Appendix 2-A

Meteorological Monitoring Quarterly Reports

New Mexico Copper Corporation

Copper Flat Mine

Meteorological Quarterly Summary Report
Copper Flat Met 1

Fourth Quarter 2010
(October through December 2010)

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1.0 INTRODUCTION

This report is a summary of the basic meteorological data collected at Copper Flat Mine 10-meter meteorological tower for the Fourth quarter of 2010. Data reduction and performance audits during this quarter were performed by Class One Technical Services. The most recent field performance audit was conducted on January 13, 2011.

The Copper Flat meteorological tower is located on the Copper Flat Mine. The site coordinates in the UTM Coordinate System are:

Site - Met 1

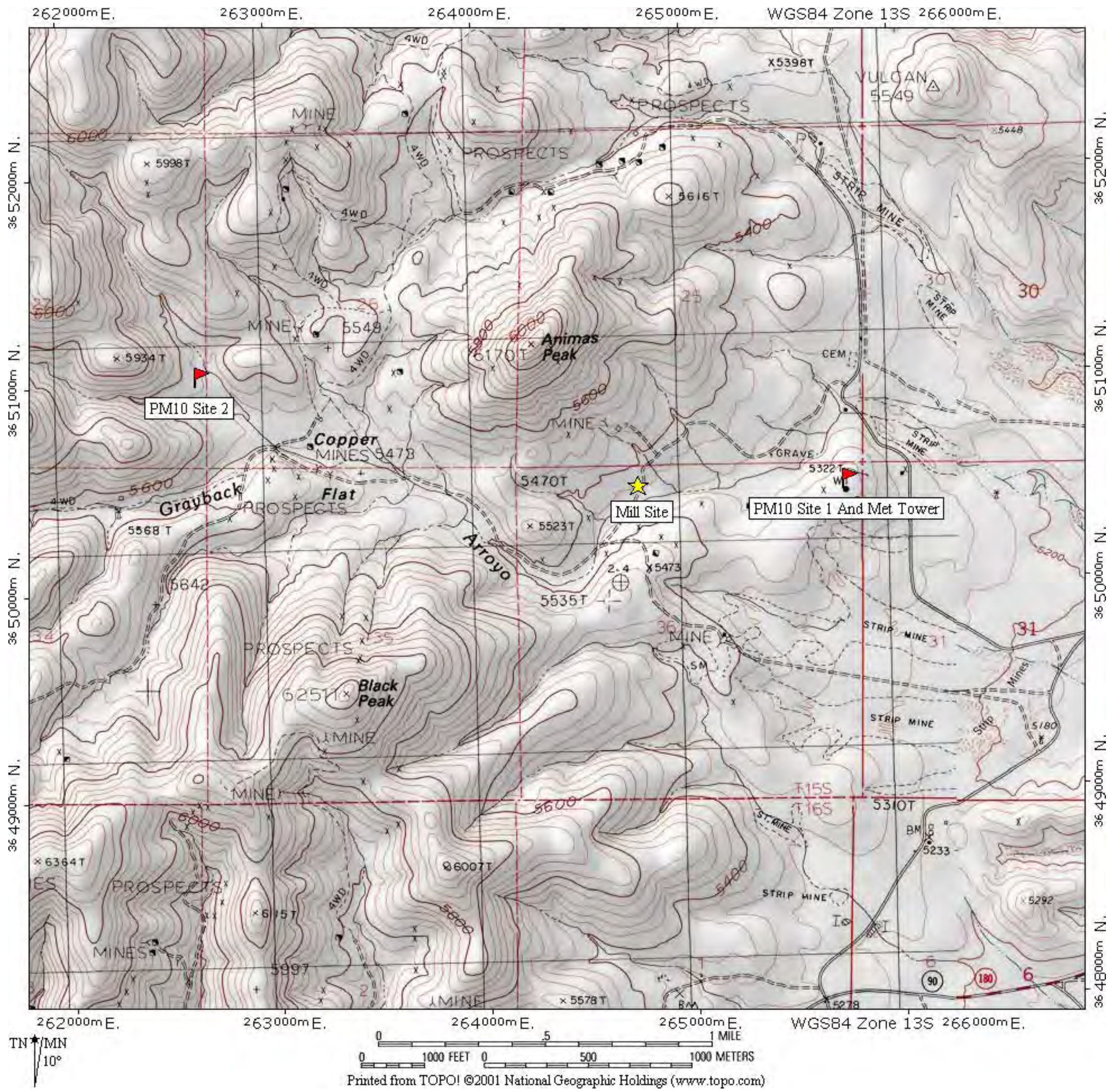
North: 3,650,579
East: 265,718

The tower location and general environs of the tower are shown in Figure 1. The tower site includes the following instrumentation:

Instrument	Manufacture	Model	Range
Wind Speed (10m)	Climatronics	F460	0-50 m/s
Wind Direction (10m)	Climatronics	F460	0-360 deg
Temperature (10m)	Climatronics	100093	-30 ^{o}C to +50 ^{o}C
Temperature (2m)	Climatronics	100093	-30 ^{o}C to +50 ^{o}C
Relative Humidity	Rotronic	MP801A	0-100%
Precipitation	Climatronics	100508-G0	0.01 in (per tip)
Net Radiation	Kipp & Zonen (Wavelength)	NR LITE	0.20 - 100 micron
Barometric Pressure	Climatronics	102663-G1	17.72 to 32.49 in. Hg
Evaporation Pan	NovaLynx	255-100	0 to 9 inches water
Data Logger	Campbell CR1000		

The wind speed, wind direction, temperature, and relative humidity sensors are mounted at ten (10) meters above ground level. The wind speed and wind direction sensors are mounted at three (3) meters. The temperature, solar radiation, and barometric pressure sensors are mounted at two (2) meters above ground level. The precipitation gauge is located at ground level.

