	3/16/1984									<0.005			14			<0.05	<0.01	1.1	<0.1			<0.05	<0.001	<0.05	
	5/30/1984									<0.005			16			<0.05	<0.01	1	<0.1			<0.05	<0.001	<0.05	
	9/12/1984									<0.005			16			<0.05	<0.01	1	<0.1			<0.05	<0.001	<0.05	
	11/27/1984									<0.005			14			<0.05	<0.01	1	<0.1			<0.05	<0.001	<0.05	
	5/27/1985												14												
	11/13/1985												14												
	5/23/1986												16												
	10/8/1986												16												
	7/21/1994		<0.05	0.0064	<0.005	<0.1	<0.002	262	<0.1	<0.0005	59	0	16	<0.025	<0.05	<0.025		0.99	<0.05	<0.005	19	<0.03	<0.001	<0.05	<0.05
GWQ94-13	11/15/1994		<0.05	<0.005	<0.005	<0.1	<0.002	159	<0.1	<0.0005	270	0	190	<0.025	<0.05	<0.025		0.36	0.11	<0.005	56	<0.03	<0.001	<0.05	<0.05
	7/1/1996		<0.025	<0.002	<0.005	<0.05	<0.002	156	<0.05	<0.0005	290	0	200	<0.025	<0.05	<0.025		0.34	<0.05	<0.005	62	<0.03	<0.001	<0.05	<0.05
	7/2/2010	120	<0.020	<0.0010	<0.0010	0.040	<0.0020	120	<0.040	<0.0020	320	<2.0	290	<0.0060	<0.0060	<0.0060		0.35	<0.020	<0.0050	62	<0.0020	0.00026	<0.0080	<0.010
	10/5/2010	120	<0.02	<0.001	<0.005	0.038	<0.002	120	<0.04	<0.002	300	<2	280	<0.006	<0.006	<0.006		0.32	<0.02	<0.005	62	<0.002	<0.0002	<0.008	<0.01
	5/11/2011	130	<0.02	<0.001	0.0038	0.037	<0.002	130	<0.04	<0.002	310	<2	290	<0.006	<0.006	<0.006	<0.005	0.33	<0.02	<0.005	61	<0.002	<0.0002	<0.008	<0.01

Table 8-11
Groundwater Quality Analytical Results

Well Name	Collection Date	Nitrate (As N)+Nitrite (As N) (mg/L)	Nitrate as N (NO3) (mg/L)	Nitrogen, Nitrate (As N) (mg/L)	Nitrogen, Nitrite (As N) (mg/L)	pH	Potassium (mg/L)	Selenium (mg/L)	Silicon (mg/L)	Silver (mg/L)	Sodium (mg/L)	Specific Conductance (µmhos/cm)	Sulfate (mg/L)	Suspended Solids (mg/L)	Thallium (mg/L)	Total Dissolved Solids (mg/L)	Uranium (mg/L)	Vanadium (mg/L)	Zinc (mg/L)
GWQ-11	3/15/1992					7.91							260.2			765			
	5/25/1992					7.45							258.1			761			
	10/8/1992					7.42							226.9			755			
	11/27/1992					7.85							248.4			763			
	12/15/1992					7.59							220			741			
	2/25/1993					7.64							273.3			762			
	3/30/1993		4.1			7.7	2.9	<0.005		<0.01	68	1170	271			776			0.03
	9/28/1993					7.57							207.7			800			
	5/25/1994		3.8			7.88	3.5	<0.005		<0.025	55	1130	260			820			<0.05
	6/23/1994					7.42							274.6			802			
	7/22/1994		3.8			7.7	3.4	<0.005		<0.025	66	1210	272		<0.005	808			<0.05
	9/22/1994					7.37							234.5			816			
	1/29/1995					7.6							158.7			861			
	3/29/1995					7.96							136.9			793			
	6/27/1995					7.67							278.8			835			
	9/21/1995					7.58							289.5			865			
	1/10/1996					7.36							287.5			777			
	4/3/1996					7.38							276.5			767			
	9/25/1996					7.78							229.9			835			
	1/15/1997					7.68							303.9			860			
GWQ-12	2/21/1983		2.2			7.7		<0.005					53			360			
	5/13/1983		2.1			8.1		<0.005					37			330			
	8/9/1983		1.1			7.8		<0.005					130			480			
	11/1/1983		2.8			8.2		<0.005					38			340			
	3/16/1984		3.8			8.2		<0.005					44			320			
	5/30/1984		2.5			8		<0.005					47			320			
	9/12/1984		2.2			8		<0.005					38			330			
	11/27/1984		2.3			7.8		<0.005					37			340			
	5/27/1985					8							36			370			
	11/13/1985					7.8							35			310			
	5/23/1986					7.8							31			330			
	10/8/1986					7.6							35			310			
	7/21/1994		2.1			7.75	3.2	<0.005		<0.025	29	537	38		<0.005	358			<0.05
GWQ94-13	11/15/1994		4.6			7.74	3.9	<0.005		<0.025	110	2026	720		<0.005	1570			<0.05
	7/1/1996		5.2			7.76	3.6	0.0068		<0.05	120	2000	620		<0.001	1520			<0.05
	7/2/2010	5.9				8	3.4	0.024	16	<0.0050	110	2200	770	10	<0.0010	1730	0.0016	<0.050	<0.010
	10/5/2010	5.8				7.39	3.4	0.024	16	<0.005	110	2100	760	<10	<0.001	1670	0.0015	<0.05	<0.01
	5/11/2011	6.5				7.66	3.3	0.028	16	<0.005	120	2100	800	<10	<0.001	1670	0.0017	<0.05	0.037

Table 8-11
Groundwater Quality Analytical Results

Well Name	Collection Date	Alkalinity, Total (As CaCO3) (mg/L CaCO3)	Aluminum (mg/L)	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Bicarbonate (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Calcium (mg/L)	Carbonate (mg/L)	Chloride (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Cyanide (mg/L)	Fluoride (mg/L)	Iron (mg/L)	Lead (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)	Nickel (mg/L)
GWQ94-14	6/30/1996		<0.025	<0.002	<0.005	<0.05	<0.002	261	<0.05	<0.0005	87	5	26	<0.025	<0.05	<0.025		0.48	<0.05	<0.005	23	<0.03	<0.001	<0.05	<0.05
	1/29/2010	210	<0.02	<0.0025	0.0032	0.045	<0.002	210	<0.04	<0.002	96	<2	50	<0.006	<0.006	<0.006	<0.005	0.48	<0.02	<0.005	26	<0.002	<0.0002	<0.008	<0.01
	6/29/2010	210	<0.020	<0.0010	0.0023	0.048	<0.0020	210	<0.040	<0.0020	98	<2.0	49	<0.0060	<0.0060	<0.0060		0.48	<0.020	<0.0050	25	<0.0020	<0.00020	<0.0080	<0.010
	10/5/2010	210	<0.02	<0.001	0.0024	0.045	<0.002	210	<0.04	<0.002	94	<2	50	<0.006	<0.006	<0.006		0.53	<0.02	<0.005	27	<0.002	<0.0002	<0.008	<0.01
	5/13/2011	210	<0.02	<0.001	0.0028	0.045	<0.002	210	<0.04	<0.002	97	<2	48	<0.006	<0.006	<0.006	0.012	0.55	<0.02	<0.005	27	<0.002	<0.0002	<0.008	<0.01
GWQ94-15	11/14/1994		<0.05	<0.005	<0.005	<0.1	<0.002	265	<0.1	<0.0005	110	0	110	<0.025	<0.05	<0.025		0.46	<0.05	<0.005	29	<0.03	<0.001	<0.05	<0.05
	7/1/1996		<0.025	<0.002	<0.005	<0.05	<0.002	227	<0.05	<0.0005	140	0	130	<0.025	<0.05	<0.025		0.42	0.41	<0.005	38	<0.03	<0.001	<0.05	<0.05
	1/29/2010	160	<0.020	<0.0025	0.0042	0.058	<0.0020	160	<0.040	<0.0020	180	<2.0	170	<0.0060	<0.0060	<0.0060	<0.005	0.30	<0.020	<0.0050	47	<0.0020	<0.00020	<0.0080	<0.010
	6/29/2010	180	<0.020	<0.0010	<0.0010	0.059	<0.0020	180	<0.040	<0.0020	140	<2.0	110	<0.0060	<0.0060	<0.0060		0.43	<0.020	<0.0050	34	0.0049	<0.00020	<0.0080	<0.010
	10/1/2010	190	<0.02	<0.001	<0.001	0.056	<0.002	190	<0.04	<0.002	130	<2	110	<0.006	<0.006	<0.006	<0.01	0.44	<0.02	<0.005	37	<0.002	<0.0002	<0.008	<0.01
	5/13/2011	190	<0.02	<0.001	0.0036	0.056	<0.002	190	<0.04	<0.002	130	<2	120	<0.006	<0.006	<0.006	<0.005	0.43	<0.02	<0.005	38	<0.002	<0.0002	<0.008	<0.01
GWQ94-16	11/13/1994		<0.05	<0.005	<0.005	<0.1	<0.002	199	<0.1	<0.0005	190	0	190	<0.025	<0.05	<0.025		0.66	<0.05	<0.005	51	0.038	<0.001	<0.05	<0.05
	7/1/1996		<0.025	<0.002	<0.005	<0.05	<0.002	193	<0.05	<0.0005	200	0	200	<0.025	<0.05	<0.025		0.57	0.22	<0.005	54	<0.03	<0.001	<0.05	<0.05
	6/29/2010	180	<0.020	<0.0010	0.0022	0.039	<0.0020	180	0.048	<0.0020	210	<2.0	180	<0.0060	<0.0060	<0.0060		0.62	<0.020	<0.0050	50	<0.0020	<0.00020	<0.0080	<0.010
	9/30/2010	180	<0.02	<0.001	0.0024	0.038	<0.002	180	0.053	<0.002	200	<2	190	<0.006	<0.006	<0.006	<0.01	0.67	<0.02	<0.005	51	<0.002	<0.0002	<0.008	<0.01
	5/10/2011	180	<0.02	<0.001	0.0026	0.038	<0.002	180	0.056	<0.002	200	<2	190	<0.006	<0.006	<0.006	<0.01	0.57	<0.02	<0.005	49	<0.002	<0.0002	<0.008	<0.01
GWQ94-17	11/15/1994		<0.05	<0.005	<0.005	<0.1	<0.002	232	<0.1	<0.0005	120	0	110	<0.025	<0.05	<0.025		0.46	<0.05	<0.005	33	<0.03	<0.001	<0.05	<0.05
	6/30/1996		<0.025	<0.002	<0.005	<0.05	<0.002	227	<0.05	<0.0005	120	7	81	<0.025	<0.05	<0.025		0.46	0.062	<0.005	28	<0.03	<0.001	<0.05	<0.05
	7/6/2010	200	<0.020	<0.0010	0.0022	0.047	<0.0020	200	<0.040	<0.0020	110	<2.0	68	<0.0060	<0.0060	<0.0060		0.52	<0.020	<0.0050	27	<0.0020	<0.00020	<0.0080	<0.010
GWQ94-20	11/15/1994		<0.05	<0.005	<0.005	<0.1	<0.002	296	0.11	<0.0005	48	0	19	<0.025	<0.05	<0.025		0.36	<0.05	<0.005	9.8	0.42	<0.001	<0.05	<0.05
	6/30/1996		<0.025	<0.002	<0.005	0.12	<0.002	273	0.086	<0.0005	58	19	21	<0.025	<0.05	<0.025		0.29	<0.05	<0.005	10	<0.03	<0.001	<0.05	<0.05
GWQ94-21A	11/13/1994		<0.05	<0.005	<0.005	<0.1	<0.002	267	<0.1	<0.0005	82	0	18	<0.025	<0.05	<0.025		0.57	<0.05	<0.005	23	0.2	<0.001	<0.05	<0.05
	6/30/1996		<0.025	<0.002	<0.005	<0.05	<0.002	268	<0.05	<0.0005	86	0	16	<0.025	<0.05	<0.025		0.51	<0.05	<0.005	22	<0.03	<0.001	<0.05	<0.05
GWQ94-21B	11/13/1994		<0.05	<0.005	<0.005	<0.1	<0.002	255	<0.1	<0.0005	71	0	19	<0.025	<0.05	<0.025		0.39	<0.05	<0.005	18	0.37	<0.001	<0.05	<0.05
	6/30/1996		<0.025	<0.002	<0.005	<0.05	<0.002	256	<0.05	<0.0005	87	10	17	<0.025	<0.05	<0.025		0.52	<0.05	<0.005	22	<0.03	<0.001	<0.05	<0.05
GWQ96-22A	7/13/1996		<0.025	<0.003	<0.005	<0.05	<0.002	124	<0.05	<0.0005	71	0	89	<0.025	<0.05	<0.025		3.3	<0.05	<0.005	6.7	0.075	<0.001	<0.05	<0.05
	4/9/1997												20			<0.025		0.8	6.5			2.8	<0.001		
	8/8/1997		0.028		<0.005	0.057	<0.002	177	0.23	<0.002	73	0	89	<0.025	<0.05	<0.05		2.2	0.13	<0.005	8.2	0.53		<0.05	<0.05
	1/30/2010	320	<0.020	<0.0025	0.0029	0.094	<0.0020	320	0.28	<0.0020	51	<2.0	81	<0.0060	<0.0060	<0.0060		2.6	2.1	<0.0050	3.8	0.74	<0.00020	<0.0080	<0.010
	7/1/2010	310	<0.020	<0.0010	0.0035	0.079	<0.0020	310	0.28	<0.0020	53	<2.0	70	<0.0060	<0.0060	<0.0060		2.7	0.021	<0.0050	3.7	0.65	<0.00020	<0.0080	<0.010
	10/7/2010	340	<0.02	<0.001	0.0035	0.084	<0.002	340	0.28	<0.002	49	<2	75	<0.006	<0.006	<0.006		2.7	0.32	<0.005	3.9	0.49	<0.0002	<0.008	<0.01
GWQ96-22B	7/13/1996		<0.025	<0.003	<0.005	0.096	<0.002	141	0.12	<0.0005	66	0	210	<0.025	<0.05	<0.025		1.8	<0.05	<0.005	10	0.41	<0.001	<0.05	<0.05
	10/7/2010	480	<0.02	<0.001	0.0057	0.11	<0.002	480	0.24	<0.002	72	<2	110	<0.006	<0.006	<0.006		3	9.3	<0.005	5.7	1.2	<0.0002	<0.008	<0.01
GWQ96-23A	7/14/1996		0.28	<0.003	<0.005	0.064	<0.002	280	<0.05	<0.0005	59	0	22	<0.025	<0.05	<0.025		0.84	0.26	<0.005	18	0.05	<0.001	<0.05	<0.05
	4/9/1997												16			<0.025		1.4	0.1			0.75	<0.001		
	8/8/1997		0.036		<0.005	0.13	<0.002	328	0.067	<0.002	130	0	18	<0.025	<0.05	<0.025		1.2	0.82	<0.005	36	1.6		<0.05	<0.05
	1/30/2010	640	<0.020	<0.0025	0.0027	0.091	<0.0020	640	0.074	<0.0020	150	<2.0	12	<0.0060	<0.0060	<0.0060		1.7	0.66	<0.0050	45	0.63	<0.00020	<0.0080	<0.010
	7/1/2010	510	<0.020	<0.0010	0.0011	0.13	<0.0020	510	0.068	<0.0020	150	<2.0	14	<0.0060	<0.0060	<0.0060		1.5	0.048	<0.0050	40	0.37	<0.00020	<0.0080	<0.010
	10/6/2010	580	<0.02	<0.001	<0.001	0.087	<0.002	580	0.08	<0.002	140	<2	12	<0.006	<0.006	<0.006		1.6	0.31	<0.005	45	0.41	<0.0002	<0.008	<0.01
	5/12/2011	600	<0.02	<0.001	<0.001	0.078	<0.002	600	0.071	<0.002	150	<2	13	<0.006	<0.006	<0.006	<0.005	1.7	0.043	<0.005	42	0.29	<0.0002	<0.008	<0.01