Figure 1: Map of Particulate Sampler Locations



2.0 REPORTING CRITERIA

The following criteria have been used in preparing the quarterly summaries for the El Segundo meteorological data for this report:

a. Temperature Summaries (10-m temperature, 2-m temperature, delta temperature, and temperature lapse rate)

For each day of each month in the quarter the mean, maximum and minimum temperature, in degrees, Celsius are reported. The maxima and the minima are based on one-hour averages. For a 24-hour mean value to be *valid*, at least 18 hourly values must have been present during the 24-hour period. If less than 18 hours of valid data are available, the mean *is calculated, but data may not be representative and should be used with care*. Similarly, maxima and minima are *included* for these periods. Even though some data may have been available on these days, the maxima and minima may be misleading if the missing data happened to occur during the hottest or coldest part of the day.

For each month in the quarter the mean temperature for the month is calculated from all the hourly data, including data on those days which did not have enough data to calculate a 24-hour mean. Monthly averages *are calculated for months with less than* 4 valid 24-hour means in the month. *The* monthly maximum *and* minimum are reported as well. While 4 valid days are *considered valid* to report a mean, means for months with less than 18 days of valid data may not be representative and should be used with care.

Means, maxima and minima are reported for the entire quarter if there is at least one valid month of data in the quarter. As such, these values may not be truly representative of the entire quarter if significant amounts of data are missing. The validity of the quarterly values depends on their intended use and care should be taken with quarters with low data capture.

b. Wind Speed Summary

For each day of each month the 24-hour mean wind speed and the maximum hourly wind speed has been reported in units of meters per second. The criterion for valid 24-hour means is the same as that described above for mean temperatures.

For each month, the mean wind speed and the maximum wind speed are reported. The criteria for determining the monthly values are the same as those described above for monthly temperature values. For each quarter, the mean for the entire quarter and the maximum hourly value in the quarter is reported. The criteria for reporting quarterly values are the same as those described above for quarterly temperature values.

c. Wind Data Summary

The Wind Data Summary report gives a JFD (Joint Frequency Distribution) of wind direction and wind speed. Wind directions are divided into 16 sectors, each 22.5 degrees wide. The north sector covers 348.75 degrees to 11.25 degrees (i.e. it is symmetrical about zero degrees). Wind speeds are divided into 8 categories. The data in each wind speed/wind direction category are given as a fraction of the total month to the nearest 1 percent. The total fraction for each wind direction sector and each wind speed category is also given.

A quarterly JFD is printed if at least one valid month of data existed in the quarter. As such, it is possible that the quarterly JFD may not be truly representative of the full quarter if only one month of data is available.

d. Precipitation Summary

For each day in the quarter, the total precipitation in inches is reported along with a running precipitation total beginning at the first day of the quarter. Precipitation for a day is reported if at least one hour of data is available during the day.

For each quarter, the total precipitation for the quarter is reported along with the total number of hours during which precipitation occurred. A quarterly precipitation value is reported if there is any valid precipitation during the quarter. Care must be taken in use of the quarterly precipitation values if there were significant missing data during the quarter.

e. Relative Humidity Summaries

For each day in the quarter the mean, maximum and minimum relative humidity, in percent, is reported. The maxima and the minima are based on one-hour averages. For a 24-hour mean value to be *valid*, at least 18 hourly values must have been present during the 24-hour period. If less than 18 hours of valid data are available, the mean i*s calculated*, *but data may not be representative and should be used with care*. Similarly, maxima and minima are *included* for these periods. Even though some data may have been available on these days, the maxima and minima may be misleading if the missing data happened to occur during the hottest or coldest part of the day.

For each month in the quarter the mean temperature for the month is calculated from all the hourly data, including data on those days which did not have enough data to calculate a 24-hour mean. Monthly averages *are calculated for months with less than* 4 valid 24-hour means in the month. *The* monthly maximum *and* minimum are reported as well. While 4 valid days are *considered valid* to report a mean, means for months with less than 18 days of valid data may not be representative and should be used with care.

Means, maxima and minima are reported for the entire quarter if there is at least one valid month of data in the quarter. As such, these values may not be truly representative of the entire quarter if significant amounts of data are missing.

f. Data Capture Summary

For each month and each parameter the percent of valid data, based on hourly values, is reported as well as the average data capture for the entire month. Also, the percent of valid data for the quarter for each parameter and the average data capture for the quarter are given.

g. Barometric Pressure Summary

Barometric pressure is summarized in inches of Mercury (in. Hg). The pressure data are the actual site pressures; they have not been "corrected" to sea level as is typically done with National Weather Service data. The reporting requirements for valid averages, maxima, and minima are the same as those for temperature and relative humidity summaries.

h. Net Radiation Summary

For each day in the quarter the daily maximum net radiation in watts per square meter is reported. The maxima are based on one-hour averages.

i. Evaporation Summary

For each day of the quarter, the total, minimum, and maximum evaporation values are reported in inches. Minima and maxima are based on one-hour averages. Positive values indicate evaporation, or loss of water from the evaporation pan, whereas negative values indicate precipitation or addition of water to the evaporation pan by other means.

For a 24-hour total value to be *valid*, at least 18 hourly values must have been present during the 24-hour period. If less than 18 hours of valid data are available, the total i*s calculated, but data may not be representative and should be used with care*. Similarly, maxima and minima are *included* for these periods. Even though some data may have been available on these days, the maxima and minima may be misleading if the missing data happened to occur during the hottest or coldest part of the day, or during a precipitation event.

For each month in the quarter, the total evaporation is calculated from all the hourly data, including data on those days which did not have enough data to calculate a 24-hour total. The monthly maximum and minimum are reported as well.

3.0 Meteorological Data Summary

The Copper Flat Met 1 meteorological data for Fourth quarter 2010 is presented in section 5.0 Numerical Summaries, on pages 14-24. The following text and tables represent the summarized data in section 5.0 Numerical Summaries.

Wind Speed

The average ten-meter wind speed for the Fourth quarter was 4.4 m/s. The maximum hourly ten-meter wind speed for the meteorological tower was 19.0 m/s and was recorded December 30, 2010 at 1000 MST. Thirty-five percent of the hourly wind speeds at the ten-meter level were observed in the >1.0 to 3.0 m/s wind speed class, while thirty-four percent were in the >3.0 to 5.0 m/s wind speed class.

Table 1 below summarizes the monthly hourly average and maximum wind speeds in meters per second (m/s).

Table 1: Monthly Wind Speed Summary

Month	Mean Hourly Wind Speed (meters/second)	Maximum Hourly Wind Speed (meters/second)	Date of Maximum Hourly Wind Speed
October	4.2	14.0	Oct. 25 @ 1100
November	5.2	15.7	Nov. 28 @ 1400
December	3.9	19.0	Dec. 30 @ 1000

Wind Direction

The prevailing wind direction for the quarter was from the West sector. Winds from this sector occurred approximately seventeen percent of the time. Winds from the west occurred seven percent of the time in the >1.0 to 3.0 m/s wind speed class.

The next most common wind direction was from the South-southeast (SSE) occurring ten percent of the time. Winds from the SSE occurred five percent of the time in the >3.0 to 5.0 m/s class.

Temperature

The mean quarterly 10-meter temperature was 12.3 degrees Celsius (^{o}C). The maximum hourly temperature of 28.2^{o}C was recorded on October 1, 2010 at 1600 MST. The minimum temperature of -8.0^{o}C was recorded on December 31, 2010 at 2300 MST.

The mean quarterly 2-meter temperature was 11.9^{o}C. The maximum hourly temperature of 29.4^{o}C was recorded on October 1, 2010 from 1400 to 1500 MST. The minimum hourly temperature of –8.2^{o}C was recorded on December 31, 2010 at 2300 MST.

Table 2 below represents the monthly mean, minimum, and maximum temperatures for the 10 and 2-meter levels of the meteorological tower.

Table 2: Monthly Temperature Summary

10-Meter Temperature

Month	Max Hrly Temp ^{o}C	Date of Max Temp	Min Hrly Temp ^{o}C	Date of Min Temp	Mean Hrly Temp ^{o}C
October	28.2	Oct. 1 @ 1600	6.9	Oct. 22 @ 0700	17.6
November	23.1	Nov. 7 @ 1500	-4.1	Nov. 26 @ 0500	9.9
December	19.6	Dec. 14 @ 1700	-8.0	Dec. 31 @ 1400	9.3

2-Meter Temperature

Month	Max Hrly Temp ^{o}C	Date of Max Temp	Min Hrly Temp ^{o}C	Date of Min Temp	Mean Hrly Temp ^{o}C
October	29.4	Oct. 1 @ 14-1500	5.8	Oct. 22 @ 0400	17.4
November	24.3	Nov. 7 @ 1500	-5.1	Nov. 26 @ 0500	9.6
December	19.8	Dec. 15 @ 1300	-8.2	Dec. 31 @ 2300	8.8

Net Radiation

The maximum hourly net radiation for the Fourth Quarter 2010 was 586 w/m^2 and occurred on October 5, 2010 at 1200 MST. Table 4 below summarizes the monthly maximum net radiation in watts per square meter (w/m^2).

Table 4: Monthly Net Radiation Summary

Month	Maximum Hrly Net Radiation (w/m^2)	Date of Maximum Hourly Net Radiation
October	586	Oct. 5 @ 1200
November	419	Nov. 3 @ 1200
December	373	Dec. 19 @ 1100

Precipitation

The total precipitation for Fourth Quarter 2010 was 0.55 inches, with a duration of 11 hours. Sixty-seven percent, 0.37 inches, of the observed precipitation fell in the month of October. The largest single day precipitation amount was 0.16 inches was recorded on October 4, 2010. Table 5 summarizes the total monthly precipitation for October, November, and December 2010.

Table 5: Monthly Precipitation Summary

Month	Total Precipitation (inches)	Percent Of Total (%)	Max. Daily Precipitation Event (inches)	Date of Max Daily Precip Event
October	0.37	67	0.16	Oct. 4
November	0.02	4	0.02	Nov. 5
December	0.16	29	0.16	Dec. 30

Relative Humidity

The mean relative humidity for the quarter was 35 percent. The maximum hourly relative humidity of 94 percent was recorded on December 30, 2010. The minimum hourly relative humidity value of 7 percent was recorded on December 14, 2010. Table 6 below represents the monthly mean, minimum and maximum relative humidity values for the meteorological tower.

Table 6: Monthly Relative Humidity Summary

Month	Mean Hrly Relative Humidity (%)	Minimum Hrly Relative Humidity (%)	Maximum Hrly Relative Humidity (%)
October	38	9	88
November	28	8	73
December	37	7	94

Barometric Pressure

The mean barometric pressure for the Fourth Quarter 2010 was 844 milibars. The maximum hourly barometric pressure value of 857 mbars occurred on October 28, 2010. Table 7 below represents the monthly mean, minimum and maximum barometric pressure values for the meteorological tower.

Table 7: Monthly Barometric Pressure Summary

Month	Mean Hrly Barometric Pressure (mbars)	Minimum Hrly Barometric Pressure (mbars)	Maximum Hrly Barometric Pressure (mbars)
October	845	831	857
November	844	830	855
December	843	823	852

Evaporation

Table 8 represents the monthly net sum, minimum and maximum evaporation values for the meteorological tower. The evaporation gauge was disconnected for the season on November 11, 2010.

The net sum evaporation for the quarter was 4.997 inches. The minimum hourly evaporation for the quarter was -0.083 inches and occurred on October 5, 2010. The maximum hourly evaporation for the quarter was 0.039 inches and occurred on October 8, 2010.

Table 8: Monthly Evaporation Summary

Month	Total Monthly Net Evaporation (inches)	Minimum Hourly Evaporation (inches)	Maximum Hourly Evaporation (inches)
October	3.95	-0.08	0.04
November	1.04	-0.08	0.03
December	---	---	---

4.0 DATA CAPTURE DESCRIPTION

Overall data capture for the Fourth quarter of 2010 was approximately ninety-nine (99) percent (excluding Evaporation data and edits).

October 2010

Overall data capture for the month was one hundred (100) percent for all parameters.

November 2010

Overall data capture for the month was one hundred (100) percent for all parameters.

December 2010

Overall data capture for the month was ninety-nine (99) percent for all parameters. All data loss is due to two hours of incomplete data that occurred during a download from the tower.