Table 8-11
Groundwater Quality Analytical Results

Well Name	Collection Date	Nitrate (As N)+Nitrite (As N) (mg/L)	Nitrate as N (NO3) (mg/L)	Nitrogen, Nitrate (As N) (mg/L)	Nitrogen, Nitrite (As N) (mg/L)	pH	Potassium (mg/L)	Selenium (mg/L)	Silicon (mg/L)	Silver (mg/L)	Sodium (mg/L)	Specific Conductance (µmhos/cm)	Sulfate (mg/L)	Suspended Solids (mg/L)	Thallium (mg/L)	Total Dissolved Solids (mg/L)	Uranium (mg/L)	Vanadium (mg/L)	Zinc (mg/L)
GWQ94-14	6/30/1996		1.5			8.44	1.9	<0.005		<0.05	51	641	140		<0.001	520			<0.05
	1/29/2010	2.2				8	2	0.0068		<0.005	49	820	150		<0.0025	550			0.01
	6/29/2010	2.3				8	1.7	0.0052	19	<0.0050	45	820	150	<10	<0.0010	573	0.0014	<0.050	<0.010
	10/5/2010	2.2				7.57	1.7	0.0053	18	<0.005	47	840	150	<10	<0.001	563	0.0013	<0.05	<0.01
	5/13/2011			2.2	<0.1	7.84	1.8	0.0061	18	<0.005	49	840	150	<10	<0.001	570	0.0015	<0.05	0.052
GWQ94-15	11/14/1994		2.1			7.74	2.5	<0.005		<0.025	68	1058	180		<0.005	790			<0.05
	7/1/1996		2.5			7.31	2.4	<0.005		<0.05	77	1190	240		<0.001	780			<0.05
	1/29/2010	4.1				7	3.0	0.021		<0.0050	84	1500	420		<0.0025	1080			0.022
	6/29/2010	2.7				8	2.1	0.0095	18	<0.0050	60	1100	260	<10	<0.0010	805	0.0017	<0.050	<0.010
	10/1/2010	2.7				7.52	2.2	0.012	17	<0.005	65	1100	260	<10	<0.001	794	0.0018	<0.05	<0.01
	5/13/2011			2.8	<2	7.74	2.3	0.012	16	<0.005	68	1200	270	<10	<0.001	808	0.0018	<0.05	<0.01
GWQ94-16	11/13/1994		3.8			7.55	3.7	<0.005		<0.025	78	1600	410		<0.005	1140			<0.05
	7/1/1996		3.7			7.95	3.4	<0.005		<0.05	80	1620	500		<0.001	1160			<0.05
	6/29/2010	3.7				8	3.1	0.011	22	<0.0050	74	1600	440	<10	<0.0010	1190	0.0025	<0.050	<0.010
	9/30/2010	3.9				7.5	3.1	0.015	21	<0.005	78	1500	440	<10	<0.001	1170	0.0024	<0.05	<0.01
	5/10/2011			4	<2	7.58	3.1	0.012	22	<0.005	74	1600	430	<10	<0.001	1150	0.0023	<0.05	0.011
GWQ94-17	11/15/1994		2.4			7.71	2.4	<0.005		<0.025	62	1147	240		<0.005	820			<0.05
	6/30/1996		2			8.56	2	<0.005		<0.05	61	925	190		<0.001	690			<0.05
	7/6/2010	2.0				8	1.8	0.0062	19	<0.0050	49	880	180	61	<0.0010	629	0.0016	<0.050	<0.010
GWQ94-20	11/15/1994		1			7.66	3.2	<0.005		<0.025	67	588	40		<0.005	370			<0.05
	6/30/1996		<1			8.79	3.1	<0.005		<0.05	75	597	56		<0.001	390			<0.05
GWQ94-21A	11/13/1994		1			7.25	2.1	<0.005		<0.025	39	672	130		<0.005	480			<0.05
	6/30/1996		1.1			8.22	1.5	<0.005		<0.05	37	649	120		<0.001	470			<0.05
GWQ94-21B	11/13/1994		<1			7.57	2.6	<0.005		<0.025	56	669	130		<0.005	440			<0.05
	6/30/1996		1.1			8.6	1.7	<0.005		<0.05	40	648	120		<0.001	470			<0.05
GWQ96-22A	7/13/1996		<1			7.5	2.5	<0.005		<0.05	150	1040	250		<0.001	700			<0.05
	4/9/1997					7.58		<0.005				930	150			770			
	8/8/1997		<1			7.65	6.2	<0.005		<0.025	170	1140	230		<0.001	700			<0.05
	1/30/2010	<1.0				8	2.8	<0.0025		<0.0050	160	920	44		<0.0025	557			<0.010
	7/1/2010	<1.0				8	2.8	0.0011	13	<0.0050	150	920	52	19	<0.0010	573	<0.0010	<0.050	<0.010
	10/7/2010	<1				8	2.8	<0.001	13	<0.005	150	720	34	11	<0.001	564	<0.001	<0.05	<0.01
GWQ96-22B	7/13/1996		<1			7.75	10	<0.005		<0.05	130	1070	79		<0.001	650			<0.05
	10/7/2010	2.1				7.52	3.6	0.0011	16	<0.005	200	1200	<0.5	25	<0.001	730	<0.001	<0.05	<0.01
GWQ96-23A	7/14/1996		<1			7.95	4.2	<0.005		<0.05	98	760	140		<0.001	520			<0.05
	4/9/1997							<0.005				850	170			580			
	8/8/1997		<1			7.68	2.5	<0.005		<0.025	72	1310	410		<0.001	920			<0.05
	1/30/2010	<1.0				8	1.6	<0.0025		<0.0050	69	1100	5.6		<0.0025	689			<0.010
	7/1/2010	<1.0				8	1.5	0.0014	15	<0.0050	81	1200	140	13	<0.0010	804	0.0025	<0.050	<0.010
	10/6/2010	<1				7.89	1.3	0.0013	15	<0.005	80	1200	99	<10	<0.001	769	0.0037	<0.05	<0.01
	5/12/2011			<0.1	<0.1	8.16	1.3	0.0012	14	<0.005	78	1100	74	<10	<0.001	752	0.003	<0.05	0.02

Table 8-11
Groundwater Quality Analytical Results

Well Name	Collection Date	Alkalinity, Total (As CaCO3) (mg/L CaCO3)	Aluminum (mg/L)	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Bicarbonate (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Calcium (mg/L)	Carbonate (mg/L)	Chloride (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Cyanide (mg/L)	Fluoride (mg/L)	Iron (mg/L)	Lead (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)	Nickel (mg/L)
GWQ96-23B	7/14/1996		7.4	<0.003	<0.005	0.093	<0.002	234	0.058	<0.0005	67	0	20	<0.025	<0.05	<0.025		1.1	3.7	<0.005	20	0.13	<0.001	<0.05	<0.05
	10/6/2010	480	<0.02	<0.001	<0.001	0.1	<0.002	480	0.14	<0.002	78	<2	19	<0.006	<0.006	<0.006		2.1	1.4	<0.005	22	0.36	<0.0002	<0.008	<0.01
	5/12/2011	490	<0.02	<0.001	<0.001	0.11	<0.002	490	0.14	<0.002	81	<2	17	<0.006	<0.006	<0.006	<0.005	2.1	0.93	<0.005	22	0.34	<0.0002	<0.008	<0.01
IW-1	3/4/1987							193			564		575												
	7/19/1991				<0.002	<0.01		222.1		<0.005	635.5	0	632.6	<0.02		<0.02		0.69	<0.05	<0.005	181.6	<0.02	0.0005		
	8/29/1991												642.4												
	11/26/1991												615.1												
	3/15/1992												610.7												
	5/25/1992												598.2												
	7/16/1992												584.6												
	10/8/1992												616.9												
	11/27/1992												604.8												
	12/15/1992												608.9												
	9/28/1993												521.1												
	3/17/1994												404.8												
	5/24/1994		0.94	<0.005	<0.005	<0.1		248		<0.0005	550	0	470	<0.025		<0.025		0.7	1	<0.005	170	<0.03	<0.001		<0.05
	6/23/1994												473.8												
	7/22/1994		<0.05	<0.005	<0.005	<0.1	<0.002	256	0.1	<0.0005	570	0	431	<0.025	<0.05	<0.025		0.72	<0.05	<0.005	200	<0.03	<0.001	<0.05	<0.05
	9/22/1994												435.9												
	1/29/1995												663												
	3/29/1995												419.4												
	6/27/1995												446.1												
	9/21/1995												458.7												
	1/10/1996												442.2												
	9/25/1996												568												
	1/15/1997												410												
IW-2	9/2/1982							185		<0.001	320		409.07					1.22			173.7	<0.05		<0.01	
	5/25/1994		22	<0.005	<0.005	0.12		534		<0.0005	430	0	340	0.046		<0.025		0.66	16	0.0073	94	0.77	<0.001		0.097
	7/22/1994		<0.05	<0.005	<0.005	<0.1	<0.002	300	0.15	<0.0005	390	0	380	<0.025	<0.05	<0.025		0.69	<0.05	<0.005	110	0.036	<0.001	<0.05	<0.05
	1/31/2010	260	0.13	<0.0025	0.0092	0.024	<0.0020	260	0.075	<0.0020	390	<2.0	600	<0.0060	0.0065	<0.0060	<0.005	0.74	1.3	<0.0050	120	1.6	<0.00020	0.020	<0.010
	6/29/2010	250	<0.020	<0.0010	<0.0010	0.029	<0.0020	250	0.061	<0.0020	390	<2.0	580	<0.0060	<0.0060	<0.0060		0.67	0.87	<0.0050	110	2.2	0.00048	0.024	<0.010
	9/30/2010	250	0.044	<0.001	<0.001	0.028	<0.002	250	0.073	<0.002	360	<2	500	<0.006	<0.006	<0.006	<0.01	0.68	0.41	<0.005	110	2.2	<0.0002	0.02	<0.01
	5/9/2011	240	<0.02	0.0032	<0.001	0.037	<0.002	240	0.081	<0.002	370	<2	520	<0.006	0.017	<0.006	<0.01	0.62	0.36	<0.005	110	3.6	<0.0002	0.021	<0.01
IW-3	9/2/1982							179		<0.001	233.6		159.12					0.42			42.1	<0.05		<0.01	
	2/25/1993												589.5												
	5/26/1994		32	<0.005	<0.005	0.2		341		<0.0005	240	0	209	0.059		6		0.47	22	0.077	51	0.35	<0.001		0.19
	7/23/1994		<0.05	0.0055	<0.005	<0.1	<0.002	255	<0.1	<0.0005	200	0	206	<0.025	<0.05	0.058		0.48	<0.05	<0.005	66	0.13	<0.001	0.062	<0.05
	4/3/1996												432.6												
LRG 04159	11/4/2010	300	<0.02	<0.001	<0.001	0.018	<0.002	300	<0.04	<0.002	110	<2	23	<0.006	<0.006	<0.006	<0.01	0.66	0.036	<0.005	23	<0.002	<0.0002	<0.008	<0.01

Table 8-11
Groundwater Quality Analytical Results

Well Name	Collection Date	Nitrate (As N)+Nitrite (As N) (mg/L)	Nitrate as N (NO3) (mg/L)	Nitrogen, Nitrate (As N) (mg/L)	Nitrogen, Nitrite (As N) (mg/L)	pH	Potassium (mg/L)	Selenium (mg/L)	Silicon (mg/L)	Silver (mg/L)	Sodium (mg/L)	Specific Conductance (µmhos/cm)	Sulfate (mg/L)	Suspended Solids (mg/L)	Thallium (mg/L)	Total Dissolved Solids (mg/L)	Uranium (mg/L)	Vanadium (mg/L)	Zinc (mg/L)
GWQ96-23B	7/14/1996		<1			8.15	4	<0.005		<0.05	79	780	170		<0.001	550			<0.05
	10/6/2010	<1				7.85	1.6	0.0011	12	<0.005	110	900	<0.5	<10	<0.001	554	<0.001	<0.05	<0.01
	5/12/2011			<0.1	<0.1	7.99	1.7	0.0014	12	<0.005	110	890	<0.5	24	<0.001	556	<0.001	<0.05	0.074
IW-1	3/4/1987					6.6	3.12				273.7	3950	1901			3802			
	7/19/1991		9.06			7.87	7	0.015		<0.02	375	6460	1985			4235			
	8/29/1991					7.13							1917.9			4120			
	11/26/1991					7.53							1634			3979			
	3/15/1992					7.88							2201			4026			
	5/25/1992					7.09							2203			4155			
	7/16/1992					7.12							1775			4297			
	10/8/1992					6.96							1726.8			3996			
	11/27/1992					7.71							1716.6			4004			
	12/15/1992					7.4							1414.6			3969			
	9/28/1993					7.12							1150			3661			
	3/17/1994					7							1569			3684			
	5/24/1994		5.8			7.84	2.9	<0.005		<0.025	250	3920	1500			3500			0.053
	6/23/1994					7.69							1444			3555			
	7/22/1994		5.9			7.51	2.5	0.018		<0.025	280	4100	1480		0.0063	3450			<0.05
	9/22/1994					7.05							1348			3466			
	1/29/1995					7.18							1478.5			3395			
	3/29/1995					7.49							1350.7			3465			
	6/27/1995					6.99							1680.1			3599			
	9/21/1995					6.82							1710.8			34.87			
	1/10/1996					7.23							1595.5			3437			
	9/25/1996					7.17							1493			3551			
	1/15/1997					7.44							1694.5			35.97			
IW-2	9/2/1982		1.38			7.3	234	<0.005			720	4250	2252			4010			
	5/25/1994		1.5			7.75	3.2	<0.005		<0.025	290	2890	1000			2400			0.084
	7/22/1994		<1			7.78	1.3	0.014		<0.025	360	3400	1040		0.0073	2390			<0.05
	1/31/2010	<2.0				8	1.6	0.033		<0.0050	290	3200	1200		<0.0025	2770			<0.010
	6/29/2010	<2.0				7	1.8	0.029	28	<0.0050	260	3400	1100	31000	<0.0010	2700	0.0060	<0.050	<0.010
	9/30/2010	<2				7.36	1.6	0.037	27	<0.005	270	3000	1000	71000	<0.001	2280	0.0057	<0.05	0.018
	5/9/2011			1.7	<2	7.31	2.3	0.031	28	<0.005	260	3200	1100	20000	<0.001	2360	0.0062	<0.05	0.023
IW-3	9/2/1982		4.12			7.2	3.51	<0.005			168	1700	707.3			1562			
	2/25/1993					7.27							1738.9			3892			
	5/26/1994		5.7			7.83	4	<0.005		<0.025	69	1790	415			1870			0.15
	7/23/1994		5			7.76	3.5	0.011		<0.025	89	1860	437		<0.005	1300			<0.05
	4/3/1996					7.04							1566.3			3364			
LRG 04159	11/4/2010			0.33	<0.1	7.31	<1	0.0049	12	<0.005	98	1100	220	<10	<0.001	730	0.004	<0.05	0.037

Table 8-11
Groundwater Quality Analytical Results

Well Name	Collection Date	Alkalinity, Total (As CaCO3) (mg/L CaCO3)	Aluminum (mg/L)	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Bicarbonate (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Calcium (mg/L)	Carbonate (mg/L)	Chloride (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Cyanide (mg/L)	Fluoride (mg/L)	Iron (mg/L)	Lead (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)	Nickel (mg/L)
McCravey-Greyback	3/31/1993		<0.1		<0.005	<0.5		302	<0.04	<0.002	97	0	30	<0.02	<0.05	<0.01	<0.01	0.51	0.05	<0.02	24	<0.02	<0.001	<0.02	<0.01
MW-1	1/1/1975							215			28	0	10					0.7			1				
	9/28/2010	150	<0.02	<0.001	0.0039	0.022	<0.002	150	0.044	<0.002	43	<2	14	<0.006	<0.006	<0.006	<0.01	0.4	0.11	<0.005	6.8	0.0054	<0.0002	<0.008	<0.01
MW-2	5/7/1975							209			9	0	8					2.3			0				
	7/20/1994		<0.05	<0.005	0.019	<0.1	<0.002	149	0.16	<0.0005	2.5	19	5.5	<0.025	<0.05	<0.025		3.1	0.069	<0.005	0.16	<0.03	<0.001	<0.05	<0.05
	9/28/2010	150	<0.02	<0.001	0.02	<0.002	<0.002	120	0.15	<0.002	1.9	28	5.8	0.032	<0.006	<0.006	<0.01	3.3	<0.02	<0.005	<1	<0.002	<0.0002	<0.008	<0.01
MW-4	6/13/1975							226			46	0	15					0.63			10				
	7/20/1994		<0.05	<0.005	<0.005	<0.1	<0.002	139	<0.1	<0.0005	15	2	17	<0.025	<0.05	<0.025		0.28	<0.05	<0.005	13	<0.03	<0.001	<0.05	<0.05
MW-5	9/19/1975							157			26	0	30					0.61			3				
	7/20/1994		<0.05	<0.005	<0.005	<0.1	<0.002	274	<0.1	<0.0005	71	0	17	<0.025	<0.05	<0.025		0.18	<0.05	<0.005	11	<0.03	<0.001	<0.05	<0.05
MW-6	1/1/1975							146			19	0	66					3.4			1				
	8/2/1994		<0.05	0.01	0.013	<0.1	<0.002	154	0.16	<0.0005	14	0	75	<0.025	<0.05	<0.025		1.6	0.41	<0.005	0.95	<0.03	<0.001	<0.05	<0.05
	7/8/2010	120	<0.020	<0.0010	0.018	0.0095	<0.0020	120	0.15	<0.0020	13	<2.0	75	0.016	<0.0060	<0.0060		8.1	0.024	<0.0050	<1.0	0.0027	<0.00020	0.013	<0.010
	9/27/2010	130	<0.02	<0.001	0.02	0.0093	<0.002	130	0.16	<0.002	13	<2	73	0.016	<0.006	<0.006	<0.01	8.2	0.021	<0.005	<1	<0.002	<0.0002	0.013	<0.01
MW-8	1/1/1975							222			34	0	10					0.86			10				
	7/21/1994		<0.05	<0.005	0.012	<0.1	<0.002	196	<0.1	<0.0005	4.8	16	6.6	<0.025	<0.05	<0.025		1	0.14	<0.005	1	<0.03	<0.001	<0.05	<0.05
	10/12/2010	210	<0.02	<0.001	0.013	<0.002	<0.002	210	0.085	<0.002	2.9	<2	6.5	<0.006	<0.006	<0.006	<0.005	1.1	<0.02	<0.005	1.1	0.0033	<0.0002	<0.008	<0.01
MW-9	11/16/1994		<0.05	<0.005	<0.005	<0.1	<0.002	149	<0.1	<0.0005	12	0	12	<0.025	<0.05	<0.025		1.4	<0.05	<0.005	1	<0.03	<0.001	<0.05	<0.05
	7/7/2010	110	<0.020	<0.0010	0.0039	0.0023	<0.0020	110	<0.040	<0.0020	12	<2.0	13	<0.0060	<0.0060	<0.0060		1.4	<0.020	<0.0050	<1.0	<0.0020	<0.00020	<0.0080	<0.010
	10/4/2010	110	<0.02	<0.001	0.0039	<0.002	<0.002	110	0.051	<0.002	12	<2	13	<0.006	<0.006	<0.006		1.3	<0.02	<0.005	<1	<0.002	<0.0002	<0.008	<0.01
	5/11/2011	120	<0.02	<0.001	0.0041	0.002	<0.002	110	0.048	<0.002	12	<2	13	<0.006	<0.006	<0.006	<0.005	1.3	<0.02	<0.005	1.2	<0.002	<0.0002	<0.008	<0.01
MW-10	11/16/1994		<0.05	<0.005	<0.005	<0.1	<0.002	262	<0.1	<0.0005	59	0	14	<0.025	<0.05	<0.025		0.43	<0.05	<0.005	9.4	<0.03	<0.001	<0.05	<0.05
MW-11	11/16/1994		<0.05	<0.005	<0.005	<0.1	<0.002	263	<0.1	<0.0005	63	0	15	<0.025	<0.05	<0.025		0.45	<0.05	<0.005	9.7	<0.03	<0.001	<0.05	<0.05
	7/7/2010	190	<0.020	<0.0010	0.0015	0.018	<0.0020	190	<0.040	<0.0020	59	<2.0	14	<0.0060	<0.0060	<0.0060		0.49	<0.020	<0.0050	8.1	<0.0020	<0.00020	<0.0080	<0.010
	10/4/2010	210	<0.02	<0.001	0.0016	0.02	<0.002	210	<0.04	<0.002	62	<2	14	<0.006	<0.006	<0.006		0.49	<0.02	<0.005	8.9	<0.002	<0.0002	<0.008	<0.01
	5/10/2011	210	<0.02	<0.001	0.0017	0.02	<0.002	210	<0.04	<0.002	64	<2	15	<0.006	<0.006	<0.006	<0.01	0.5	<0.02	<0.005	8.6	<0.002	<0.0002	<0.008	<0.01
NP-1	10/8/1981		<0.25		<0.004	<1		266	<0.004	<0.01	55.7	<1	24.9	<0.05	<0.05	<0.05	<0.05	0.84	0.27	<0.05	13.7	0.92	<1	<0.1	<0.05
	11/4/1981		<0.01		<0.01	<0.2			<0.1	<0.005	54		28	<0.01	<0.02	<0.05	0.04	1	<0.1	<0.02		0.6	<0.001	<0.05	<0.05
	11/13/1981		<0.25		<0.005	0.2		274.4	0.044	0.006	71.6		24.08	<0.005			0.001	0.83		<0.005	19.28	1.34	<0.0005	0.011	<0.05
	11/17/1981		<0.01		<0.005	0.24			<0.1	<0.005	59		24	<0.01	<0.02	0.069	<0.01	0.8	<0.1	<0.02		1.4	<0.001	0.06	<0.05
	11/23/1981		<0.01		<0.01	0.02			<0.1	<0.005	58		26	<0.02	<0.02	<0.05	<0.01	0.8	<0.1	<0.02		1.2	<0.001	<0.05	<0.05
	12/7/1981		<0.01		<0.01	<0.2			<0.1	<0.005	58		24	<0.01	<0.02	<0.05	<0.01	0.8	<0.1	<0.02		1.2	<0.001	<0.05	<0.05
	12/15/1981		<0.01		<0.01	<0.2			<0.1	<0.005	68		24	<0.01	<0.02	<0.05	<0.01	0.8	<0.1	<0.02		1.2	<0.001	<0.05	<0.05
	12/22/1981		<0.01		<0.01	<0.2			<0.1	<0.005	66		22	<0.01	<0.02	<0.05	<0.01	0.8	<0.1	<0.02		1	<0.001	<0.05	<0.05
	1/5/1982		<0.01		<0.01	<0.2			<0.1	<0.005	67		22	<0.01	<0.02	<0.05	<0.01	0.8	0.14	<0.02		0.71	0.0012	<0.05	<0.05
	1/26/1982									<0.005			22			<0.05	<0.01	0.7	<0.1			0.45	<0.001	<0.1	
	2/22/1982									<0.005			24			0.48	<0.01	0.7	0.83			0.26	<0.001	<0.05	
	4/26/1982									<0.005			26			<0.05	<0.01	0.6	1.2			0.16	<0.001	<0.05	
	5/24/1982																		<0.1			0.28			