5.0 Numerical Summaries

Copper Flat Met 1

Fourth Quarter 2010

Copper Flat - Met 1

Q4 - 2010 Quarterly Data Capture Report
(percentages)
10/01/2010 to 12/31/2010

Parameter	October Values Count	October Capture Pct	November Values Count	November Capture Pct	December Values Count	December Capture Pct	Qtr Total Count	Qtr Total Capture Pct
Wind Speed 10m	744	100.00	720	100.00	742	99.73	2206	99.91
Wind Direction 10m	744	100.00	720	100.00	742	99.73	2206	99.91
Sigma Theta 10m	744	100.00	720	100.00	742	99.73	2206	99.91
Temp 10m	744	100.00	720	100.00	742	99.73	2206	99.91
Temp 2m	744	100.00	720	100.00	742	99.73	2206	99.91
Delta Temp	744	100.00	720	100.00	742	99.73	2206	99.91
Relative Humidity	744	100.00	720	100.00	742	99.73	2206	99.91
Net Radiation	744	100.00	720	100.00	742	99.73	2206	99.91
Precipitation	744	100.00	720	100.00	742	99.73	2206	99.91
Evaporation	691	92.88	701	97.36	742	99.73	2134	96.65
Barometric Pressure	744	100.00	720	100.00	742	99.73	2206	99.91
Station AVERAGE	739	99.33	718	99.72	742	99.73	2199	99.59

Report Date
08/01/2011

Copper Flat - Met 1

Q4 - 2010 Quarterly Summary Report For Wind Speed 10m (m/s)

10/01/2010 to 12/31/2010

DAY	October Mean	October Min	October Max	November Mean	November Min	November Max	December Mean	December Min	December Max
1	4.0	2.0	5.1	5.3	2.6	7.4	2.7	1.3	4.7
2	4.9	2.1	7.2	4.2	2.6	7.5	2.9	0.7	4.7
3	3.8	1.4	6.6	5.3	1.5	8.8	2.0	0.7	3.1
4	4.1	1.1	12.9	5.1	2.1	8.2	3.6	1.7	5.9
5	3.7	1.2	7.7	4.0	1.3	6.7	2.6	0.8	6.3
6	4.2	1.8	8.7	3.8	1.5	8.1	3.8	1.4	8.9
7	5.1	2.0	7.7	4.1	1.3	8.4	6.2	1.9	11.7
8	5.1	1.6	7.6	4.3	1.2	8.8	3.7	1.6	7.1
9	4.8	2.2	9.2	6.8	4.0	11.4	2.7	1.5	5.0
10	4.8	2.0	10.1	4.0	1.4	8.7	2.8	1.2	4.6
11	3.8	1.5	6.2	4.9	1.5	10.1	2.8	1.4	7.5
12	4.3	2.4	7.5	5.3	1.4	9.5	3.1	1.3	5.6
13	3.4	1.1	5.0	3.6	2.4	6.1	2.9	1.5	4.9
14	4.3	2.3	5.6	3.4	1.4	6.2	2.3	0.9	5.8
15	3.6	0.8	5.2	6.3	1.6	13.4	3.8	1.4	14.0
16	3.5	1.9	6.1	4.1	1.8	9.0	4.6	1.5	7.5
17	3.8	1.6	6.5	4.0	1.1	8.9	4.0	1.5	7.3
18	3.7	1.2	6.4	4.0	1.3	6.7	3.2	1.1	8.2
19	3.8	2.3	5.6	4.0	1.2	8.6	3.1	1.3	6.6
20	3.9	1.8	8.2	6.1	1.8	9.9	4.3	1.3	6.8
21	4.6	1.7	8.3	9.5	4.2	14.4	4.3	1.4	7.5
22	4.0	1.2	9.7	8.7	1.6	14.6	3.0	0.9	7.5
23	4.2	1.2	9.0	4.8	1.7	10.9	5.2	1.6	8.8
24	3.7	1.0	7.8	7.9	3.4	12.2	4.6	1.2	7.2
25	6.4	1.7	14.0	5.0	1.7	8.1	3.0	0.9	4.4
26	3.6	1.5	7.1	2.8	1.3	5.9	5.3	1.5	10.6
27	3.6	1.4	7.5	3.8	1.1	9.6	2.8	2.1	3.8
28	4.5	2.2	7.1	8.8	1.4	15.7	3.5	1.3	6.1
29	4.4	1.1	9.3	6.9	2.4	10.7	5.8	1.3	10.0
30	4.8	0.8	9.4	4.2	1.9	8.1	10.6	5.4	19.0
31	3.9	0.9	10.4				7.0	3.3	10.8
Monthly Mean	4.2			5.2			3.9		
Monthly Min		0.8			1.1			0.7	
Monthly Max			14.0			15.7			19.0
Quarterly Mean	4.4								
Quarterly Min	0.7								
Quarterly Max	19.0								

Copper Flat - Met 1

Q4 - 2010 Quarterly Wind Summary Report
(Wind Direction 10m vs Wind Speed 10m)
10/01/2010 to 12/31/2010

WS CLASS	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTALS
CALM	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
0.5 TO 1.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.0059
>1.0 TO 3.0	0.012	0.005	0.009	0.011	0.014	0.026	0.020	0.013	0.012	0.010	0.015	0.024	0.070	0.050	0.034	0.020	0.3450
>3.0 TO 5.0	0.012	0.009	0.007	0.010	0.004	0.007	0.021	0.049	0.020	0.028	0.029	0.019	0.056	0.022	0.018	0.025	0.3377
>5.0 TO 9.0	0.014	0.005	0.005	0.000	0.000	0.000	0.004	0.032	0.017	0.024	0.035	0.020	0.028	0.015	0.012	0.035	0.2448
>9.0 TO 15.0	0.003	0.001	0.000	0.000	0.000	0.000	0.000	0.003	0.001	0.002	0.009	0.019	0.013	0.005	0.005	0.003	0.0639
>15.0 TO 20.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.0027
>20.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
TOTAL	0.040	0.020	0.020	0.022	0.018	0.034	0.045	0.097	0.050	0.065	0.089	0.084	0.168	0.093	0.069	0.084	