Table 8-11
Groundwater Quality Analytical Results

Well Name	Collection Date	Nitrate (As N)+Nitrite (As N) (mg/L)	Nitrate as N (NO3) (mg/L)	Nitrogen, Nitrate (As N) (mg/L)	Nitrogen, Nitrite (As N) (mg/L)	pH	Potassium (mg/L)	Selenium (mg/L)	Silicon (mg/L)	Silver (mg/L)	Sodium (mg/L)	Specific Conductance (µmhos/cm)	Sulfate (mg/L)	Suspended Solids (mg/L)	Thallium (mg/L)	Total Dissolved Solids (mg/L)	Uranium (mg/L)	Vanadium (mg/L)	Zinc (mg/L)
McCravey-Greyback	3/31/1993		3			7.8	2	<0.005		<0.01	78	927	207			632			0.01
MW-1	1/1/1975		6.1			8.1	10.6				85	480	73			433			
	9/28/2010	1.9				8.1	3.9	<0.005	15	<0.005	40	440	48	<10	<0.001	303	0.0016	<0.05	0.43
MW-2	5/7/1975					7.9	5.3				89	400	40			327			
	7/20/1994		<1			9	<1	<0.005		<0.025	79	347	18		<0.005	254			<0.05
	9/28/2010	<1				9.27	<1	<0.005	23	<0.005	80	360	18	<10	<0.001	274	0.0022	0.065	<0.01
MW-4	6/13/1975					7.9	4.4				73	620	110						
	7/20/1994		<1			8.34	3.4	<0.005		<0.025	56	408	66		<0.005	256			<0.05
MW-5	9/19/1975		<0.5			7.7	4.1				54	390	26			260			
	7/20/1994		<1			7.97	3.6	<0.005		<0.025	33	507	24		<0.005	440			<0.05
MW-6	1/1/1975		4.3			7.6	7.3				90	520	38			260			
	8/2/1994		<1			8.09	6.2	<0.005		<0.025	120	626	45		<0.005	436			<0.05
	7/8/2010	8.5				8	6.0	0.0015	46	<0.0050	120	610	49	<10	<0.0010	456	<0.0010	<0.050	<0.010
	9/27/2010	<1				8.44	6.3	<0.005	45	<0.005	120	620	49	<10	<0.001	468	<0.001	<0.05	<0.01
MW-8	1/1/1975		15.4			7.7	6.2				45	440	21			293			
	7/21/1994		<1			8.88	3.4	<0.005		<0.025	89	438	18		<0.005	290			<0.05
	10/12/2010	<1				9.23	3.7	0.0016	14	<0.005	97	450	16	49	<0.001	287	0.0016	<0.05	<0.01
MW-9	11/16/1994		<1			8.05	2.3	<0.005		<0.025	52	293	12		<0.005	230			<0.05
	7/7/2010	1.1				8	2.0	<0.0010	15	<0.0050	54	290	12	<10	<0.0010	206	0.0012	<0.050	<0.010
	10/4/2010	7.4				8.06	2	<0.001	14	<0.005	51	300	11	<10	<0.001	194	0.0012	<0.05	<0.01
	5/11/2011	2.1				8.38	2.1	<0.001	15	<0.005	55	300	12	<10	<0.001	206	0.0013	<0.05	0.048
MW-10	11/16/1994		<1			7.84	1.9	<0.005		<0.025	29	473	25		<0.005	310			<0.05
MW-11	11/16/1994		<1			7.79	1.5	<0.005		<0.025	23	480	21		<0.005	314			<0.05
	7/7/2010	<1.0				7	1.3	<0.0010	20	<0.0050	23	420	15	<10	<0.0010	289	<0.0010	<0.050	<0.010
	10/4/2010	<1				7.32	1.5	<0.001	20	<0.005	24	470	14	12	<0.001	301	<0.001	<0.05	<0.01
	5/10/2011			<0.1	<0.1	7.54	1.4	<0.001	20	<0.005	23	470	14	<10	<0.001	308	0.0015	<0.05	<0.01
NP-1	10/8/1981		0.47			7.6	8.25	0.003		<0.02	61.7		108			496			0.4
	11/4/1981		0.3			8.1		<0.005		<0.02			148			470			0.14
	11/13/1981		0.09			7.65	5.85	0.029		<0.001	39.1	625	130.7			470			0.44
	11/17/1981		0.2			8		<0.005		<0.02			154			460			3.9
	11/23/1981		0.2			7.7		<0.005		<0.02			146			530			4.1
	12/7/1981		0.2			7.3		<0.005		<0.02			158			490			5.1
	12/15/1981		<0.2			7.8		<0.005		<0.02			151			480			5.3
	12/22/1981		0.3			7.8		<0.005		<0.02			149			450			4.1
	1/5/1982		0.7			7.6		<0.02		<0.02			163			400			4.1
	1/26/1982		0.5			7.9		<0.005					154			440			
	2/22/1982		0.6			7.9		<0.005					158			460			
	4/26/1982		0.7			7.9		<0.005					154			440			
	5/24/1982																		

Table 8-11
Groundwater Quality Analytical Results

Well Name	Collection Date	Alkalinity, Total (As CaCO3) (mg/L CaCO3)	Aluminum (mg/L)	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Bicarbonate (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Calcium (mg/L)	Carbonate (mg/L)	Chloride (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Cyanide (mg/L)	Fluoride (mg/L)	Iron (mg/L)	Lead (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)	Nickel (mg/L)
NP-1	5/28/1982																		<0.1			0.22			
	6/8/1982									<0.005			20			<0.05	<0.01	0.6	<0.1			0.25	<0.001	<0.05	
	6/30/1982									<0.005			18			<0.05	<0.01	0.6	<0.1			0.18	<0.001	<0.05	
	10/27/1982									<0.005			20			<0.05	<0.01	0.7	0.45			0.058	<0.001	<0.05	
	2/21/1983									<0.005			18			<0.05	<0.01	0.7	<0.1			<0.05	<0.001	<0.05	
	5/13/1983									<0.005			24			<0.05	<0.01	0.6	<0.1			<0.05	<0.001	<0.05	
	8/9/1983									<0.005			22			<0.05	<0.01	0.6	0.22			<0.05	<0.001	<0.05	
	11/1/1983									<0.005			18			<0.05	<0.01	0.6	0.14			<0.05	<0.001	<0.05	
	3/16/1984									<0.005			22			<0.05	<0.01	0.6	<0.1			<0.05	0.0083	<0.05	
	5/30/1984									<0.005			22			<0.05	<0.01	0.6	<0.1			<0.05	<0.001	<0.05	
	9/12/1984									<0.005			22			<0.05	<0.01	0.6	<0.1			<0.05	<0.001	<0.05	
	11/27/1984									<0.005			16			<0.05	<0.01	0.6	<0.1			<0.05	<0.001	<0.05	
	5/17/1985												20												
	11/13/1985												16												
	5/23/1986												18												
	10/8/1986												22												
	3/30/1989		<0.1			<0.1	<0.1	279	<0.1	<0.1	88		14.9	<0.1	<0.05	<0.1			<0.1	<0.1	23	<0.05		<0.1	<0.1
	7/19/1991				0.003	0.02		256.3		<0.005	81.1	0	21.6	<0.02				0.58	0.59	0.007	23.9	<0.02	<0.0002		
	8/29/1991												21.1												
	11/26/1991												22.7												
	3/15/1992												22.1												
	5/25/1992												28.6												
	7/16/1992												21.7												
	10/8/1992												21.7												
	11/27/1992												21.3												
	12/15/1992												23.7												
	2/25/1993												22.6												
	3/30/1993		<0.1		<0.005	<0.5		306	0.03	<0.002	79	0	22	<0.02	<0.05	<0.01	<0.01	0.59	0.17	<0.02	27	<0.02	<0.001	<0.02	<0.01
	9/28/1993												36.2												
	3/17/1994												24												
	5/24/1994		0.83	<0.005	0.005	<0.1		263		0.0096	79	0	22	<0.025		<0.025		0.56	9.5	0.016	23	0.1	<0.001		<0.05
	6/23/1994												40.3												
	7/21/1994		<0.05	<0.005	<0.005	<0.1	<0.002	249	<0.1	<0.0005	71	0	23	<0.025	<0.05	<0.025		0.65	0.052	<0.005	23	0.27	<0.001	<0.05	<0.05
	9/22/1994												24.3												
	1/29/1995												26.2												
	3/29/1995												23.3												
	6/27/1995												24.1												

Table 8-11
Groundwater Quality Analytical Results

Well Name	Collection Date	Nitrate (As N)+Nitrite (As N) (mg/L)	Nitrate as N (NO3) (mg/L)	Nitrogen, Nitrate (As N) (mg/L)	Nitrogen, Nitrite (As N) (mg/L)	pH	Potassium (mg/L)	Selenium (mg/L)	Silicon (mg/L)	Silver (mg/L)	Sodium (mg/L)	Specific Conductance (µmhos/cm)	Sulfate (mg/L)	Suspended Solids (mg/L)	Thallium (mg/L)	Total Dissolved Solids (mg/L)	Uranium (mg/L)	Vanadium (mg/L)	Zinc (mg/L)
NP-1	5/28/1982																		
	6/8/1982		1.1			7.5		<0.005					162			500			
	6/30/1982		1.1			7.7		<0.005					143			500			
	10/27/1982		1.3			7.7		<0.005					151			470			
	2/21/1983		1.3			7.7		<0.005					156			490			
	5/13/1983		1.1			7.9		<0.005					149			470			
	8/9/1983		1.1			7.8		<0.005					130			480			
	11/1/1983		2.1			7.8		<0.005					125			500			
	3/16/1984		1.8			8.2		<0.005					124			480			
	5/30/1984		0.7			7.5		<0.005					154			510			
	9/12/1984		1.1			7.7		<0.005					137			480			
	11/27/1984		1.1			7.8		<0.005					144			480			
	5/17/1985					7.6							144			510			
	11/13/1985					7.3							149			480			
	5/23/1986					7.6							142			500			
	10/8/1986					7.4							107			470			
	3/30/1989						3			<0.1	46		137			492			2.6
	7/19/1991		0.99			8.04	2	<0.002		<0.02	31.2	761	133.4			530			
	8/29/1991					7.69							140.7			501			
	11/26/1991					7.12							136.8			1484			
	3/15/1992					7.8							146.2			510			
	5/25/1992					7.49							128.2			608			
	7/16/1992					7.5							142.2			487			
	10/8/1992					7.35							128.8			517			
	11/27/1992					7.85							142.4			498			
	12/15/1992					7.58							125			502			
	2/25/1993					7.42							138.3			510			
	3/30/1993		1.1			7.7	1.8	<0.005		<0.01	52	767	145			496			1.13
	9/28/1993					7.48							110.1			508			
	3/17/1994					7.3							134.2			516			
	5/24/1994		1.1			7.53	2.5	<0.005		<0.025	48	680	130			510			5.7
	6/23/1994					7.5							142.3			453			
	7/21/1994		<1			7.87	2.2	<0.005		<0.025	47	698	133		<0.005	464			4.9
	9/22/1994					7.49							118.8			488			
	1/29/1995					7.94							125.4			407			
	3/29/1995					7.98							86.2			392			
	6/27/1995					8.02							113.7			385			

Table 8-11
Groundwater Quality Analytical Results

Well Name	Collection Date	Alkalinity, Total (As CaCO3) (mg/L CaCO3)	Aluminum (mg/L)	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Bicarbonate (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Calcium (mg/L)	Carbonate (mg/L)	Chloride (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Cyanide (mg/L)	Fluoride (mg/L)	Iron (mg/L)	Lead (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)	Nickel (mg/L)
NP-1	9/21/1995												27.2												
	1/10/1996												26.1												
	4/3/1996												25.7												
	9/25/1996												23.6												
	1/15/1997												25.6												
	1/31/2010	220	<0.020	<0.0025	<0.0025	0.037	<0.0020	220	<0.040	<0.0020	87	<2.0	38	<0.0060	<0.0060	<0.0060	<0.005	0.55	0.10	<0.0050	29	0.0088	<0.00020	<0.0080	<0.010
	6/28/2010	230	<0.020	<0.0010	0.0034	0.043	<0.0020	230	<0.040	<0.0020	90	<2.0	37	<0.0060	<0.0060	<0.0060		0.61	<0.020	<0.0050	26	<0.0020	<0.00020	<0.0080	<0.010
	10/5/2010	220	0.14	<0.001	0.0035	0.041	<0.002	220	0.04	<0.002	86	<2	35	<0.006	<0.006	<0.006		0.58	<0.02	<0.005	28	<0.002	<0.0002	<0.008	<0.01
NP-2	10/8/1981		<0.25		0.024	<1		159	0.08	<0.01	46	<1	45.1	<0.05	<0.05	<0.05	<0.05	1.78	<0.1	<0.05	14.6	0.62	<1	<0.1	<0.05
	11/6/1981		<0.01		<0.01	<0.2			<0.1	<0.005	53		35	<0.01	<0.02	<0.05	<0.01	1.4	<0.1	<0.02		0.39	<0.001	0.21	<0.05
	11/13/1981		<0.25		<0.005	<0.1		221.3	0.04	<0.001	65.1		30.79	<0.005			0.0026	1.14		<0.005	18.67	0.79	<0.0005	0.04	<0.01
	11/23/1981		<0.01		<0.01	0.02			<0.1	<0.005	57		30	<0.02	<0.02	<0.05	<0.01	0.9	<0.1	<0.02		0.54	<0.001	0.06	<0.05
	12/7/1981		<0.01		<0.01	<0.2			<0.1	<0.005	53		30	<0.01	<0.02	<0.05	<0.01	0.8	<0.1	<0.02		0.54	<0.001	0.06	<0.05
	12/15/1981		<0.01		<0.01	<0.2			<0.1	<0.005	62		32	<0.01	<0.02	<0.05	<0.01	0.9	<0.1	<0.02		0.52	<0.001	0.072	<0.05
	12/22/1981		<0.01		<0.01	0.21			<0.1	<0.005	73		32	<0.01	<0.02	<0.05	<0.01	0.6	0.12	<0.02		0.51	<0.001	0.053	<0.05
	1/5/1982		<0.01		<0.01	<0.2			<0.1	<0.005	65		28	<0.01	<0.02	<0.05	<0.01	0.9	0.14	<0.02		0.49	<0.001	0.07	<0.05
	1/26/1982									<0.005			24			<0.05	<0.01	0.7	<0.1			0.34	<0.001	<0.1	
	2/22/1982									<0.005			30			0.069	<0.01	0.7	0.37			0.3	<0.001	<0.05	
	4/26/1982									<0.005			42			<0.05	<0.01	1	1.2			0.29	<0.001	<0.05	
	5/18/1982									0.015			34			<0.05	<0.01	0.6	0.68			0.078	<0.001	<0.05	
	5/24/1982																		<0.1			<0.05			
	5/28/1982																		<0.1			<0.05			
	6/8/1982									<0.005			26			<0.05	<0.01	0.5	<0.1			<0.05	<0.001	<0.05	
	6/30/1982									<0.005			26			<0.05	<0.01	0.6	<0.1			<0.05	<0.001	<0.05	
	9/2/1982							316		<0.001	73.8		26.49					0.54			17.9	<0.05		<0.01	
	10/27/1982									<0.005			26			<0.05	<0.01	0.6	0.29			<0.05	<0.001	<0.05	
	2/21/1983									<0.005			24			<0.05	<0.01	0.6	0.12			<0.05	<0.001	<0.05	
	5/13/1983									<0.005			24			<0.05	<0.01	0.6	<0.1			<0.05	<0.001	<0.05	
	8/9/1983									<0.005			36			<0.05	<0.01	0.6	<0.1			<0.05	<0.001	<0.05	
	11/1/1983									<0.005			24			<0.05	<0.01	0.6	0.17			<0.05	<0.001	<0.05	
	3/16/1984									<0.005			30			<0.05	<0.01	0.8	<0.1			<0.05	0.001	<0.05	
	5/30/1984									<0.005			32			<0.05	<0.01	0.6	<0.1			<0.05	<0.001	<0.05	
	9/12/1984									<0.005			22			<0.05	<0.01	0.6	<0.1			<0.05	<0.001	<0.05	
	11/27/1984									<0.005			20			<0.05	<0.01	0.6	<0.1			<0.05	<0.001	<0.05	
	5/17/1985												22												
	11/13/1985												22												
	5/23/1986												28												
	10/8/1986												24												
	3/30/1989		<0.1			<0.1	<0.1	183	<0.1	<0.1	52		29.2	<0.1	<0.05	<0.1			<0.1	<0.1	18	0.06		<0.1	<0.1