Report Date
08/01/2011

Copper Flat - Met 1

Q4 - 2010 Quarterly Summary Report For Temp 10m
(deg C)
10/01/2010 to 12/31/2010

DAY	October Mean	October Min	October Max	November Mean	November Min	November Max	December Mean	December Min	December Max
1	23.7	19.1	28.2	14.9	11.2	19.7	5.6	0.5	11.4
2	23.2	19.7	28.1	13.4	9.4	17.6	9.8	6.4	14.8
3	19.0	16.6	22.2	15.9	12.9	19.7	11.2	8.0	15.7
4	18.0	14.3	23.9	13.3	10.7	16.3	12.8	10.0	16.4
5	16.1	13.1	21.3	13.3	9.0	18.3	10.4	6.5	14.8
6	19.4	14.6	25.1	14.9	10.2	20.7	11.8	7.2	17.9
7	20.6	17.0	24.6	16.0	10.3	23.1	11.8	8.9	15.6
8	20.3	14.8	25.2	15.6	11.2	21.2	8.6	5.4	13.0
9	19.3	14.1	25.1	12.0	7.3	14.3	9.9	5.4	15.5
10	17.6	13.5	21.3	9.1	4.2	15.1	13.5	9.2	19.0
11	18.4	14.7	23.4	9.8	5.8	14.3	13.0	9.5	17.1
12	20.1	16.6	24.0	6.7	2.8	10.9	9.2	6.0	13.5
13	18.2	13.8	22.2	7.9	3.7	12.6	10.7	6.2	16.0
14	18.6	14.9	22.5	9.1	4.2	13.8	12.1	6.7	19.6
15	19.2	15.1	22.8	9.2	6.1	12.4	13.0	9.5	18.9
16	18.9	14.2	23.0	9.6	4.3	16.5	11.8	9.9	14.6
17	19.1	15.2	23.3	10.1	7.7	12.8	8.3	5.9	11.4
18	18.5	15.6	22.6	9.7	5.3	14.4	8.7	4.9	14.4
19	17.4	13.2	21.6	12.3	6.8	19.7	11.4	7.2	15.9
20	17.6	14.8	21.3	14.2	8.7	18.2	13.7	10.6	17.3
21	13.1	9.4	16.3	12.0	9.2	14.6	12.2	8.4	17.1
22	11.1	6.9	16.9	9.5	6.4	13.1	11.8	8.4	15.4
23	13.6	10.2	18.2	8.2	2.7	14.5	9.5	5.3	12.0
24	14.6	9.4	21.1	10.8	8.9	13.5	7.2	2.9	10.7
25	16.7	12.4	20.5	3.4	0.4	8.4	6.1	2.5	9.2
26	13.2	7.9	19.7	1.8	-4.1	7.4	7.0	3.9	11.3
27	13.6	8.8	18.2	5.9	2.1	11.4	6.4	3.7	8.2
28	12.6	8.2	17.4	6.3	1.4	9.8	6.6	3.6	10.7
29	15.9	10.9	21.5	0.5	-1.3	2.7	6.4	2.7	10.3
30	19.5	13.7	24.7	1.6	-1.9	6.6	1.6	-4.8	6.0
31	17.3	12.0	22.1				-3.5	-8.0	-0.0
Monthly Mean	17.6			9.9			9.3		
Monthly Min		6.9			-4.1			-8.0	
Monthly Max			28.2			23.1			19.6
Quarterly Mean	12.3								
Quarterly Min	-8.0								
Quarterly Max	28.2								

Report Date
08/01/2011

Copper Flat - Met 1

Q4 - 2010 Quarterly Summary Report For Temp 2m
(deg C)
10/01/2010 to 12/31/2010

DAY	October Mean	October Min	October Max	November Mean	November Min	November Max	December Mean	December Min	December Max
1	23.7	17.8	29.4	14.8	10.0	20.9	4.8	-1.1	12.1
2	23.2	18.5	29.4	13.1	8.6	18.4	8.8	4.0	15.5
3	18.9	15.9	22.8	15.3	11.2	20.8	10.1	5.7	16.2
4	17.9	13.7	25.2	13.2	9.1	17.5	12.1	7.3	17.4
5	15.9	12.3	22.1	13.0	7.5	19.4	9.9	4.6	15.6
6	19.2	13.4	25.9	14.4	8.2	21.8	11.3	5.7	18.7
7	20.6	15.9	25.7	15.5	8.4	24.3	11.1	7.1	16.0
8	20.2	13.6	26.6	15.0	8.9	22.7	7.9	3.8	14.0
9	19.0	12.9	26.2	12.0	6.6	14.9	9.0	3.6	16.4
10	17.6	12.7	22.2	8.6	2.1	16.2	12.7	7.0	19.5
11	18.2	13.2	24.3	9.8	5.2	15.2	12.2	7.7	17.8
12	19.9	15.0	25.0	6.5	2.1	12.0	8.5	4.8	14.1
13	18.1	12.2	23.2	7.4	2.2	13.4	9.9	4.5	16.7
14	18.7	14.2	23.7	8.7	2.9	14.5	11.3	4.5	19.1
15	19.0	13.6	23.8	8.8	5.4	13.0	12.3	8.7	19.8
16	18.8	12.7	24.4	9.1	2.5	17.4	11.6	8.7	15.6
17	18.7	13.7	24.8	9.3	6.0	13.7	8.2	4.9	12.2
18	18.3	14.1	23.7	9.2	3.3	15.3	8.5	4.2	15.2
19	17.0	11.4	22.7	11.8	4.8	20.5	10.9	5.8	16.4
20	17.3	13.1	22.0	14.2	8.0	19.4	13.6	9.8	18.4
21	13.0	8.4	17.7	12.0	8.6	15.5	11.9	8.1	18.3
22	11.0	5.8	17.8	9.4	5.2	13.9	11.2	7.2	16.0
23	13.4	8.8	19.3	7.7	0.8	15.5	9.3	4.2	13.2
24	14.4	7.7	21.9	10.7	8.2	14.4	6.8	1.9	11.5
25	16.4	11.2	21.4	3.2	0.2	7.2	5.6	1.1	10.1
26	13.0	6.4	20.8	1.2	-5.1	7.9	6.7	3.1	12.1
27	13.3	8.4	19.1	5.1	-0.3	12.4	6.1	2.7	8.9
28	12.4	7.7	18.3	6.1	0.3	10.6	6.4	2.8	11.4
29	15.5	8.8	22.3	0.3	-2.9	3.0	6.0	1.6	11.2
30	19.4	12.9	25.9	1.4	-3.0	7.3	1.5	-4.8	6.5
31	16.9	11.1	22.7				-3.5	-8.2	0.8
Monthly Mean	17.4			9.6			8.8		
Monthly Min		5.8			-5.1			-8.2	
Monthly Max			29.4			24.3			19.8
Quarterly Mean	11.9								
Quarterly Min	-8.2								
Quarterly Max	29.4								