Table 8-11
Groundwater Quality Analytical Results

Well Name	Collection Date	Nitrate (As N)+Nitrite (As N) (mg/L)	Nitrate as N (NO3) (mg/L)	Nitrogen, Nitrate (As N) (mg/L)	Nitrogen, Nitrite (As N) (mg/L)	pH	Potassium (mg/L)	Selenium (mg/L)	Silicon (mg/L)	Silver (mg/L)	Sodium (mg/L)	Specific Conductance (µmhos/cm)	Sulfate (mg/L)	Suspended Solids (mg/L)	Thallium (mg/L)	Total Dissolved Solids (mg/L)	Uranium (mg/L)	Vanadium (mg/L)	Zinc (mg/L)
NP-1	9/21/1995					7.96							145			373			
	1/10/1996					7.73							109.4			277			
	4/3/1996					7.89							123.3			300			
	9/25/1996					8.22							94.4			320			
	1/15/1997					8.42							109.13			318			
	1/31/2010	1.4				8	2.0	0.0055		<0.0050	52	780	140		<0.0025	514			0.38
	6/28/2010	1.4				8	1.9	0.0045	19	<0.0050	46	790	150	<10	<0.0010	548	0.0019	<0.050	0.047
	10/5/2010	4.9				7.63	1.9	0.0045	18	<0.005	50	800	140	13	<0.001	537	0.0018	<0.05	0.055
NP-2	10/8/1981		0.23			7.39	9.57	<0.002		<0.02	93.5		198			476			0.31
	11/6/1981		0.4			7.6		<0.005		<0.02			164			450			1.7
	11/13/1981		0.25			7.65	3.9	0.017		<0.001	59.8	675	162.4			466			3.18
	11/23/1981		0.7			7.7		<0.005		<0.02			156			520			3.5
	12/7/1981		0.6			7.5		<0.005		<0.02			160			490			4.4
	12/15/1981		0.5			8		<0.005		<0.02			161			480			2.9
	12/22/1981		0.8			8		<0.005		<0.02			161			440			2.8
	1/5/1982		0.9			7.6		<0.02		<0.02			158			400			3.2
	1/26/1982		1.1			8		<0.005					160			450			
	2/22/1982		0.8			8		<0.005					151			440			
	4/26/1982		2.4			8		<0.005					149			450			
	5/18/1982		1.8			7.9		<0.005					128			460			
	5/24/1982																		
	5/28/1982																		
	6/8/1982		0.9			7.8		<0.005					158			490			
	6/30/1982		1.4			7.8		<0.005					133			490			
	9/2/1982		1.66			7.4	1.95	<0.005			57.5	650	127			468			
	10/27/1982		1.6			7.9		<0.005					120			440			
	2/21/1983		1.6			7.8		<0.005					127			440			
	5/13/1983		1.5			8.1		<0.005					139			460			
	8/9/1983		1.6			7.9		<0.005					148			560			
	11/1/1983		2.3			8		<0.005					111			470			
	3/16/1984		1.6			8.2		<0.005					146			500			
	5/30/1984		1.4			7.7		<0.005					175			520			
	9/12/1984		1.7			7.8		<0.005					134			470			
	11/27/1984		1.7			7.9		<0.005					125			470			
	5/17/1985					7.8							120			480			
	11/13/1985					7.4							115			460			
	5/23/1986					7.6							113			480			
	10/8/1986					7.4							100			430			
	3/30/1989						3			<0.1	65		124			376			0.5

Table 8-11
Groundwater Quality Analytical Results

Well Name	Collection Date	Alkalinity, Total (As CaCO3) (mg/L CaCO3)	Aluminum (mg/L)	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Bicarbonate (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Calcium (mg/L)	Carbonate (mg/L)	Chloride (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Cyanide (mg/L)	Fluoride (mg/L)	Iron (mg/L)	Lead (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)	Nickel (mg/L)
NP-2	7/19/1991				<0.002	<0.01		56.1		<0.005	34.2	0	60.9	<0.02		<0.02		0.64	<0.05	<0.005	24	<0.02	<0.0002		
	8/29/1991												62.8												
	11/26/1991												63												
	3/15/1992												67.6						<0.05						
	5/25/1992												66.6						<0.05						
	7/16/1992												65.3						<0.05						
	10/8/1992												78.2												
	11/27/1992												63.7												
	12/15/1992												82.5						<0.05						
	2/25/1993												77.8												
	3/30/1993		0.5		<0.005	0.6		289	0.1	<0.002	163	0	239	<0.02	<0.05	0.01	<0.01	1.33	1.85	<0.02	61	0.07	<0.001	<0.02	<0.01
	9/28/1993												207												
	3/17/1994												118.2												
	5/24/1994		4.6	<0.005	<0.005	<0.1		261		0.00097	120	0	130	<0.025		<0.025		0.97	4.5	0.0079	47	0.19	<0.001		<0.05
	6/23/1994												124.3												
	7/22/1994		<0.05	0.0059	<0.005	<0.1	<0.002	270	<0.1	<0.0005	120	0	128	<0.025	<0.05	<0.025		0.94	<0.05	<0.005	43	<0.03	<0.001	<0.05	<0.05
	9/22/1994												123.8												
	1/29/1995												94.1												
	3/29/1995												90.7												
	6/27/1995												95.9												
	9/21/1995												86.6												
	1/10/1996												78.6												
	4/3/1996												76.8												
	9/25/1996												57.2												
	1/15/1997												56												
	1/31/2010	160	<0.020	<0.0025	0.0032	0.058	<0.0020	160	<0.040	<0.0020	120	<2.0	150	<0.0060	<0.0060	<0.0060	<0.005	0.48	0.089	<0.0050	35	0.19	<0.00020	<0.0080	<0.010
	6/28/2010	170	<0.020	<0.0010	<0.0010	0.057	<0.0020	170	<0.040	<0.0020	130	<2.0	170	<0.0060	<0.0060	<0.0060		0.44	<0.020	<0.0050	35	0.021	<0.00020	<0.0080	<0.010
NP-3	10/8/1981		<0.25		0.005	<1		211	0.188	<0.01	40.9	<1	28.6	<0.05	<0.05	<0.05	<0.05	1.58	<0.1	<0.05	9.55	0.81	<1	<0.1	<0.05
	10/27/1981		<0.01		<0.01	0.2			<0.1	<0.005	41		28	<0.01	<0.02	<0.05	<0.01	1.9	0.39	<0.02		1	<0.001	0.16	<0.05
	10/30/1981		<0.25		<0.005	<1			0.29	<0.01			31.2	<0.05	<0.05	<0.05	<0.05	1.6	<0.1	<0.05		1.03	<0.001	<0.1	<0.02
	11/6/1981		<0.01		<0.01	<0.2			<0.1	<0.005	39		28	<0.01	<0.02	<0.05	<0.01	1.6	<0.1	<0.02		0.47	<0.001	0.26	<0.05
	11/13/1981		<0.25		0.009	<0.1		190.3	0.034	<0.001	55.2		26.71	<0.005				1.39		<0.005	13.05	1.01	<0.0005	0.065	<0.05
	11/17/1981		<0.01		<0.01	0.24			<0.1	<0.005	44		26	<0.01	<0.02	<0.05	<0.01	1.4	<0.1	<0.02		1	<0.001	0.2	<0.05
	11/23/1981		<0.01		<0.01	0.02			<0.1	<0.005	47		26	<0.02	<0.02	<0.05	<0.01	1.2	<0.1	<0.02		0.96	<0.001	0.15	<0.05
	12/7/1981		<0.01		<0.01	<0.2			<0.1	<0.005	47		28	<0.01	<0.02	<0.05	<0.01	1.1	<0.1	<0.02		0.78	<0.001	0.13	<0.05
	12/15/1981		<0.01		<0.01	<0.2			<0.1	<0.005	56		26	<0.01	<0.02	<0.05	<0.01	1.1	<0.1	<0.02		0.87	<0.001	0.094	<0.05
	12/22/1981		<0.01		<0.01	<0.2			<0.1	<0.005	73		26	<0.01	<0.02	<0.05	<0.01	0.9	<0.1	<0.02		0.76	<0.001	0.1	<0.05

Table 8-11
Groundwater Quality Analytical Results

Well Name	Collection Date	Nitrate (As N)+Nitrite (As N) (mg/L)	Nitrate as N (NO3) (mg/L)	Nitrogen, Nitrate (As N) (mg/L)	Nitrogen, Nitrite (As N) (mg/L)	pH	Potassium (mg/L)	Selenium (mg/L)	Silicon (mg/L)	Silver (mg/L)	Sodium (mg/L)	Specific Conductance (µmhos/cm)	Sulfate (mg/L)	Suspended Solids (mg/L)	Thallium (mg/L)	Total Dissolved Solids (mg/L)	Uranium (mg/L)	Vanadium (mg/L)	Zinc (mg/L)
NP-2	7/19/1991		0.02			7.55	0.8	0.018		<0.02	47.8	726	180.8			453			
	8/29/1991					8.11							197.6			471			
	11/26/1991					7.45							170			460			
	3/15/1992					8.07							194.2			467			
	5/25/1992					8.34							161.7			456			
	7/16/1992					8.13							183.7			479			
	10/8/1992					8.26							178.9			494			
	11/27/1992					8.38							179.4			451			
	12/15/1992					8.43							166.8			612			
	2/25/1993					8.62							197.2			475			
	3/30/1993		3.3			7.7	0.9	0.005		<0.01	163	1910	436			1310			0.67
	9/28/1993					7.92							299.9			1170			
	3/17/1994					7.65							300.5			971			
	5/24/1994		<0.1			8.03	2.3	<0.005		<0.025	100	1250	300			878			4.1
	6/23/1994					7.69							267.6			848			
	7/22/1994		1.5			7.88	1.3	<0.005		<0.025	120	1360	299		<0.005	878			1.2
	9/22/1994					7.55							252.7			963			
	1/29/1995					7.57							120.9			791			
	3/29/1995					7.69							228.7			1164			
	6/27/1995					7.93							247.1			778			
	9/21/1995					7.36							211.8			722			
	1/10/1996					7.1							173.1			632			
	4/3/1996					7.23							168.7			603			
	9/25/1996					7.68							118			598			
	1/15/1997					7.44							148.4			536			
	1/31/2010	2.5				8	2.4	0.017		<0.0050	75	1100	210		<0.0025	746			1.1
	6/28/2010	2.7				7	2.2	0.012	17	<0.0050	71	1200	260	740	<0.0010	846	0.0017	<0.050	0.26
NP-3	10/8/1981		<0.05			6.98	9.71	0.005		<0.02	79		94.5			460			1.25
	10/27/1981		0.4			8		<0.005		<0.02			148			390			0.98
	10/30/1981		<0.05			7.89		<0.002		<0.02			102			428			0.93
	11/6/1981		0.2			7.9		<0.005		<0.02			140			380			1.1
	11/13/1981		0.16			7.6	5.85	0.023		0.023	43.7	600	140.6			446			1.59
	11/17/1981		<0.2			8.1		<0.005		<0.02			144			390			1.2
	11/23/1981		0.2			7.8		<0.005		<0.01			144			460			1.9
	12/7/1981		<0.2			7.9		<0.005		<0.02			153			450			3.5
	12/15/1981		0.2			7.8		<0.005		<0.02			149			450			2.5
	12/22/1981		0.2			7.9		<0.005		<0.02			149			410			2.1

Table 8-11
Groundwater Quality Analytical Results

Well Name	Collection Date	Alkalinity, Total (As CaCO3) (mg/L CaCO3)	Aluminum (mg/L)	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Bicarbonate (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Calcium (mg/L)	Carbonate (mg/L)	Chloride (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Cyanide (mg/L)	Fluoride (mg/L)	Iron (mg/L)	Lead (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)	Nickel (mg/L)
NP-3	1/5/1982		<0.01		<0.01	<0.2			<0.1	<0.005	56		26	<0.01	<0.02	<0.05	<0.01	1.1	0.31	<0.02		0.72	<0.001	0.01	<0.05
	1/26/1982									<0.005			30			<0.05	<0.01	1	<0.1			0.7	<0.001	<0.1	
	2/22/1982									<0.005			28			<0.05	<0.01	0.9	0.14			0.66	<0.001	<0.05	
	4/26/1982									<0.005			28			<0.05	<0.01	0.8	0.24			0.4	<0.001	<0.05	
	5/17/1982									<0.005			562			<0.05	<0.01	0.7	0.16			0.23	<0.001	<0.05	
	5/24/1982																		<0.1			0.053			
	5/28/1982																		<0.1			0.063			
	6/8/1982									<0.005			30			<0.05	<0.01	0.5	<0.1			0.1	<0.001	<0.05	
	6/30/1982									<0.005			26			<0.05	<0.01	0.5	<0.1			0.081	<0.001	<0.05	
	9/2/1982							308		<0.001	77.4		27.82					0.53			15.1	<0.05		<0.01	
	10/27/1982									<0.005			26			<0.05	<0.01	0.6	<0.1			<0.05	<0.001	<0.05	
	2/21/1983									<0.005			26			<0.05	<0.01	0.5	<0.1			<0.05	<0.001	<0.05	
	5/13/1983									<0.005			64			<0.05	<0.01	0.5	<0.1			<0.05	<0.001	<0.05	
	8/9/1983									<0.005			114			<0.05	<0.01	0.5	<0.1			<0.05	<0.001	<0.05	
	11/1/1983									<0.005			162			<0.05	<0.01	0.5	0.14			<0.05	<0.001	<0.05	
	3/16/1984									<0.005			228			<0.05	<0.01	0.6	<0.1			<0.05	0.001	<0.05	
	5/30/1984									<0.005			248			<0.05	<0.01	0.4	<0.1			<0.05	<0.001	<0.05	
	9/12/1984									<0.005			270			<0.05	<0.01	0.4	<0.1			<0.05	<0.001	<0.05	
	11/27/1984									<0.005			290			<0.05	<0.01	0.4	<0.1			<0.05	<0.001	<0.05	
	5/17/1985												310												
	11/13/1985												288												
	5/23/1986												282												
	10/8/1986												272												
	3/3/1987																								
	3/4/1987							188			320		283								67.1				
	5/25/1987																								
	1/12/1988		<0.1			<0.1	<0.1	30	<0.1	<0.1	268		359	<0.1	<0.05	<0.1			<0.1	<0.1	57	0.57		<0.1	<0.1
	4/4/1988												254												
	8/23/1988												251.4												
	2/9/1989												254.3												
	6/1/1989												241.1												
	11/30/1989												158.9												
	11/14/1990												228.7												
	2/11/1991				<0.001								255.9												
	7/19/1991				<0.002	<0.01		191.6		<0.005	287	0	239.2	<0.02		<0.02		0.66	0.28	<0.005	53.4	0.08	0.0002		
	8/29/1991												254.3												
	11/26/1991												248.1												

Table 8-11
Groundwater Quality Analytical Results

Well Name	Collection Date	Nitrate (As N)+Nitrite (As N) (mg/L)	Nitrate as N (NO3) (mg/L)	Nitrogen, Nitrate (As N) (mg/L)	Nitrogen, Nitrite (As N) (mg/L)	pH	Potassium (mg/L)	Selenium (mg/L)	Silicon (mg/L)	Silver (mg/L)	Sodium (mg/L)	Specific Conductance (µmhos/cm)	Sulfate (mg/L)	Suspended Solids (mg/L)	Thallium (mg/L)	Total Dissolved Solids (mg/L)	Uranium (mg/L)	Vanadium (mg/L)	Zinc (mg/L)
NP-3	1/5/1982		0.2			7.7		<0.02		<0.02			154			360			1.7
	1/26/1982		0.2			8.1		<0.005					151			400			
	2/22/1982		<0.2			8		<0.005					137			420			
	4/26/1982		<0.2			7.9		<0.005					146			410			
	5/17/1982		12			7.6		<0.005					900			2460			
	5/24/1982																		
	5/28/1982																		
	6/8/1982		1.9			7.9		<0.005					150			500			
	6/30/1982		1.8			7.9		<0.005					128			510			
	9/2/1982		1.94			7.5	3.9	<0.005			64.4	750	123.8			498			
	10/27/1982		1.6			8		<0.005					132			450			
	2/21/1983		1.4			8.2		<0.005					131			410			
	5/13/1983		2.1			8		<0.005					139			500			
	8/9/1983		2.3			7.8		<0.005					100			630			
	11/1/1983		3.8			7.9		<0.005					163			760			
	3/16/1984		3.2			8.1		<0.005					216			870			
	5/30/1984		2.9			7.8		<0.005					292			1060			
	9/12/1984		3.1			7.7		<0.005					292			1140			
	11/27/1984		3.5			7.8		<0.005					348			1150			
	5/17/1985					7.7							453			1470			
	11/13/1985					7.2							541			1520			
	5/23/1986					7.5							624			1590			
	10/8/1986					7.4							620			1710			
	3/3/1987												695						
	3/4/1987					6.8	4.29				117.3	1850	695			1882			
	5/25/1987												735.5						
	1/12/1988						38			<0.1	142		755			1584			1.1
	4/4/1988												587			1772			
	8/23/1988												835.2			1744			
	2/9/1989												763.4			1583			
	6/1/1989												713.6			1596			
	11/30/1989												742.9			1600			
	11/14/1990												821.6			1675			
	2/11/1991									255.9			970.5			1551			
	7/19/1991		0.23			8.29	7	0.011		<0.02	189.7	2520	820.3			1663			
	8/29/1991					7.84							854.1			1616			
	11/26/1991					7.08							745.2			1613			