Report Date
08/01/2011

Copper Flat - Met 1

Q4 - 2010 Quarterly Summary Report For Delta Temp
(deg C)
10/01/2010 to 12/31/2010

DAY	October Mean	October Min	October Max	November Mean	November Min	November Max	December Mean	December Min	December Max
1	-0.06	-1.54	1.30	0.18	-1.36	1.36	0.75	-1.07	2.15
2	-0.02	-1.61	1.58	0.31	-1.23	2.63	0.97	-1.09	2.46
3	0.14	-0.61	0.87	0.56	-1.55	2.28	1.05	-0.86	2.34
4	0.05	-1.39	1.04	0.08	-1.47	1.70	0.75	-1.21	2.77
5	0.16	-1.18	1.34	0.33	-1.33	1.76	0.51	-1.04	2.04
6	0.18	-1.30	1.31	0.51	-1.39	2.23	0.53	-1.24	1.99
7	-0.03	-1.50	1.14	0.58	-1.38	2.08	0.64	-0.78	1.88
8	0.06	-1.58	1.76	0.58	-1.51	2.45	0.74	-1.13	2.42
9	0.31	-1.39	2.25	-0.03	-1.44	1.43	0.92	-1.08	2.59
10	0.07	-1.58	1.65	0.52	-1.44	2.16	0.79	-1.16	2.33
11	0.17	-1.43	1.93	0.04	-1.30	1.32	0.75	-0.90	2.10
12	0.16	-1.56	1.60	0.17	-1.49	1.91	0.66	-1.09	2.27
13	0.12	-1.47	1.71	0.43	-1.09	1.84	0.79	-1.00	2.06
14	-0.06	-1.58	1.03	0.44	-1.21	2.06	0.83	-1.23	2.34
15	0.13	-1.43	2.25	0.33	-0.61	1.53	0.74	-0.85	2.46
16	0.14	-1.47	1.58	0.45	-1.14	2.16	0.24	-1.12	1.77
17	0.36	-1.58	2.24	0.74	-1.31	2.38	0.12	-0.80	1.02
18	0.19	-1.42	1.62	0.59	-1.23	2.57	0.20	-1.09	1.19
19	0.41	-1.56	1.88	0.57	-1.23	2.33	0.53	-1.01	1.66
20	0.31	-1.30	1.88	0.03	-1.39	1.04	0.16	-1.13	1.27
21	0.07	-1.49	1.36	-0.03	-1.10	0.88	0.23	-1.31	1.40
22	0.12	-1.26	1.64	0.10	-0.94	1.44	0.59	-0.92	1.71
23	0.14	-1.16	1.59	0.52	-1.31	2.13	0.25	-1.16	1.28
24	0.18	-1.41	1.71	0.02	-0.93	0.73	0.47	-1.10	1.88
25	0.36	-0.90	1.98	0.15	-1.26	1.29	0.49	-1.20	1.63
26	0.22	-1.35	1.59	0.57	-1.04	2.14	0.27	-1.14	1.94
27	0.21	-1.23	2.09	0.86	-1.29	2.54	0.29	-0.82	1.44
28	0.24	-1.34	1.92	0.13	-0.82	1.13	0.25	-1.13	1.31
29	0.42	-1.52	2.21	0.19	-1.07	1.69	0.33	-0.93	1.83
30	0.12	-1.46	1.41	0.26	-0.93	1.44	0.08	-0.41	0.30
31	0.40	-1.23	2.21				-0.03	-0.82	0.44
Monthly Mean	0.17			0.34			0.51		
Monthly Min		-1.61			-1.55			-1.31	
Monthly Max			2.25			2.63			2.77
Quarterly Mean	0.34								
Quarterly Min	-1.61								
Quarterly Max	2.77								

Report Date
08/01/2011

Copper Flat - Met 1

Q4 - 2010 Quarterly Summary Report For Net Radiation
(W/m2)
10/01/2010 to 12/31/2010

DAY	October Mean	October Min	October Max	November Mean	November Min	November Max	December Mean	December Min	December Max
1	83	-104	496	45	-105	417	31	-81	344
2	76	-93	492	47	-97	418	29	-89	332
3	-5	-85	149	51	-98	419	20	-66	297
4	78	-153	552	45	-82	387	21	-70	297
5	61	-94	586	45	-92	385	22	-75	319
6	99	-85	536	44	-94	388	33	-74	316
7	84	-92	495	37	-102	379	28	-97	323
8	74	-108	473	31	-99	371	18	-94	322
9	73	-108	510	29	-103	356	25	-79	309
10	79	-102	496	33	-98	381	25	-78	312
11	74	-103	487	46	-82	388	21	-83	309
12	70	-99	481	36	-99	395	22	-86	323
13	74	-91	472	34	-96	382	20	-88	316
14	69	-96	460	39	-96	353	13	-105	304
15	72	-88	465	32	-86	400	14	-75	339
16	67	-81	478	33	-91	369	26	-66	281
17	53	-84	451	31	-99	372	17	-79	213
18	60	-92	457	27	-99	355	25	-76	341
19	65	-98	463	32	-92	351	18	-76	373
20	39	-85	389	23	-94	324	16	-73	335
21	31	-85	350	20	-91	327	32	-76	344
22	51	-73	346	18	-99	327	-1	-87	180
23	60	-86	445	26	-87	332	19	-89	306
24	61	-90	437	14	-96	303	23	-84	322
25	4	-84	234	9	-103	370	24	-84	317
26	60	-88	441	25	-93	350	18	-78	295
27	58	-103	437	23	-96	328	18	-63	248
28	52	-93	432	22	-83	314	29	-83	371
29	55	-92	413	8	-86	314	-0	-69	247
30	46	-99	404	24	-88	343	3	-76	213
31	34	-104	400				21	-86	314
Monthly Mean	60			31			20		
Monthly Min		-153			-105			-105	
Monthly Max			586			419			373
Quarterly Mean	37								
Quarterly Min	-153								
Quarterly Max	586								

Report Date
08/01/2011

Copper Flat - Met 1

Q4 - 2010 Quarterly Precipitation Summary
(inches)
10/01/2010 to 12/31/2010

Day of Month	October Precip (inches)	October Sum	October Duration (hours)	November Precip (inches)	November Sum	November Duration (hours)	December Precip (inches)	December Sum	December Duration (hours)
1	0.00	0.00		0.00	0.00		0.00	0.00	
2	0.00	0.00		0.00	0.00		0.00	0.00	
3	0.06	0.06	1:00	0.00	0.00		0.00	0.00	
4	0.16	0.22	3:00	0.00	0.00		0.00	0.00	
5	0.15	0.37	1:00	0.02	0.02	1:00	0.00	0.00	
6	0.00	0.37		0.00	0.02		0.00	0.00	
7	0.00	0.37		0.00	0.02		0.00	0.00	
8	0.00	0.37		0.00	0.02		0.00	0.00	
9	0.00	0.37		0.00	0.02		0.00	0.00	
10	0.00	0.37		0.00	0.02		0.00	0.00	
11	0.00	0.37		0.00	0.02		0.00	0.00	
12	0.00	0.37		0.00	0.02		0.00	0.00	
13	0.00	0.37		0.00	0.02		0.00	0.00	
14	0.00	0.37		0.00	0.02		0.00	0.00	
15	0.00	0.37		0.00	0.02		0.00	0.00	
16	0.00	0.37		0.00	0.02		0.00	0.00	
17	0.00	0.37		0.00	0.02		0.00	0.00	
18	0.00	0.37		0.00	0.02		0.00	0.00	
19	0.00	0.37		0.00	0.02		0.00	0.00	
20	0.00	0.37		0.00	0.02		0.00	0.00	
21	0.00	0.37		0.00	0.02		0.00	0.00	
22	0.00	0.37		0.00	0.02		0.00	0.00	
23	0.00	0.37		0.00	0.02		0.00	0.00	
24	0.00	0.37		0.00	0.02		0.00	0.00	
25	0.00	0.37		0.00	0.02		0.00	0.00	
26	0.00	0.37		0.00	0.02		0.00	0.00	
27	0.00	0.37		0.00	0.02		0.00	0.00	
28	0.00	0.37		0.00	0.02		0.00	0.00	
29	0.00	0.37		0.00	0.02		0.00	0.00	
30	0.00	0.37		0.00	0.02		0.16	0.16	5:00
31	0.00	0.37					0.00	0.16	
Monthly Total:	0.37		5:00	0.02		1:00	0.16		5:00
Qtrly Total:	0.55		11:00						

Report Date
08/01/2011

Copper Flat - Met 1

Q4 - 2010 Quarterly Summary Report For Relative Humidity (%)

10/01/2010 to 12/31/2010

DAY	October Mean	October Min	October Max	November Mean	November Min	November Max	December Mean	December Min	December Max
1	31.8	18.3	47.0	28.0	16.1	40.3	21.7	14.2	31.2
2	30.7	19.6	45.9	34.7	22.3	48.0	19.1	11.2	27.6
3	50.4	38.5	67.2	30.6	25.0	42.7	17.8	11.6	25.2
4	62.7	32.0	84.0	39.7	31.3	50.2	16.1	10.7	22.6
5	71.8	45.6	88.1	37.0	22.3	56.7	27.0	20.0	33.8
6	50.6	24.7	78.0	28.5	16.7	42.6	29.3	16.9	40.2
7	39.3	23.8	62.9	22.3	10.7	36.6	25.8	11.8	44.5
8	29.6	11.2	56.1	19.9	11.0	27.6	27.9	19.2	35.2
9	22.4	8.6	35.7	30.8	19.7	43.4	23.9	13.3	34.3
10	29.0	19.7	40.6	24.0	8.1	35.7	25.3	21.6	31.1
11	29.0	17.4	38.9	26.5	18.6	52.6	32.2	24.7	40.2
12	25.5	16.5	34.6	35.9	20.3	60.9	37.0	25.6	48.5
13	38.9	27.8	57.0	24.1	15.9	33.5	36.4	23.4	51.5
14	37.9	22.9	55.4	22.9	15.5	30.9	25.6	7.2	43.4
15	29.9	16.9	40.9	36.8	25.2	50.3	24.4	17.0	38.2
16	37.1	24.0	55.9	35.0	17.3	52.2	41.0	30.9	51.6
17	36.6	23.4	50.0	26.7	10.7	45.5	53.7	30.7	76.4
18	32.9	18.7	47.5	21.5	16.8	29.9	50.4	37.0	60.6
19	34.9	23.9	47.7	23.2	12.7	32.9	52.8	36.7	70.5
20	39.5	31.3	47.1	20.9	10.8	34.8	35.3	16.1	52.7
21	48.1	31.0	74.2	31.2	23.1	41.5	42.3	26.8	53.0
22	51.5	28.2	71.1	34.1	19.4	49.0	43.5	30.5	59.8
23	41.2	26.6	55.4	30.7	13.1	48.6	42.9	31.8	54.0
24	38.6	22.6	55.0	16.4	12.1	23.0	52.1	37.6	68.6
25	38.7	27.3	56.3	32.7	14.6	53.8	53.8	39.1	72.5
26	48.8	20.3	69.0	16.7	9.5	27.6	38.6	29.0	49.2
27	40.0	22.1	62.3	18.8	12.7	26.4	43.4	37.1	51.0
28	24.8	18.3	34.1	29.1	13.5	53.5	51.6	34.9	69.2
29	32.5	24.7	42.7	40.2	31.1	72.9	48.3	27.1	76.5
30	28.5	11.6	49.0	30.6	17.4	44.1	68.0	42.6	93.9
31	20.6	13.1	27.6				41.4	31.2	65.3
Monthly Mean	37.9			28.3			37.1		
Monthly Min		8.6			8.1			7.2	
Monthly Max			88.1			72.9			93.9
Quarterly Mean	34.5								
Quarterly Min	7.2								
Quarterly Max	93.9								