Table 8-11
Groundwater Quality Analytical Results

Well Name	Collection Date	Alkalinity, Total (As CaCO3) (mg/L CaCO3)	Aluminum (mg/L)	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Bicarbonate (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Calcium (mg/L)	Carbonate (mg/L)	Chloride (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Cyanide (mg/L)	Fluoride (mg/L)	Iron (mg/L)	Lead (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)	Nickel (mg/L)
NP-3	3/15/1992												227.8												
	5/25/1992												216.4												
	7/16/1992												226.1												
	10/8/1992												211.6												
	11/27/1992												254.7												
	12/15/1992												223.2			0.01									
	2/25/1993												219.3												
	3/30/1993		0.1		<0.005	<0.5		29	0.02	<0.002	296	0	205	<0.02	<0.05	0.01	<0.01	0.54	4.99	<0.02	35	0.32	<0.001	<0.02	<0.01
	9/28/1993												210.3			<0.001			<0.05			0.24			
	3/17/1994												169.5			0.012			0.24			0.33			
	6/23/1994												205.7												
	7/22/1994		<0.05	<0.005	<0.005	<0.1	<0.002	118	<0.1	<0.0005	320	0	194	<0.025	<0.05	<0.025		0.34	<0.05	<0.005	73	0.61	<0.001	<0.05	<0.05
	9/22/1994												195.5												
	1/29/1995												566.4												
	3/29/1995												185.5												
	6/27/1995												202.7												
	9/21/1995												208.4												
	1/10/1996												208.5												
	4/3/1996												208.3												
	9/25/1996												190.5												
	1/15/1997												207												
	7/8/2010	120	<0.020	<0.0010	<0.0010	0.030	<0.0020	120	<0.040	<0.0020	310	<2.0	270	<0.0060	<0.0060	<0.0060		0.36	0.049	<0.0050	60	0.031	<0.00020	<0.0080	<0.010
	10/7/2010	120	<0.02	<0.001	<0.005	0.031	<0.002	120	<0.04	<0.002	290	<2	290	<0.006	<0.006	<0.006		0.29	0.1	<0.005	60	0.015	<0.0002	<0.008	<0.01
	5/11/2011	130	<0.02	<0.001	0.0029	0.032	<0.002	130	<0.04	<0.002	300	<2	270	<0.006	<0.006	<0.006	<0.005	0.34	0.039	<0.005	57	0.022	<0.0002	<0.008	<0.01
NP-4	4/26/1982									<0.005			46			0.051	<0.01	1.5	3.8			0.6	<0.001	0.07	
	5/17/1982									<0.005			46			<0.05	<0.01	1	0.11			<0.05	<0.001	<0.05	
	5/24/1982																		<0.1			<0.05			
	5/28/1982																		<0.1			<0.05			
	6/8/1982									<0.005			26			<0.05	<0.01	0.5	<0.1			<0.05	<0.001	<0.05	
	6/30/1982									<0.005			28			<0.05	<0.01	0.4	<0.1			<0.05	<0.001	<0.05	
	9/2/1982							63.1		<0.001	7.2		28.72					0.4			3.5	<0.05		<0.01	
	10/27/1982									0.0061			36			<0.05	<0.01	0.4	0.34			<0.05	<0.001	<0.05	
	2/21/1983									<0.005			48			<0.05	<0.01	0.4	0.28			<0.05	0.001	<0.05	
	5/13/1983									<0.005			76			<0.05	<0.01	0.4	<0.1			<0.05	<0.001	<0.05	
	8/9/1983									<0.005			94			<0.05	<0.01	0.3	<0.1			<0.05	<0.001	<0.05	
	11/1/1983									<0.005			114			<0.05	<0.01	0.3	<0.1			<0.05	<0.001	<0.05	
	3/16/1984									<0.005			126			<0.05	<0.01	0.6	<0.1			<0.05	0.001	<0.05	

Table 8-11
Groundwater Quality Analytical Results

Well Name	Collection Date	Nitrate (As N)+Nitrite (As N) (mg/L)	Nitrate as N (NO3) (mg/L)	Nitrogen, Nitrate (As N) (mg/L)	Nitrogen, Nitrite (As N) (mg/L)	pH	Potassium (mg/L)	Selenium (mg/L)	Silicon (mg/L)	Silver (mg/L)	Sodium (mg/L)	Specific Conductance (µmhos/cm)	Sulfate (mg/L)	Suspended Solids (mg/L)	Thallium (mg/L)	Total Dissolved Solids (mg/L)	Uranium (mg/L)	Vanadium (mg/L)	Zinc (mg/L)
NP-3	3/15/1992					7.63							921.3			1644			
	5/25/1992					7.85							752.9			1607			
	7/16/1992					7.26							802.2			1578			
	10/8/1992					7.69							799.1			1445			
	11/27/1992					7.49							796.1			1640			
	12/15/1992					7.75							545.3			1558			
	2/25/1993					7.65							793.6			1580			
	3/30/1993					7.4	4.1	<0.005		<0.01	129	2070	825			1560			6.98
	9/28/1993					7.88							619.4			1544			1.04
	3/17/1994					7.46							746.9			1609			2.58
	6/23/1994					7.77							778.6			1628			
	7/22/1994		<1			7.83	4.5	<0.005		<0.025	120	2160	796		<0.005	1620			1.8
	9/22/1994					7.65							707.1			1691			
	1/29/1995					7.45							651.9			1623			
	3/29/1995					7.48							558			1639			
	6/27/1995					7.38							717			1607			
	9/21/1995					7.5							822			1557			
	1/10/1996					7.32							724.1			1464			
	4/3/1996					7.29							722.6			1415			
	9/25/1996					7.72							536.5			1472			
	1/15/1997					7.51							657.4			1478			
	7/8/2010	6.8				8	3.6	0.023	15	<0.0050	120	2100	790	100	<0.0010	1740	0.0014	<0.050	0.44
	10/7/2010	5.6				7.57	3.5	0.023	15	<0.005	110	2000	830	97	<0.001	1660	0.0015	<0.05	0.31
	5/11/2011	6.2				7.69	3.3	0.027	15	<0.005	120	2100	790	400	<0.001	1640	0.0015	<0.05	0.24
NP-4	4/26/1982		0.6			8.6		<0.005					132			410			
	5/17/1982		1.3			9.4		<0.005					138			310			
	5/24/1982																		
	5/28/1982																		
	6/8/1982		4.5			8.4		<0.005					140			420			
	6/30/1982		<0.2			9.5		<0.005					115			270			
	9/2/1982		0.03			8.5	3.9	<0.005			71.3	410	107.1			252			
	10/27/1982		<0.2			8.9		<0.005					108			230			
	2/21/1983		0.2			9.3		<0.005					115			250			
	5/13/1983		<0.2			7.9		<0.005					134			340			
	8/9/1983		<0.2			8.8		<0.005					156			430			
	11/1/1983		0.6			8.2		<0.005					206			530			
	3/16/1984		0.2			8		<0.005					256			540			

Table 8-11
Groundwater Quality Analytical Results

Well Name	Collection Date	Alkalinity, Total (As CaCO3) (mg/L CaCO3)	Aluminum (mg/L)	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Bicarbonate (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Calcium (mg/L)	Carbonate (mg/L)	Chloride (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Cyanide (mg/L)	Fluoride (mg/L)	Iron (mg/L)	Lead (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)	Nickel (mg/L)
NP-4	5/30/1984									<0.005			134			<0.05	<0.01	0.3	<0.1			<0.05	<0.001	<0.05	
	9/12/1984									<0.005			134			<0.05	<0.01	0.3	<0.1			<0.05	<0.001	<0.05	
	11/27/1984									<0.005			140			<0.05	<0.01	0.3	<0.1			<0.05	<0.001	<0.05	
	5/17/1985												146												
	11/13/1985												142												
	5/23/1986												136												
	10/8/1986												134												
	5/25/1987																								
	1/12/1988		<0.1			<0.1	<0.1	24.4	<0.1	<0.1	76		137	<0.1	<0.05	<0.1			<0.1	<0.1	21	0.06		<0.1	<0.1
	4/4/1988												130.4												
	8/23/1988												132.1												
	2/9/1989												130												
	6/1/1989												116.4												
	11/30/1989												96.9												
	11/14/1990												153.1												
	2/11/1991				<0.001								126.1												
	7/19/1991				<0.002	0.28		54.9		<0.005	63.4	0	112.3	<0.02				0.41	5.14	<0.005	20.8	<0.02	<0.0002		
	8/29/1991												110.7												
	11/26/1991												99												
	3/15/1992												102.9												
	5/25/1992												106.2												
	7/16/1992												94.4												
	10/8/1992												102.9												
	11/27/1992												97.5												
	12/15/1992												84.4												
	2/25/1993												76.6												
	3/31/1993		0.3		<0.005	<0.5		275	0.04	<0.002	76	0	45	<0.02	<0.05	0.01	<0.01	0.53	0.62	<0.02	17	0.84	0.009	<0.02	<0.01
	9/28/1993												56.9												
	5/26/1994		3.5	<0.005	<0.005	<0.1		320		0.0034	73	0	39	<0.025		<0.025		0.46	15	0.018	15	0.16	<0.001		<0.05
	6/23/1994												48.5												
	7/23/1994		<0.05	0.01	<0.005	<0.1	<0.002	279	<0.1	<0.0005	88	0	34	<0.025	<0.05	<0.025		0.48	<0.05	<0.005	16	<0.03	<0.001	<0.05	<0.05
	9/22/1994												36.9												
	1/29/1995												34.5												
	3/29/1995												33.8												
	6/27/1995												33.2												
	9/21/1995												35.3												
	1/10/1996												34.7												

Table 8-11
Groundwater Quality Analytical Results

Well Name	Collection Date	Nitrate (As N)+Nitrite (As N) (mg/L)	Nitrate as N (NO3) (mg/L)	Nitrogen, Nitrate (As N) (mg/L)	Nitrogen, Nitrite (As N) (mg/L)	pH	Potassium (mg/L)	Selenium (mg/L)	Silicon (mg/L)	Silver (mg/L)	Sodium (mg/L)	Specific Conductance (µmhos/cm)	Sulfate (mg/L)	Suspended Solids (mg/L)	Thallium (mg/L)	Total Dissolved Solids (mg/L)	Uranium (mg/L)	Vanadium (mg/L)	Zinc (mg/L)
NP-4	5/30/1984		<0.2			8		<0.005					320			630			
	9/12/1984		0.9			8		<0.005					339			760			
	11/27/1984		0.2			8.5		<0.005					354			740			
	5/17/1985					8.2							348			770			
	11/13/1985					8							292			690			
	5/23/1986					8							300			690			
	10/8/1986					7.8							290			660			
	5/25/1987												278.5						
	1/12/1988						5			<0.1	86		256			612			0.1
	4/4/1988												328.8			610			
	8/23/1988												292.2			688			
	2/9/1989												266.8			604			
	6/1/1989												243.5			580			
	11/30/1989												237.4			572			
	11/14/1990												254.5			262			
	2/11/1991												288.9			676			
	7/19/1991		0.07			7.81	3.1	<0.002		<0.02	66.7	802	198.5			532			
	8/29/1991					8.37							232			532			
	11/26/1991					8.54							193.6			522			
	3/15/1992					8.85							216.5			465			
	5/25/1992					8.62							171.4			439			
	7/16/1992					7.64							176.8			458			
	10/8/1992					9.01							182.9			535			
	11/27/1992					8.12							201.7			495			
	12/15/1992					9.52							151.2			424			
	2/25/1993					9.85							150.8			349			
	3/31/1993		3.7			7.6	2.2	<0.005		<0.01	79	813	134			504			2.41
	9/28/1993					8.2							108.5			437			
	5/26/1994		4.3			8.1	3	<0.005		<0.025	62	800	131			666			12
	6/23/1994					8.13							133.5			498			
	7/23/1994		4.6			7.9	2.5	<0.005		<0.025	72	828	120		<0.005	536			0.51
	9/22/1994					7.73							111			547			
	1/29/1995					7.88							110.7			447			
	3/29/1995					7.86							121.7			494			
	6/27/1995					7.37							134.1			487			
	9/21/1995					7.51							132.1			509			
	1/10/1996					7.35							123.1			483			

Table 8-11
Groundwater Quality Analytical Results

Well Name	Collection Date	Alkalinity, Total (As CaCO3) (mg/L CaCO3)	Aluminum (mg/L)	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Bicarbonate (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Calcium (mg/L)	Carbonate (mg/L)	Chloride (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Cyanide (mg/L)	Fluoride (mg/L)	Iron (mg/L)	Lead (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)	Nickel (mg/L)
NP-4	4/3/1996												26												
	9/25/1996												31.7												
	1/15/1997												98												
	1/31/2010	210	<0.020	<0.0025	<0.0025	0.036	<0.0020	210	<0.040	<0.0020	100	<2.0	40	<0.0060	<0.0060	<0.0060	<0.005	0.46	0.040	<0.0050	18	0.0098	<0.00020	<0.0080	<0.010
	7/2/2010	210	<0.020	<0.0010	<0.0010	0.039	<0.0020	210	<0.040	<0.0020	110	<2.0	39	<0.0060	<0.0060	<0.0060		0.46	<0.020	<0.0050	18	0.0020	<0.00020	<0.0080	<0.010
NP-5	11/4/1981		<0.01		<0.01	<0.2			<0.1	<0.005	86		50	<0.01	<0.02	<0.05	<0.01	1.3	<0.1	<0.02		0.1	<0.001	<0.05	<0.05
	11/13/1981		0.239		<0.005	0.218		186.7	0.07	<0.001	88.6		37.89	<0.005		<0.1	0.001	1.28		<0.005	14.4	0.14	<0.0005	0.015	0.019
	11/17/1981		<0.01		<0.01	<0.2			<0.1	<0.005	72		42	<0.01	<0.02	<0.05	<0.01	1.3	<0.1	<0.02		0.3	<0.001	0.07	<0.05
	11/23/1981		<0.01		<0.01	<0.2			<0.1	<0.005	73		36	<0.02	<0.02	<0.05	<0.01	1.2	<0.1	<0.02		0.091	<0.001	<0.05	<0.05
	12/7/1981		<0.01		<0.01	<0.2			<0.1	<0.005	66		34	<0.01	<0.02	<0.05	<0.01	1.2	<0.1	<0.02		<0.05	<0.001	<0.05	<0.05
	12/15/1981		<0.01		<0.01	<0.2			<0.1	<0.005	90		36	<0.01	<0.02	<0.05	<0.01	1.2	<0.1	<0.02		0.08	<0.001	<0.05	<0.05
	12/22/1981		<0.01		<0.01	<0.2			<0.1	<0.005	101		36	<0.01	<0.02	<0.05	<0.01	1.1	<0.1	<0.02		<0.05	<0.001	<0.05	<0.05
	1/5/1982		<0.01		<0.01	<0.2			<0.1	<0.005	87		34	<0.01	<0.02	<0.05	<0.01	1.1	0.18	<0.02		<0.05	<0.001	<0.05	<0.05
	1/26/1982									<0.005			32			<0.05	<0.01	1.1	<0.01			<0.05	<0.001	<0.1	
	2/22/1982									<0.005			32			<0.05	<0.01	1	0.12			<0.05	<0.001	<0.05	
	4/26/1982									<0.005			30			0.31	0.04	1.1	3.8			6.9	<0.001	<0.05	
	5/17/1982									<0.005			36			<0.05	<0.01	1.1	0.14			<0.05	<0.001	<0.05	
	5/24/1982																		<0.1			<0.05			
	5/28/1982																		<0.1			<0.05			
	6/8/1982									<0.005			30			<0.05	<0.01	0.9	0.44			<0.05	<0.001	<0.05	
	6/30/1982									<0.005			28			<0.05	<0.01	0.9	0.36			<0.05	<0.001	<0.05	
	9/2/1982							206		<0.001	72.6		33.98					0.82			21.8	<0.05		<0.01	
	10/27/1982									<0.005			34			<0.05	<0.01	0.8	0.21			<0.05	<0.001	<0.05	
	2/21/1983									<0.005			26			<0.05	<0.01	0.5	<0.1			<0.05	<0.001	<0.05	
	5/13/1983									<0.005			70			<0.05	<0.01	0.4	<0.1			<0.05	<0.001	<0.05	
	8/9/1983									<0.005			26			<0.05	<0.01	0.8	<0.1			<0.05	<0.001	<0.05	
	11/1/1983									<0.005			30			<0.05	<0.01	0.8	0.1			<0.05	<0.001	<0.05	
	3/16/1984									<0.005			26			<0.05	<0.01	0.4	<0.1			<0.05	<0.001	<0.05	
	5/30/1984									<0.005			22			<0.05	<0.01	0.8	<0.1			<0.05	<0.001	<0.05	
	9/12/1984									<0.005			28			<0.05	<0.01	0.8	<0.1			<0.05	<0.001	<0.05	
	11/27/1984									<0.005			28			<0.05	<0.01	0.8	<0.1			<0.05	<0.001	<0.05	
	5/17/1985												28												
	11/13/1985												24												
	5/23/1986												28												
	10/8/1986												28												
	3/30/1989		<0.1			<0.1	<0.1	211	<0.1	<0.1	82		32	<0.1	<0.05	<0.1			<0.1	<0.1	22	<0.05		<0.1	<0.1
	8/29/1991												38.7												
	11/26/1991												37.7												
	3/15/1992												46.7												
	5/25/1992												75.5												
	7/16/1992												37.8												

Table 8-11
Groundwater Quality Analytical Results

Well Name	Collection Date	Nitrate (As N)+Nitrite (As N) (mg/L)	Nitrate as N (NO3) (mg/L)	Nitrogen, Nitrate (As N) (mg/L)	Nitrogen, Nitrite (As N) (mg/L)	pH	Potassium (mg/L)	Selenium (mg/L)	Silicon (mg/L)	Silver (mg/L)	Sodium (mg/L)	Specific Conductance (µmhos/cm)	Sulfate (mg/L)	Suspended Solids (mg/L)	Thallium (mg/L)	Total Dissolved Solids (mg/L)	Uranium (mg/L)	Vanadium (mg/L)	Zinc (mg/L)
NP-4	4/3/1996					7.19							123.3			475			
	9/25/1996					7.75							125.6			504			
	1/15/1997					7.43							1113			2651			
	1/31/2010	7.4				8	2.4	0.0057		<0.0050	79	900	190		<0.0025	626			1.3
	7/2/2010	7.5				8	2.1	0.0043	15	<0.0050	70	910	190	140	<0.0010	640	0.0023	<0.050	0.82
NP-5	11/4/1981		4.1			8		<0.005		<0.02			196			570			0.14
	11/13/1981		3.56			7.7	5.07	0.014		<0.001	43.7	650	162			488			<0.05
	11/17/1981		2.7			8		<0.005		<0.02			158			500			0.19
	11/23/1981		4			7.8		<0.005		<0.1			161			580			0.21
	12/7/1981		3.1			7.9		<0.005		<0.02			172			510			0.24
	12/15/1981		3.3			7.8		<0.005		<0.02			168			500			0.37
	12/22/1981		3.8			7.9		<0.005		<0.02			161			460			0.32
	1/5/1982		4.1			7.7		<0.02		<0.02			163			420			0.4
	1/26/1982		2.9			8		<0.005					158			440			
	2/22/1982		2			8		<0.005					150			450			
	4/26/1982		1.1			7.9		<0.005					154			450			
	5/17/1982		6.7			8		<0.005					165			490			
	5/24/1982																		
	5/28/1982																		
	6/8/1982		4.5			8.1		<0.005					150			420			
	6/30/1982		3.9			8.1		<0.005					133			460			
	9/2/1982		4.2			7.6	3.9	<0.005			46	650	137.2			472			
	10/27/1982		3.7			8		<0.005					139			440			
	2/21/1983		1.3			8.3		<0.005					139			420			
	5/13/1983		0.2			8.9		<0.005					134			290			
	8/9/1983		3.7			8.1		<0.005					108			460			
	11/1/1983		5.2			8.2		<0.005					111			440			
	3/16/1984		3			8		<0.005					130			380			
	5/30/1984		2.9			7.8		<0.005					139			400			
	9/12/1984		3.4			8		<0.005					125			420			
	11/27/1984		3.2			8.2		<0.005					120			420			
	5/17/1985					7.9							130			450			
	11/13/1985					7.8							134			400			
	5/23/1986					7.9							120			430			
	10/8/1986					7.8							113			420			
	3/30/1989						3			<0.1	39		125			458			0.4
	8/29/1991					7.68							152.1			499			
	11/26/1991					7							129.5			472			
	3/15/1992					7.89							140.7			456			
	5/25/1992					7.8							131.1			490			
	7/16/1992					7.63							132.4			476			

Table 8-11
Groundwater Quality Analytical Results

Well Name	Collection Date	Alkalinity, Total (As CaCO3) (mg/L CaCO3)	Aluminum (mg/L)	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Bicarbonate (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Calcium (mg/L)	Carbonate (mg/L)	Chloride (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Cyanide (mg/L)	Fluoride (mg/L)	Iron (mg/L)	Lead (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)	Nickel (mg/L)
NP-5	10/8/1992												39.4												
	11/27/1992												117.2												
	12/15/1992												40.4			0.025									
	2/25/1993												41.4												
	3/30/1993		0.2		<0.005	<0.5		221	0.04	<0.002	76	0	39	<0.02	<0.05	<0.01	<0.01	0.77	0.29	<0.02	26	0.02	<0.001	<0.02	<0.01
	9/28/1993												48.1												
	5/24/1994		1.1	<0.005	<0.005	<0.1		211		<0.0005	86	0	41	<0.025		<0.025		0.74	1.2	0.0077	26	0.086	<0.001		<0.05
	6/23/1994												54.1												
	7/23/1994		<0.05	<0.005	<0.005	<0.1	<0.002	206	<0.1	<0.0005	79	0	41	<0.025	<0.05	<0.025		0.71	<0.05	<0.005	24	<0.03	<0.001	<0.05	<0.05
	9/22/1994												42.8												
	1/29/1995												43.5												
	3/29/1995												42.4												
	6/27/1995												43.4												
	9/21/1995												44.3												
	1/10/1996												41.6												
	4/3/1996												31.8												
	9/25/1996												42.5												
	1/15/1997												45.7												
	6/28/2010	160	<0.020	<0.0010	0.0014	0.018	<0.0020	160	<0.040	<0.0020	100	<2.0	80	<0.0060	<0.0060	<0.0060		0.68	<0.020	<0.0050	31	<0.0020	<0.00020	<0.0080	<0.010
	9/30/2010	170	<0.02	<0.001	0.0015	0.018	<0.002	170	0.041	<0.002	99	<2	83	<0.006	<0.006	<0.006	<0.01	0.71	<0.02	<0.005	33	0.005	<0.0002	<0.008	<0.01
	5/10/2011	160	<0.02	<0.001	0.0018	0.019	<0.002	160	0.041	<0.002	99	<2	80	<0.006	<0.006	<0.006	<0.01	0.63	<0.02	<0.005	31	<0.002	<0.0002	<0.008	<0.01
Pague	8/20/1946							242			63		26					1.2			21				
PW-1	12/23/1975							145			22	0	16					0.46			3				
	8/14/1981				<0.01			171			28	0	32			<0.05	<0.01	0.9	0.2	<0.02	4				
PW-2	1/15/1976							153			21	0	17					0.66			3				
	11/27/1984									<0.005			20			<0.05	<0.01	0.6	<0.1			<0.05	<0.001		
	8/2/1994		<0.05	0.011	<0.005	<0.1	<0.002	273	<0.1	<0.0005	60	0	24	<0.025	<0.05	<0.025		0.39	0.062	<0.005	8.4	0.032	<0.001	<0.05	<0.05
PW-3	1/27/1976							158			23	0	24					0.64			3				
	8/14/1981				<0.01			139			16	0	66			<0.05	0.01	2.5	0.31	<0.02	1				
PW-4	8/2/1994		<0.05	0.0062	0.0058	<0.1	<0.002	190	<0.1	<0.0005	21	0	27	<0.025	<0.05	<0.025		0.46	<0.05	<0.005	1.7	<0.03	<0.001	<0.05	<0.05
Saladone Well	12/5/1992							213.2			54.8	<0.3									23				
SHB-27	9/22/1976				<0.01			205	<0.1	<0.001	5.86		20.6	0.002	<0.001	0.002		0.77	0.007	<0.001	21.4	0.039	<0.0004	0.002	
SHB-28	9/22/1976							264	<0.1	<0.001	163		51.2	0.002	<0.001	0.005		0.97	0.015	<0.001	32	0.42	<0.0004	0.003	
SHB-29	9/22/1976								0.1	0.001	65.1			0.004	0.001	0.002			0.52	0.002	14.5	0.049	<0.0004	0.003	
SHB-30	9/22/1976				0.02			211	<0.1	<0.001	84.8		21	0.004	<0.001	0.002		0.79	0.009	<0.001	21.3	0.036	<0.0004	0.002	
SHB-34	9/22/1976							12	<0.1	0.001	3.67		<1	0.002	<0.001	0.002		0.14	0.009	0.001	0.52	0.004	<0.0004	<0.001	

Note: Blank indicates not analyzed.

Table 8-11
Groundwater Quality Analytical Results

Well Name	Collection Date	Nitrate (As N)+Nitrite (As N) (mg/L)	Nitrate as N (NO3) (mg/L)	Nitrogen, Nitrate (As N) (mg/L)	Nitrogen, Nitrite (As N) (mg/L)	pH	Potassium (mg/L)	Selenium (mg/L)	Silicon (mg/L)	Silver (mg/L)	Sodium (mg/L)	Specific Conductance (µmhos/cm)	Sulfate (mg/L)	Suspended Solids (mg/L)	Thallium (mg/L)	Total Dissolved Solids (mg/L)	Uranium (mg/L)	Vanadium (mg/L)	Zinc (mg/L)
NP-5	10/8/1992					7.64							133.2			431			
	11/27/1992					8.01							133.9			475			
	12/15/1992					7.8							104			402			
	2/25/1993					7.65							140.8			487			
	3/30/1993		4			7.8	2.5	<0.005		<0.01	43	746	146			488			0.19
	9/28/1993					7.79							109.2			518			
	5/24/1994		3.4			7.84	3.4	<0.005		<0.025	40	680	130			520			2.3
	6/23/1994					7.66							142.3			466			
	7/23/1994		3.3			7.89	3.1	<0.005		<0.025	45	749	131		<0.005	494			<0.05
	9/22/1994					7.73							117.7			526			
	1/29/1995					7.99							101.2			490			
	3/29/1995					7.94							130.8			449			
	6/27/1995					7.64							119.4			525			
	9/21/1995					7.71							134.6			483			
	1/10/1996					8.04							136.6			406			
	4/3/1996					7.67							130			405			
	9/25/1996					8.09							129.4			504			
	1/15/1997					7.76							140.69			498			
	6/28/2010	3.9				8	2.9	0.0067	20	<0.0050	44	900	180	23	<0.0010	623	0.0013	<0.050	0.29
	9/30/2010	4				7.72	2.8	0.0079	19	<0.005	46	910	170	31	<0.001	629	0.0013	<0.05	0.2
	5/10/2011			4.1	<0.1	7.76	2.9	0.0076	20	<0.005	43	940	180	130	<0.001	636	0.0013	<0.05	0.25
Pague	8/20/1946		1.2									409	80			348			
PW-1	12/23/1975		3.5			7.8	4.5				38	340	10			217			
	8/14/1981		0.7			8.1					53		24			250			<0.05
PW-2	1/15/1976		3.5			8.1	4.3				39	310	<5			257			
	11/27/1984		1.7			7.9		<0.005					125			470			
	8/2/1994		<1			7.63	3.4	<0.005		<0.025	46	506	27		<0.005	338			<0.05
PW-3	1/27/1976		2.6			8	5.1				44	330	<5			243			
	8/14/1981		0.8			8.2					87		31			300			0.19
PW-4	8/2/1994		<1			7.57	3.5	<0.005		<0.025	73	398	17		<0.005	274			<0.05
Saladone Well	12/5/1992		0.19			7.91	2.16				22.4	429	23			354			
SHB-27	9/22/1976		0.8			7.61	5.86	<0.01		<0.001	51.1	720	233			434			0.004
SHB-28	9/22/1976		<0.1			7.58	11.5	<0.01		<0.001	81.7	1260	353			840			0.018
SHB-29	9/22/1976		<0.1			7.98	5.02	<0.01		<0.001	60.3	640				384			0.16
SHB-30	9/22/1976		0.7			7.77	4.88	<0.01		<0.001	50.6	720	145			486			0.004
SHB-34	9/22/1976		<0.1			7.36	0.63	<0.01		<0.001	2.55	41	<1			50			0.014

Note: Blank indicates not analyzed.

Table 8-12
Descriptive Statistics of Historical Data

Sample ID	Chemical	Number of Samples	Number of Detections	Arithmatic Mean	Geometric Mean	Standard Deviation	Mean + 2 Standard Deviations	Minimum	Maximum	Upper Confidence Level (95%)	Method of Determining UCL	Distribution
Crystalline Bedrock Aquifer Wells												
GWQ96-22A	Chloride	3	3	66	54	40	146	20	89	NA	NA	NA
GWQ96-22A	Copper	3	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
GWQ96-22A	Sulfate	3	3	210	205	53	316	150	250	NA	NA	NA
GWQ96-22A	TDS	3	3	723	723	40	804	700	770	NA	NA	NA
GWQ96-23A	Chloride	3	3	19	19	3	25	16	22	NA	NA	NA
GWQ96-23A	Copper	3	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
GWQ96-23A	Sulfate	3	3	240	214	148	536	140	410	NA	NA	NA
GWQ96-23A	TDS	3	3	673	652	216	1105	520	920	NA	NA	NA
Santa Fe Group Aquifer System Wells												
IW-2	Chloride	3	3	376	375	35	446	340	409	NA	NA	NA
IW-2	Copper	2	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
IW-2	Sulfate	3	3	1431	1328	712	2854	1000	2252	NA	NA	NA
IW-2	TDS	3	3	2933	2844	932	4798	2390	4010	NA	NA	NA
MW-6	Chloride	2	2	71	70	6	83	66	75	NA	NA	NA
MW-6	Copper	1	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
MW-6	Sulfate	2	2	42	41	5	51	38	45	NA	NA	NA
MW-6	TDS	2	2	348	337	124	597	260	436	NA	NA	NA
NP-1	Chloride	53	53	23	23	4	32	15	40	24	Student's-t	NonParametric
NP-1	Copper	26	2	0.043	0.027	0.090	0.223	0.005	0.480	NA	NA	NA
NP-1	Sulfate	53	53	136	135	17	171	86	163	140	Student's-t	Normal
NP-1	TDS	53	53	486	472	153	791	277	1484	522	Student's-t	NonParametric
NP-3	Chloride	64	64	178	122	122	422	26	566	250	Chebyshev	NonParametric
NP-3	Copper	32	3	0.023	0.020	0.008	0.039	0.001	0.050	NA	NA	NA
NP-3	Sulfate	66	66	505	390	296	1096	95	971	375	Chebyshev	NonParametric
NP-3	TDS	64	64	1186	1015	565	2316	360	2460	1519	Chebyshev	NonParametric

Notes:

Historic data were collected 1981 through 1997

NA= not applicable due to entire data set being non-detected values, or not enough data to calculate meaningful statistics

Table 8-13
Descriptive Statistics of Baseline Data

Sample ID	Chemical	Number of Samples	Number of Detections	Arithmatic Mean	Geometric Mean	Standard Deviation	Mean + 2 Standard Deviations	Minimum	Maximum	Upper Confidence Level (95%)	Method of Determining UCL	Distribution
Crystalline Bedrock Aquifer Wells												
GWQ96-22A	Chloride	3	3	75	75	6	86	70	81	NA	NA	NA
GWQ96-22A	Copper	3	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
GWQ96-22A	Sulfate	3	3	43	43	9	61	34	52	NA	NA	NA
GWQ96-22A	TDS	3	3	565	565	8	581	557	573	NA	NA	NA
GWQ96-23A	Chloride	4	4	13	13	1	15	12	14	NA	NA	NA
GWQ96-23A	Copper	4	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
GWQ96-23A	Sulfate	4	4	80	49	56	192	6	140	NA	NA	NA
GWQ96-23A	TDS	4	4	754	752	48	850	689	804	NA	NA	NA
Santa Fe Group Aquifer System Wells												
IW-2	Chloride	4	4	550	548	48	645	500	600	NA	NA	NA
IW-2	Copper	4	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
IW-2	Sulfate	4	4	1100	1098	82	1263	1000	1200	NA	NA	NA
IW-2	TDS	4	4	2528	2519	243	3014	2280	2770	NA	NA	NA
MW-6	Chloride	2	2	74	74	1	77	73	75	NA	NA	NA
MW-6	Copper	2	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
MW-6	Sulfate	2	2	49	49	0	49	49	49	NA	NA	NA
MW-6	TDS	2	2	462	462	8	479	456	468	NA	NA	NA
NP-1	Chloride	3	3	37	37	2	40	35	38	NA	NA	NA
NP-1	Copper	3	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
NP-1	Sulfate	3	3	143	143	6	155	140	150	NA	NA	NA
NP-1	TDS	3	3	533	533	17	568	514	548	NA	NA	NA
NP-3	Chloride	3	3	277	277	12	300	270	290	NA	NA	NA
NP-3	Copper	3	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
NP-3	Sulfate	3	3	803	803	23	850	790	830	NA	NA	NA
NP-3	TDS	3	3	1680	1679	53	1786	1640	1740	NA	NA	NA

Notes:

Baseline data were collected January 2010 through May 2011

NA= not applicable due to entire data set being non-detected values, or not enough data to calculate meaningful statistics

Table 8-14

Descriptive Statistics of All Historic and Baseline Data Combined

Sample ID	Chemical	Number of Samples	Number of Detections	Arithmatic Mean	Geometric Mean	Standard Deviation	Mean + 2 Standard Deviations	Minimum	Maximum	Upper Confidence Level (95%)	Method of Determining UCL	Distribution
Crystalline Bedrock Aquifer Wells												
GWQ96-22A	Chloride	6	6	71	64	26	123	20	89	117	Chebyshev*	NonParametric
GWQ96-22A	Copper	6	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
GWQ96-22A	Sulfate	6	6	127	94	97	321	34	250	207	Student's-t*	Normal
GWQ96-22A	TDS	6	6	644	639	91	825	557	770	719	Student's-t*	Normal
GWQ96-23A	Chloride	7	7	15	15	4	23	12	22	18	Student's-t*	Normal
GWQ96-23A	Copper	7	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
GWQ96-23A	Sulfate	7	7	148	92	127	403	6	410	242	Student's-t*	Normal
GWQ96-23A	TDS	7	7	719	708	136	991	520	920	819	Student's-t*	Normal
Santa Fe Group Aquifer System Wells												
IW-2	Chloride	7	7	476	466	101	677	340	600	574	Student's-t*	Normal
IW-2	Copper	6	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
IW-2	Sulfate	7	7	1242	1191	451	2144	1000	2252	1136	Student's-t*	Normal
IW-2	TDS	7	7	2701	2653	605	3912	2280	4010	2648	Student's-t*	Normal
MW-6	Chloride	4	4	72	72	4	81	66	75	NA	NA	NA
MW-6	Copper	3	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
MW-6	Sulfate	4	4	45	45	5	56	38	49	NA	NA	NA
MW-6	TDS	4	4	405	394	98	600	260	468	NA	NA	NA
NP-1	Chloride	56	56	24	23	5	34	15	40	25	Student's-t	NonParametric
NP-1	Copper	29	2	0.039	0.021	0.086	0.211	0.003	0.480	NA	NA	NA
NP-1	Sulfate	56	56	136	135	17	170	86	163	140	Student's-t	Normal
NP-1	TDS	56	56	488	475	149	786	277	1484	523	Student's-t	NonParametric
NP-3	Chloride	67	67	182	126	121	424	26	566	252	Chebyshev	NonParametric
NP-3	Copper	35	3	0.021	0.017	0.010	0.040	0.001	0.050	NA	NA	NA
NP-3	Sulfate	69	69	518	403	295	1109	95	971	684	Chebyshev	NonParametric
NP-3	TDS	67	67	1208	1038	562	2331	360	2460	1531	Chebyshev	NonParametric

Notes:

NA= not applicable due to entire data set being non-detected values

* indicates less than 8 data points, which may not be adequate to compute meaningful statistics and estimates.

Table 8-15

Wells Identified in the SAP for Sampling that Were Not Sampled as Part of the BDR Program

Well Name	Inferred Aquifer	Total Depth (ft bgs)	Top of Screen (ft bgs)	Bottom of Screen (ft bgs)	Year Drilled	Diameter (inches)	Water Quality Sample Proposed	Water Level Measurement Proposed	Reason Water Level Not Measured or Water Quality Sample Not Collected
Delores Well	NA	NA	NA	NA	1932	NA		X	Inaccessible due to safety hazard – open mine shaft
Lower Percha Artesian	NA	NA	NA	NA	NA	NA		X	No access port for water level measurement. Water quality sample collected from existing pump
Upper Percha Well	NA	NA	NA	NA	NA	NA		X	No access port for water level measurement. Existing pump in well.
GWQ94-18	Qal	60.0	10.0	50.0	1994	4	X	X	Dry
IW-3	Qal	45.0	NA	45.0	1982	4		X	No permission from BLM
Saladone Well	Qal	NA	NA	NA	NA	NA		X	Well is destroyed due to flooding of Las Animas Creek
MW-1	SF	1000.0	350.0	1000.0	1975	8	X	X	No access port for water level measurement. Windmill only provided one water quality sample, as it broke during the sampling program
MW-2	SF	1500.0	133.0	1500.0	1975	8	X	X	No access port for water level measurement. Water quality sample collected from windmill. Port installed in May 2011. One sample collected.
MW-4	SF	2000.0	123.0	1500.0	1975	8	X	X	No access port for water level measurement. Existing submersible is plumbed directly to stock tank preventing collection of water quality sample
MW-5	SF	1380.0	306.0	1000.0	1975	8	X	X	No permission from BLM
MW-6	SF	1112.0	310.0	1000.0	1975	8	X	X	No access port. Existing submersible pump and plumbing prevent water quality sample collection

Notes: SF = Santa Fe Group aquifer system; Qal = Quaternary alluvium; NA = Information is not available

Table 8-16

Summary of Hydraulic Properties Estimated from Wells in the Vicinity of the Tailing Impoundment

Well	Pumping Rate (gpm)	Specific Capacity (gpm/ft)	Aquifer Thickness Tested (ft)	Transmissivity (ft^2/day)	Horizontal Hydraulic Conductivity (ft/day)
MW-4	60	0.24	1,377	80	0.06
GWQ-1	119	1.57	328	1,540	4.7
GWQ-7	21	2.33	423	440	1.0
GWQ-9	60	0.44	700	1,710	2.4
GWQ94-17	23	0.19	146	200	1.4

Notes: gpm = gallons per minute

Table 8-17

Summary of 2011 Water Level Measurements Used for Developing the Groundwater Elevation Contour Map

Well	Qtr	Date	Depth to Water (ft)	Measuring Point Elevation (ft amsl)	Water Level Elevation (ft amsl)
Animas Station 8 Well	Q4	5/4/2011	12.67	4,614.8	4,602.1
FW-1	Q4	6/30/2011	-0.30	4,316.0	4,316.3
FW-2 (Dawson irrigation well; LRG-8755)	Q4	6/29/2011	-2.30	4,302.0	4,304.3
FW-3	Q4	6/30/2011	0.00	4,357.0	4,357.0
FW-4 (livestock well)	Q4	6/30/2011	0.00	4,327.0	4,327.0
FW-7 (residence well)	Q4	6/30/2011	-34.70	4,293.0	4,327.7
FW-8	Q4	6/29/2011	-2.00	4,328.0	4,330.0
FW-9 (LRG 08752)	Q4	6/29/2011	-4.10	4,301.0	4,305.1
FW-10 (LRG 08753)	Q4	6/29/2011	-0.20	4,302.0	4,302.2
FW-13	Q4	6/29/2011	-0.20	4,324.0	4,324.2
FW-14 (house well)	Q4	6/29/2011	-3.00	4,296.0	4,299.0
FW-15	Q4	6/29/2011	-0.60	4,330.0	4,330.6
FW-16	Q4	6/29/2011	-2.40	4,290.0	4,292.4
FW-17 (Kirby-south)	Q4	6/29/2011	-1.30	4,261.0	4,262.3
FW-18 (Kirby-north)	Q4	6/29/2011	-2.40	4,266.0	4,268.4
FW-19	Q4	6/30/2011	-1.60	4,342.0	4,343.6
FW-20	Q4	6/30/2011	-1.25	4,323.0	4,324.3
FW-21	Q4	6/30/2011	-11.60	4,331.0	4,342.6
GWQ-2	Q6	12/8/2011	35.18	5,227.4	5,192.3
GWQ-3	Q6	12/8/2011	21.10	5,252.6	5,231.5
GWQ-6(N)	Q6	12/8/2011	34.45	5,395.4	5,360.9
GWQ-6(S)	Q6	12/8/2011	31.00	5,382.8	5,351.8
GWQ-11	Q4	5/4/2011	20.02	5,196.4	5,176.4
GWQ-12	Q6	12/8/2011	79.83	5,237.3	5,157.5
GWQ94-13	Q4	5/4/2011	13.02	5,200.7	5,187.7
GWQ94-14	Q4	5/4/2011	6.42	5,193.1	5,186.7
GWQ94-15	Q4	5/4/2011	4.92	5,183.2	5,178.3
GWQ94-16	Q4	5/4/2011	21.26	5,198.2	5,176.9
GWQ94-21A	Q6	12/8/2011	8.36	5,192.7	5,184.4
GWQ94-21B	Q6	12/8/2011	8.05	5,192.2	5,184.2
GWQ96-22A	Q6	12/8/2011	55.00	5,596.2	5,541.2
GWQ96-22B	Q6	12/8/2011	52.41	5,596.0	5,543.5
GWQ96-23A	Q6	12/8/2011	40.67	5,489.8	5,449.2
GWQ96-23B	Q6	12/8/2011	40.76	5,489.7	5,448.9
GWQ11-24A	Q6	12/8/2011	56.28	5,517.4	5,461.1
GWQ11-24B	Q6	12/8/2011	60.38	5,517.3	5,456.9

Well	Qtr	Date	Depth to Water (ft)	Measuring Point Elevation (ft amsl)	Water Level Elevation (ft amsl)
GWQ11-25A	Q6	12/8/2011	65.67	5,533.6	5,467.9
GWQ11-25B	Q6	12/8/2011	68.97	5,533.4	5,464.4
GWQ-5R	Q6	12/8/2011	54.07	5,412.2	5,358.1
IW-2	Q4	5/4/2011	39.01	5,208.5	5,169.5
MW-4	Q6	12/8/2011	82.20	5,125.0	5,042.8
MW-5	Q6	12/8/2011	332.95	4,712.5	4,379.5
MW-6	Q6	12/8/2011	214.45	4,768.33	4,553.88
MW-10	Q6	12/8/2011	73.31	4,454.3	4,381.7
MW-11	Q6	12/8/2011	14.17	4,454.5	4,442.0
MW-9	Q6	12/8/2011	75.10	4,455.2	4,380.5
NP-1	Q4	5/4/2011	30.80	5,188.9	5,158.1
NP-2	Q4	5/4/2011	32.92	5,192.7	5,159.8
NP-3	Q4	5/4/2011	12.02	5,200.1	5,188.1
NP-4	Q4	5/4/2011	35.22	5,225.9	5,190.7
NP-5	Q4	5/4/2011	22.63	5,199.2	5,176.6
Pague (LA-128)	Q4	5/4/2011	11.69	5,558.1	5,546.5
PW-1	Q6	12/8/2011	328.25	4,708.1	4,379.9
PW-2	Q6	12/8/2011	306.80	4,685.7	4,378.9
PW-3	Q6	12/8/2011	350.60	4,731.5	4,380.9
PW-4	Q6	12/8/2011	289.38	4,669.0	4,379.6
Irwin Well	Q6	12/8/2011	24.26	5,180.0	5,155.7
McCravey-Grayback	Q6	12/8/2011	16.40	5,201.5	5,185.1
Ladder Airstrip Well (Ladder Ranch)	Q6	12/8/2011	285.79	4,997.0	4,711.2
Upper Myers (Ladder Ranch)	Q6	12/8/2011	260.72	5,685.0	5,424.3
John Cross (Ladder Ranch)	Q6	12/8/2011	106.00	5,499.0	5,393.0
Evans (Ladder Ranch)	Q6	12/8/2011	171.28	5,192.0	5,020.7
Pit Lake	Q6	12/8/2011	2.18	5,440.0	5,442.2

Table 8-18

Measured Water Levels in Copper Flat Mine Pit

Date	Time	Staff Gauge Reading (ft)	Pit Lake Elevation (ft amsl)
6/13/2011	16:46	3.80	5,443.80
6/17/2011	14:29	3.72	5,443.72
6/30/2011	13:42	3.46	5,443.46
8/2/2011		3.08	5,443.08
8/28/2011	8:45	2.90	5,442.90
9/8/2011	14:31	2.74	5,442.74
10/20/2011	8:49	2.36	5,442.36

Table 8-19

Identified Dissolved Constituents of Concern for the Pit Lake

Constituent of Concern	Range in Observed Concentration (mg/L)
Aluminum	0.13 to 5.5
Cadmium	0.056 to 0.064
Cobalt	0.34 to 0.39
Copper	0.11 to 11.0
Manganese	39 to 45
Selenium	0.019 to 0.030
Zinc	5.0 to 6.8
Alkalinity	< 20 to 41
Chloride	380 to 420
Fluoride	15 to 18
Sulfate	5,200 to 6,200
Total Dissolved Solids (TDS)	7,770 to 8,700

Notes: mg/L - milligrams per liter

Table 8-20

Summary of Hydraulic Conductivity (Permeability) Estimates From Wells In the Vicinity of the Pit and Waste Rock Piles

Borehole and Zone	Depth Interval (ft)	Geologic Unit	Apparent Permeability	
			(cm/sec)	(ft/day)
GWQ-5R, Zone 1	64-100	Andesite	~0	~0
GWQ11-24, Zone 1	100-147	Monzonite	7×10^{-6}	0.02
GWQ11-24, Zone 2	150-197	Monzonite	3.0×10^{-5}	0.085
GWQ11-24, Zone 3	204-251	Monzonite	4.9×10^{-5}	0.14
GWQ11-25, Zone 1	100-148	Monzonite	~0	~0
GWQ11-25, Zone 2	150-198	Monzonite	2.9×10^{-5}	0.081
GWQ11-25, Zone 3	207-251	Monzonite	2.6×10^{-5}	0.074

Notes: cm/sec = centimeters per second

Table 8-21
Proposed Monitoring Plan for Copper Flat Mine Area

Monitoring Point	4th QTR 2011*	1st QTR 2012*	2nd QTR 2012*	3rd QTR 2012*
Pit Lake Area				
GWQ96-22(A,B)	WL, WQ	WL	WL	WL
GWQ96-23(A,B)	WL, WQ	WL	WL	WL
GWQ11-24(A,B)	WL, WQ	WL, WQ	WL, WQ	WL, WQ
GWQ11-25(A,B)	WL, WQ	WL, WQ	WL, WQ	WL, WQ
Pit Lake	WL, WQ	WL, WQ	WL, WQ	WL, WQ
Pit Wall Seepage (If Present)	WQ	WQ	WQ	WQ
Waste Rock Pile Area				
GWQ-5R	WL, WQ	WL, WQ	WL, WQ	WL, WQ
GWQ-3	WL, WQ	WL, WQ	WL, WQ	WL, WQ
GWQ-1	WL, WQ	WL, WQ	WL, WQ	WL, WQ
GWQ-8	WL, WQ	WL, WQ	WL, WQ	WL, WQ
Tailing Facility Area				
IW-1	WL, WQ	WL, WQ	WL, WQ	WL, WQ
IW-2	WL, WQ	WL, WQ	WL, WQ	WL, WQ
IW-3	WL, WQ	WL, WQ	WL, WQ	WL, WQ
GWQ94-13	WL, WQ	WL, WQ	WL, WQ	WL, WQ
GWQ94-14	WL, WQ	WL, WQ	WL, WQ	WL, WQ
GWQ94-16	WL, WQ	WL, WQ	WL, WQ	WL, WQ
GWQ94-18	WL, WQ	WL, WQ	WL, WQ	WL, WQ
GWQ94-19	WL, WQ	WL, WQ	WL, WQ	WL, WQ
NP-3	WL, WQ	WL, WQ	WL, WQ	WL, WQ
MW-4	WL, WQ	WL, WQ	WL, WQ	WL, WQ
Proposed MW-A	WL, WQ	WL, WQ	WL, WQ	WL, WQ
Proposed MW-B	WL, WQ	WL, WQ	WL, WQ	WL, WQ

* Refer to Stage 1 Abatement Plan proposal amendment for proposed water quality (WQ) parameters and other details.

Figures

Appendix 8-A

Surface Water and Seepage Measurement Location Field Data

Appendix 8-B

Seepage Study Report

Appendix 8-C

Surface Water Analytical Results

Appendix 8-D

Surface Sediment Analytical Results

Appendix 8-E

Pit Lake Analytical Results

Appendix 8-F

Pit Lake Sediment Analytical Results

Appendix 8-G

Water Level Data

Appendix 8-H

List of Inventoried Wells

9 Prior Mining Operations

The following history of the Copper Flat Mine and the overview of previous investigations and sampling programs were summarized from BLM (1999), Raugust (2003), and SRK (2010). The results of previous sampling programs are discussed in the applicable sections of this BDR, as relevant.

9.1 Mining History

Mining activities in the Hillsboro Mining District, including gold mining from both placer and vein deposits, began in 1877. From 1877 to 1893, numerous shafts and adits were developed along veins that radiate to the southwest and northeast from Copper Flat. Placer workings were developed along most of the major creeks that drain to the east and southwest from Black and Animas Peaks. Between 1911 and 1931, underground deposits were further developed; approximately 65 percent of the $7 million of ore produced from the district before 1931 came from underground veins (BLM, 1999). Placer mining increased after 1932 until World War II; small-scale placer mining continues in the area today (Hedlund, 1985; McLemore, 2003 as cited in Raugust, 2003).

Copper exploration began in the area in the 1950s and continued through the early 1970s. Quintana Minerals Corporation (Quintana) leased the property in 1974 and defined reserves sufficient for mine development through an extensive drilling and sampling program. The Copper Flat Partnership, Ltd., with Quintana acting as mine operator, developed and operated an open pit copper mine at the Copper Flat location in 1982 that included a 15,000 ton-per-day flotation mill and a tailings impoundment. Poor economic conditions led to the termination of mining after only 3 months of operation, although the mine remained on a maintenance status until 1986, at which point the facilities were dismantled and the Mine Permit Area was partially reclaimed (BLM, 1999). The mine produced 7.4 million pounds of copper, approximately 2,300 ounces of gold, and nearly 56,000 ounces of silver during its 3-month operational life (Hedlund, 1985). During the 1990s, several companies submitted plans to reopen the Copper Flat operation; however, none of the plans were realized. No mining activities have occurred at Copper Flat since 1982. More detail about copper exploration activities can be found in Section 11.3.

9.2 Surface Features of the Copper Flat Mine

Activity at the Copper Flat Mine in 1982 disturbed 361 acres of BLM-managed public lands and 549 acres of private lands (Figure 9-1) (SRK, 2011). Surface features of the Copper Flat Mine include the following:

- A pit lake that covers approximately 5.2 acres, contains about 60 acre-ft of water, and is roughly 30 ft deep.
- Overburden rock storage piles (disposal areas) to the north, west, south, and east of the pit.
- Former mine and mill areas including an unpaved but maintained road from NM Highway 152 to the mill area and a primitive road to the pit area, a 115-kilovolt power line, and a 20-inch welded steel water line.
- A previously state approved and permitted diversion channel re-routing Greyback Arroyo around the mine site.
- A tailing impoundment area, which is dammed by a 6,600-ft-long dam with a maximum crest height of 60 ft, and which includes at least 1.2 million tons of tailing over a 60-acre area (SRK, 1995).

9.3 Historical Investigations

A number of investigations and sampling programs have been undertaken at Copper Flat in the past 30 years; several of these provide valuable sources of baseline data as these were related to various permitting processes including EAs, a Draft EIS (DEIS) in 1996, and a Preliminary Final EIS in 1999. For example, in the 8-year period before the 1982 operations began, Quintana collected baseline data at the Mine Permit Area related to climate, soils, vegetation, wildlife, surface water, groundwater, and archeology (Glover, 1977). The geology, mining history, and mineral deposits associated with Copper Flat were described by Hedlund in 1985; the results of a later field investigation that included sampling, water supply information, and ore reserves were documented by Dunn (1992). Aquifer testing was performed as early as the late 1970s and early 1980s, as well as again related to Alta Gold's PFEIS processes in the late 1990s. At least two environmental assessments and one environmental impact statement were prepared for the Mine Permit Area during the 1990s (Raugust, 2003). A number of reports were prepared for Alta Gold in the late 1990s related to the DEIS process; these reports included but are not limited to those summarized by SRK, Adrian Brown Consultants, and ENSR; an independent evaluation was also prepared by Daniel B. Stephens & Associates, Inc. in 1997 (Raugust, 2003). During 2009 and early 2010, a Copper Flat drilling program was undertaken by NMCC to verify the historical Alta Gold data and to expand and refine the existing resources at Copper Flat (SRK, 2010).

Many of these previous investigations have focused on vegetation, wildlife, soil, potential acid rock drainage, climate and air quality, surface water and groundwater at or near the Mine Permit Area. Between 1989 and 1998, the pit lake was sampled 65 times by various investigators (BLM, 1999). Samples were typically analyzed for pH, major cations and anions, and metals (Raugust, 2003). Attempts were made to measure the flow at local springs and seeps in the 1990s and surface water sampling of creeks began before the 1982 mining operations and continued sporadically until the late 1990s. Before 1996, only one well was available at the Mine Permit Area for groundwater sampling; two additional wells were drilled during 1996 and used for subsequent sampling in the late 1990s (Raugust, 2003). Groundwater samples have also been taken from wells downgradient of the tailing impoundment dam.

Characterization of waste rock from outcrop and storage piles was undertaken in 1994 and again in 1997 to assess existing geochemical characteristics and potential for future acid generation (Raugust, 2003).Test borings in the tailing impoundment area have also been undertaken to investigate the nature of near-surface material and its suitability as borrow material (Raugust, 2003).

9.4 Prior Mining Operations

In 1982, approximately 3,000 tons of overburden, alluvium and waste rock were stripped and 1,200,000 tons of ore were mined. The ore body was mined by a 20-foot high multiple bench open pit method. Mining was initiated at the "5600" bench level and excavation had reached the "5400" bench level when operation stopped three months later (Gold Express, 1991).

Ore processing included rotary diesel-driven drills for blast holes, blasting was accomplished with primacord, ammonium nitrate and fuel oil emulsion suitable for use where wet holes were encountered. Ore and waste were hauled from the pit using en-dump, 85-ton capacity trucks. Broken rock in the pit was classified as "ore" or "waste" based on assay values of samples from the blast holes. Ore was hauled to the primary crusher and waste to the waste dump. Ore was processed on a gyratory crusher, then moved to the coarse ore stockpile. Coarse ore was drawn onto conveyor belts for transport to the semiautogenous mill (SAG mill) for reduction by crushing and attrition. Water along with various reagents were added to the SAG mill to begin conditioning of the pulp. The SAG mill discharged onto a double deck vibrating screen, cyclones and belt conveyors ground material to prepare it for flotation (Gold Express, 1991).

In the flotation process, reagents were added to pulp to collect the sulfide mineral particles and cause them to adhere to bubbles caused by induced air and frothing agents. The sulfide-laden bubbles would rise to the top of the cell and be skimmed off. Lime was added to the grinding circuit to raise the alkalinity for separation of the copper sulfides from the iron sulfides. The rougher concentrate reported to the cleaner circuit for additional grinding and flotation. The concentrate from the cleaner circuit contained the copper and molybdenum sulfide minerals and was fed to the moly plant for further flotation and grinding to separate the copper and molybdenum sulfides into copper and molybdenum concentrates. Copper concentrate was dewatered by thickener and filter plant and stored for shipment to a smelter. The moly concentrate was dewatered and dried by heat before being packed into containers for shipment to the purchaser (Gold Express, 1991).

The waste fraction of the flotation process (tails) was partially dewatered in the tailings thickener and transported by pipeline to the tailing storage area for impoundment behind the tailing dam (Gold Express, 1991).

Reagents were delivered from commercial sources by truck at the plant site where facilities were in place for off-loading, storing, mixing, and handling. Lime was received in pebble form by truck (Gold Express, 1991).

9.5 References

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Figure

10 Cultural Resources – Summary

A full Cultural Resources report will be submitted to the New Mexico State Historic Preservation Officer (SHPO).

10.1 Interpretive Summary

A brief history of historic mining within the Baseline Study Area and the potential Las Animas historic mining district is presented because an understanding of the historic context and period(s) of significance is necessary for interpreting and assessing potential districts and the individual properties they contain (Hardesty, 1990). The Las Animas (Hillsboro) mining district was discovered in 1877 within a vein between Copper Flat and Hillsboro and within placer deposits along Snake and Wicks gulches, south of the Baseline Study Area. These placer deposits were rich enough that a miner named George Wells reportedly collected $90,000 worth of gold in 1877 and 1878, leading to a gold rush as cabins and tents sprang up across the Animas Hills. Hard rock lode mining began in the late 1870s at various locations within Copper Flat and the surrounding Animas Hills, and ore was processed at a 10-stamp mill in Hillsboro beginning in 1878. Mills were constructed at Bobtail, Richmond, Bonanza, Snake, and other mines, and a small tent town named Gold Dust was founded at the south edge of the Baseline Study Area in 1881. Numerous mines reaching depths of 500 ft accessed a system of veins radiating out from Copper Flat across the Animas Hills, and placer extraction focused on the alluvial plain east of the Animas Hills along Greyback, Hunkidori, and Greenhorn gulches, and to the south along Wicks and Snake gulches. Important named mines within the Mine Permit Area include Chance Mine, Little Jewess Mine, Sweetwater Claim, the Petaluma Group, and Sternberg Mine. Although the Sternberg Mine (in the center of Copper Flat) was entirely destroyed by later mining activity, remains of other named mines were documented during this investigation.

Placer deposits consisting of detrital material eroded from Copper Flat and the Animas Hills are found on the alluvial plain east of the Animas Hills, which is dissected by Greyback, Greenhorn, and Hunkidori gulches. These placer deposits produced gold valued at more than $2,000,000 from 1871 to 1931 (Christensen, 2007), and the extant remains of exploration and extraction of material from these placer deposits make up most of the historic sites in the Baseline Study Area. Along Greyback Gulch, a small mining settlement gained a degree of permanence and was referred to as Placeres (Bussey and Naylor, 1975). The area of Slapjack and Jones Hills (known as the Luxemburg Placers) was developed by the Consolidated Gold Fields of New Mexico, Inc. during this period, while the Placer Syndicate Mining Company developed the Gold Dust Placers in the southern portion of the Baseline Study Area and also constructed a large reservoir and placer worked along Dutch and Greyback gulches, which supposedly had a capacity of more than 1000 cubic yards a day. Not surprisingly, the area along these gulches and on Jones and Slapjack Hills is extremely dense in historic mining features, camps, and prospects and mines.

As is often the case, the Las Animas mining district experienced numerous boom and bust cycles and changes in mining strategy over the years. However, new periods of lode mining production occurred from 1918 through 1921 and 1931 through 1933, with a total of 6,506 tons of ore (including 836 tons of gold) extracted from the district between 1911 and 1931. During the Great Depression, out-of-work migrants once again flocked to the district, although now the focus was on small-scale placer exploration rather than lode mining. Larger operators such as the J.I. Hallet Construction Company installed placer processing facilities beginning in 1936, although these efforts ended in 1942 (Christensen, 2007). Small-scale, sporadic efforts continued until 1975, when El Oro Mining Limited installed a placer processing plant along Greyback Gulch and Quintana Minerals Corporation initiated plans to mine the Copper Flat porphyry copper deposit. Quintana began production at Copper Flat Mine in 1982 but closed after three months due to declining copper prices, at which time the processing plant was dismantled.

As this discussion demonstrates, the Las Animas mining district cycled through periods of exploration and prospecting, intensive extraction by companies focused on subsurface veins, periods of individual prospecting and small-scale efforts, expansion of placer processing facilities, and eventually modern industrialized mining. These stages were connected to broader economic trends, such as changes in mineral prices and the development of new technologies. The end result is a potential historic mining district that contains a wide variety of historic property types (ranging from individual prospect pits and rock houses to large mine shafts and engineering features) that reflect these historic developments and convey a variety of time periods and aspects of the mining community. Determining how well the physical remains of a mining district convey a sense of time, place, and historical patterns and assessing its ability to answer questions about mining technology and communities requires the development of historic research themes that potentially can be addressed (Hardesty, 1990). At the contextual scale of the district, research themes include the timing of boom and bust cycles, settlement and abandonment, the introduction of new technologies, the relationship between the district and broader economic and technological trends, the spatial organization of mining activity, the social and economic status of miners, ethnicity and gender, and the development of frontier or folk architectural styles (Noble and Spude, 1992)—many of which can be addressed by specific resources documented during this investigation.

The lack of prehistoric resources is consistent with previous investigations at Copper Flat (Bussey and Naylor, 1975; Sechrist and Laumbach, 1995) but is nevertheless somewhat surprising, given the presence of large Mimbres sites along Animas Creek and other nearby drainages between the Black Range and the Rio Grande (Hegmon, 2002). The prehistoric sites that are present appear to be associated with low-intensity use of the area by mobile Archaic foragers. Three sites within the Baseline Study Area can be securely dated to the Late Archaic period (1500 B.C. to A.D. 300) based on diagnostic San Pedro projectile points, and most of the remaining sites are most likely also Archaic in age, based on the lack of ceramics and characteristics of the lithic assemblages. Sites are small in size, limited in flaked-stone tool diversity, and generally lack features—characteristics that are consistent with short-term or single-use residential camps. The only evidence of a later Mogollon presence is found at LA 110763, which contains rock art panels exhibiting the distinctive Mogollon style. It does not appear, however, that this portion of the Animas Hills was used even on a logistical basis by sedentary Mogollon groups.

10.2 Eligibility and Management Summary

The integrity, significance, and potential eligibility of mining properties are difficult to assess because they were often built for temporary use and then abandoned, neglected, or disturbed by subsequent mining activity over the decades (Noble and Spude, 1992). During this investigation, each site was assessed for its potential eligibility for listing in the National Register of Historic Places (NRHP) on individual merits as well as its potential to contribute to the as-yet-to-be-defined Las Animas historic mining district. The potential to contribute to the district was only assessed for sites unequivocally associated with the district's likely period of significance (1877 to 1940). Some basic guidelines were implemented during these assessments. When considering the individual eligibility of each site, the presence of structural remains and/or large artifact scatters were important factors, as these characteristics likely indicate the location of mining camps. Such camps have the potential to provide information important in local and regional history, particularly if intact subsurface deposits are present. Named mines were also considered eligible under Criterion D, because additional archival information may be available for these sites. Sites clearly associated with settlement and development of the mining district were also considered eligible under Criterion A for their association with important historic events. However, sites lacking residential features or artifact scatters but containing mining features such as prospect pits or unnamed mine shafts were not considered individually eligible for listing in the NRHP. Finally, the condition of each site also played an important role in these assessments, as much of the Baseline Study Area is badly disturbed by modern mining and development. Sites lacking in integrity to the degree that they do not exhibit information potential or no longer convey the historic period with which they are associated were recommended as not eligible.

When assessing the potential contribution of each site to the Las Animas historic mining district, the type of features present and the ability of the site to convey the feeling of the period of significance were more important than the specific information potential of the site. As a result, sites containing mining engineering features such as mine shafts, prospect pits, and waste rock piles or landscape features such as historic roads or trails were considered contributing elements of the historic district, even if residential features or artifact scatters were absent and the sites were lacking in individual distinction and did not merit individual listing in the NRHP. However, such sites were not considered contributing elements if they lacked integrity or contained only poor examples of mining feature types that are ubiquitous in the Baseline Study Area.

Fifty-three archaeological sites were discovered or re-located and fully documented during this investigation. Sites that could not be re-located, have been entirely destroyed since the time they were recorded, are mis-plotted and actually occur outside the Mine Permit Area, or should no longer be considered archaeological sites are excluded from the following eligibility discussion. Twenty-nine previously recorded sites were updated. These sites were identified during five cultural resource surveys spanning 35 years, and the recording standards and guidelines for making eligibility recommendations are understandably variable across these resources. For example, Naylor and Bussey (1975) made only informal recommendations and the SHPO does not seem to have made formal determinations for this or the subsequent Mariah Associates, Inc., survey (Evaskovich, 1991). Sites recorded during the recent Parametrix survey of the pipeline corridor (Mattson and Okun, 2011) have formal recommendations, but no SHPO or BLM determinations to date.

Of the 29 previously documented sites, 13 were previously determined eligible to the NRHP by the SHPO or were recommended as potentially eligible. Twelve of these retain sufficient integrity and are currently recommended as eligible (LA 13121, LA 13130, LA 13131, LA 82276, LA 82278, LA 82279, LA 82280, LA 82281, LA 82282, LA 110753, LA 110759, and LA 110763). LA 82277 was originally recommended as eligible but has been badly disturbed by recent mining activity, and its remaining elements no longer retain integrity; this site is now recommended as not eligible to the NRHP. Eleven sites had a previous eligibility status of undetermined. Data collected during the current investigation allowed for more definitive recommendations to be made for six of these sites: four (LA 110755, LA 110756, LA 110757, and LA 110766) are now recommended as eligible, while two (LA 110752 and LA 110764) are recommended as not eligible to the NRHP. The individual eligibility of five of the sites (LA 110754, LA 110758, LA 110760, LA 171042, and LA 171043) should remain undetermined until archaeological testing or the collection of additional data allows for a determination to be made. Five sites were previously recommended or determined to be not eligible to the NRHP under any criteria. Parametrix concurs with the previous determination of not eligible for four of these sites (LA 82334, LA 110761, LA 110765, and LA 171040). However, the status of LA 13135 should be changed to eligible. This site consists of a cemetery, and although graves and cemeteries are not usually considered eligible for inclusion in the NRHP, this site meets the NRHP special requirements under Criterion Consideration D: Cemeteries, because it has the potential to provide information on nearby sites and the Las Animas historic mining district that is not available from other sources.

Of the 23 newly documented archaeological sites in the Mine Permit Area, eight (LA 171356, LA 171359, LA 171360, LA 171364, LA 171374, LA 171372, LA 171374, and LA 171376) are recommended as individually eligible to the NRHP, 13 (LA 171353, LA 171354, LA 171355, LA 171357, LA 171358, LA 171361, LA 171363, LA 171365, LA 171366, LA 171367, LA 171368, LA 171369, LA 171375) are recommended as not eligible, and two (LA 171362 and LA 171373) are recommended as having undetermined eligibility.

Altogether, 24 sites are recommended as individually eligible to the NRHP. Most of these are recommended under Criterion A for their association with historic mining development and Criterion D for their potential to provide important historical information. Of these, 23 are also considered contributing elements of the potential Las Animas historic mining district. Seven sites are recommended as having undetermined eligibility and four of these may contribute to the historic district. Twenty-one sites are recommended as not eligible for individual inclusion in the NRHP under any criteria; these sites are either in extremely poor condition and do not exhibit integrity sufficient to convey their potential significance and/or lack information potential. Although these sites lack individual distinction and therefore do not merit individual inclusion in the NRHP, nine may be considered contributing elements of the potential Las Animas historic mining district. Individually, these sites are not likely to produce information beyond that obtained during inventory, but they help to visually convey the historic context of the district or, combined with other resources, may provide information on broader historic themes of the district such as the spatial organization of settlement of mining practices. Examples of such resources include mine shafts or landscape features such as trails.

The four historic buildings are all considered contributing elements of the potential Las Animas historic mining district, as they represent extant and highly visible examples of historic settlement during its period of significance. Two of these buildings (the Toney House and the Gold Dust Building) are also recommended eligible for individual listing, as these structures remain relatively intact, retain much of their original fenestration, and contain modifications that are historic in age or consistent with the historic style of the structures. In addition, the Toney House is a well-known local landmark associated with mining, and the Gold Dust Building is the only remaining structure associated with the location of Gold Dust. The two remaining buildings are not eligible for individual listing, as they are either in extremely poor condition and are not representative of a particular architectural style (Greyback Shack) or exhibit significant modifications including additions and changes to the front elevation (Hiltshire House).

Detailed management recommendations will be presented in a future cultural resources report. Avoidance is recommended for all archaeological sites that are recommended as eligible, undetermined, or that may be contributing elements of the potential Las Animas historic district. As avoidance will most likely not be feasible for all of these resources, it is recommended that they be included in a testing and data recovery plan in accordance with *NMAC 4.10.16.11* and *4.10.16.13*, as well as BLM guidelines.

10.3 References

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11 Present and Historic Land Use

The information in this section is summarized primarily from SRK Consulting (2010) and BLM (1999), and informed by research conducted by Tom Van Bebber, Landman for NMCC. An online review of BLM Master Title Plats and land status on GeoCommunicator, the National Integrated Land System (http://www.geocommunicator.gov/GeoComm/index.shtm) was also performed to check the current status of rights of way (ROW) and other activities on BLM lands.

The Copper Flat Mine Permit Area and associated noncontiguous mill site claims are located between the communities of Caballo and Hillsboro, north of NM State Highway 152 and south of Animas Peak. It is covered by the Hillsboro 15-minute USGS quadrangle and occupies parts of Sections 30 and 31, Township 15 South, Range 5 West (T15S, R5W); Sections 30 and 31, T15S, R6W; Sections 23 through 27 and 34 through 36, T15S, R7W; Section 6, T16S, R6W; and Section 2, T16S, R7W (all with reference to the New Mexico Principal Meridian). Some of the noncontiguous mill site claims are outside the permit boundary and are associated with water rights and water wells approximately 8 miles east of the Mine Permit Area. The center of the mineralized zone is at approximately latitude 32.970300, longitude −107.533527. Land maps and other applicant information were presented in the SAP (INTERA, 2010).

11.1 Present Land Use

11.1.1 Land Planning and Regional Land Use

Historically, most of Sierra County has been used for mining, ranching, agriculture, and tourism. The public lands on which the unpatented mining claims and mill sites are located at the Copper Flat Mine Permit Area are managed by BLM's Las Cruces Field Office. BLM manages public lands for multiple uses including recreation, range, forestry, mineral extraction and processing, watershed, fish and wildlife habitat, wilderness, and natural, scenic, scientific, and historical values. The current operational land use plan for this region is the 1986 White Sands Resource Management Plan, which covers all BLM-administered lands in Sierra and Otero counties; a new plan, the TriCounty Resource Management Plan, is in the process of being developed. The White Sands Resource Management Plan identifies the Copper Flat Mine as a mineral resource and recognizes that it could again become a producing mine, although no mining has occurred at the Mine Permit Area since 1982.

The town of Hillsboro, located approximately 5 miles southwest of the Mine Permit Area, has around 100 homes as well as several restaurants, other businesses, and government buildings. Truth or Consequences, approximately 20 miles northeast of the Mine Permit Area, has a population of about 8,000 and is the county seat. Few residences lie within 5 miles of the Copper Flat Mine: the Coalson and Clark ranches are located about 4 miles southeast of the Mine Permit Area and the Golddust Ranch is about 0.1 mile south of the mine and north of Highway 152 (formerly used as Quintana's Site headquarters).

11.1.2 Current Land Use and Structures at Mine Permit Area

Livestock grazing is the primary ongoing land use in the vicinity of the Mine Permit Area. BLM grazing allotments 16040 and 10679 cover the Mine Permit Area, and livestock grazing is permitted in areas adjacent to the Mine Permit Area.

Except for a small viewing structure and a sample storage building, no buildings currently exist on the Mine Permit Area. A state and federally approved water diversion channel exists around the Mine Permit Area. A 370-acre tailing facility exists at the Mine Permit Area along with two decant towers. Three waste rock piles that were used during the 1982 operation of the mine are located near the perimeter of the pit.

11.2 Historic Land Use

Ore was first discovered in the Hillsboro district in April 1877, and the town of Hillsboro was established that same year. A number of mining claims were patented for the Mine Permit Area between 1892 and the 1940s; these now form most of the private land occupied by the Copper Flat mine.

In 1952, Newmont began exploration in the district for porphyry copper mineralization by drilling nearly 3,599 ft in six angle holes into the Copper Flat Quartz Monzonite (CFQM) (Kuellmer, 1955). Bear Creek drilled another 9,300+ ft in 1958−1959 in 20 widely spaced core holes, hoping to find an enrichment blanket of secondary copper (which was not found). Both the Newmont and Bear Creek drill and assay data is available (Dunn, 1984). Porphyry copper exploration was advanced by Inspiration again in the late 1960s. Inspiration completed 30 core drill holes by 1973, purchased the patented claims, performed metallurgical work, and completed two water wells on the property (Dunn, 1984).

In 1974, Inspiration leased the property to Quintana, which undertook a comprehensive mine development program with metallurgical work, underground drifting, bulk sampling, and drill hole composite testing (all performed by the Colorado School of Mines Research Center). The program included detailed geologic investigations into the relationship between the breccia pipe and the quartz monzonite host rocks, as well as the relationship between host rocks and mineralization. An EA was initially prepared for state and federal agencies in 1975, but low copper prices caused the project to be shelved from late 1976 until 1979. At that time, processing methods were reviewed and semi-autogenous grinding and copper-molybdenum flotation separation became the basis for subsequent design work. Mineable reserves were estimated at 60 million standard tons (Mst) with 0.42 percent copper and 0.012 percent molybdenum, plus some gold and silver (SRK, 2010).

With Quintana as the overall project manager, the Copper Flat mine began full production in March 1982 at a rated capacity of 15,000 st a day, a waste-to-ore ratio of 1.8:1, and a cut-off grade of 0.25 percent copper. The combination of low copper prices and high interest rates on the financing loan resulted in the mine closing down just 3 months later, at the end of June. During its short operational period, the mine produced 1.48 Mst of ore containing 7.4 million pounds (lbs) of copper, 2,301 ounces (oz) of gold, and 55,955 oz of silver (SRK, 2010). By the end of 1985, the surface facilities equipment had been sold and the site reclaimed as required by state and federal guidelines. However, all structural foundations, power lines, water wells, and in- ground infrastructure were left in place.

Hydro Resources of Albuquerque, New Mexico, acquired the Copper Flat property, including all royalties, from Inspiration in 1989. Rio Gold and Tenneco Minerals (Tenneco) drilled six large-diameter holes in 1990. Gold Express optioned the property in 1993, and then sold it to Alta Gold in 1994 without performing any exploration or development. A Preliminary Final EIS for the Alta Gold mining project was issued in March 1999, but Alta Gold went bankrupt (due to financial problems with other assets) before any permits were issued. Hydro Resources reacquired all the properties in 2001 along with all royalties. Hydro Resources maintains an archive of information related to the mine, including over 14,000 sample pulps and skeleton core from the Quintana drilling programs (SRK, 2010).

Approximately 60 percent of the proposed Mine Permit Area has been disturbed by previous operations. Remnants of the 1982 mining operation include an open pit and pit lake, a tailings impoundment area, waste rock disposal areas, a number of buried building foundations, and ancillary facilities including decant towers, roads, power transmission lines, and waterlines. These features are clearly delineated on BLM geographic information system maps and aerial photographs, and have been considered as part of the proposed plan of operations. Although some reclamation was done to the area in 1986, much of the Mine Permit Area remains disturbed.

11.3 Soil Survey

NMCC retained Stetson Engineers, Inc., to perform Order 2 and Order 1 soil surveys on the 2,190-acre mine permit area. The soils surveys are discussed in detail in Section 6.0. Topsoil Survey and Sampling Results.

11.4 References

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