Report Date
08/01/2011

Copper Flat - Met 1

Q4 - 2010 Quarterly Summary Report For Barometric Pressure
(mbars)
10/01/2010 to 12/31/2010

DAY	October Mean	October Min	October Max	November Mean	November Min	November Max	December Mean	December Min	December Max
1	847	845	848	849	846	853	849	847	851
2	846	844	848	853	850	855	848	847	849
3	847	845	849	852	851	854	846	845	848
4	846	843	848	852	849	855	847	846	848
5	847	845	849	849	847	851	849	848	850
6	848	846	850	848	847	850	848	846	851
7	848	846	850	847	844	849	847	845	850
8	846	844	847	841	837	845	850	848	852
9	846	843	848	837	836	840	845	844	847
10	843	841	845	840	838	842	843	840	844
11	842	841	844	843	839	848	844	843	848
12	846	844	849	849	847	851	850	848	852
13	851	849	853	847	843	850	848	846	850
14	851	849	854	840	837	843	842	839	845
15	847	845	849	838	836	843	837	834	839
16	846	844	847	841	837	843	838	836	840
17	845	842	847	847	840	851	840	837	843
18	842	840	844	850	847	852	841	839	843
19	843	842	845	844	841	847	841	839	842
20	843	841	845	842	840	843	841	839	843
21	842	840	843	840	838	841	844	842	846
22	841	839	842	841	839	844	845	843	847
23	842	840	843	841	837	844	842	841	844
24	843	840	846	835	833	837	848	844	850
25	835	831	839	840	835	847	850	849	852
26	837	835	839	848	847	850	845	842	849
27	845	838	853	842	837	846	843	842	845
28	854	853	857	832	830	837	841	839	843
29	850	847	853	839	834	848	833	829	839
30	845	842	847	850	848	852	826	823	831
31	844	842	846				834	831	840
Monthly Mean	845			844			843		
Monthly Min		831			830			823	
Monthly Max			857			855			852
Quarterly Mean	844								
Quarterly Min	823								
Quarterly Max	857								

Copper Flat Met I

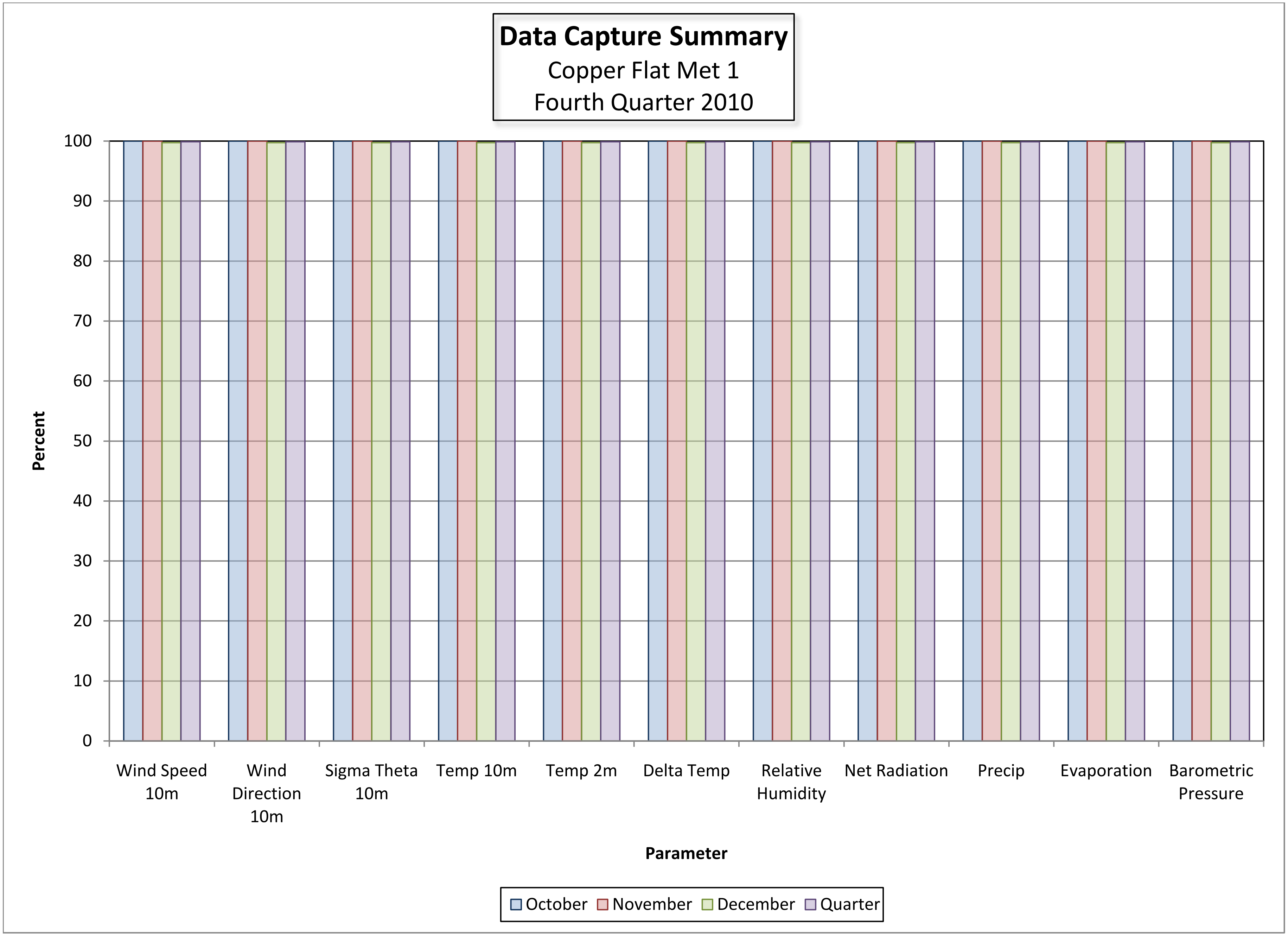
Q4 - 2010 Quarterly Summary Report for Daily Total Net Evaporation
Positive Values Indicate Evaporation
(Inches)
10/01/2010 to 12/31/2010

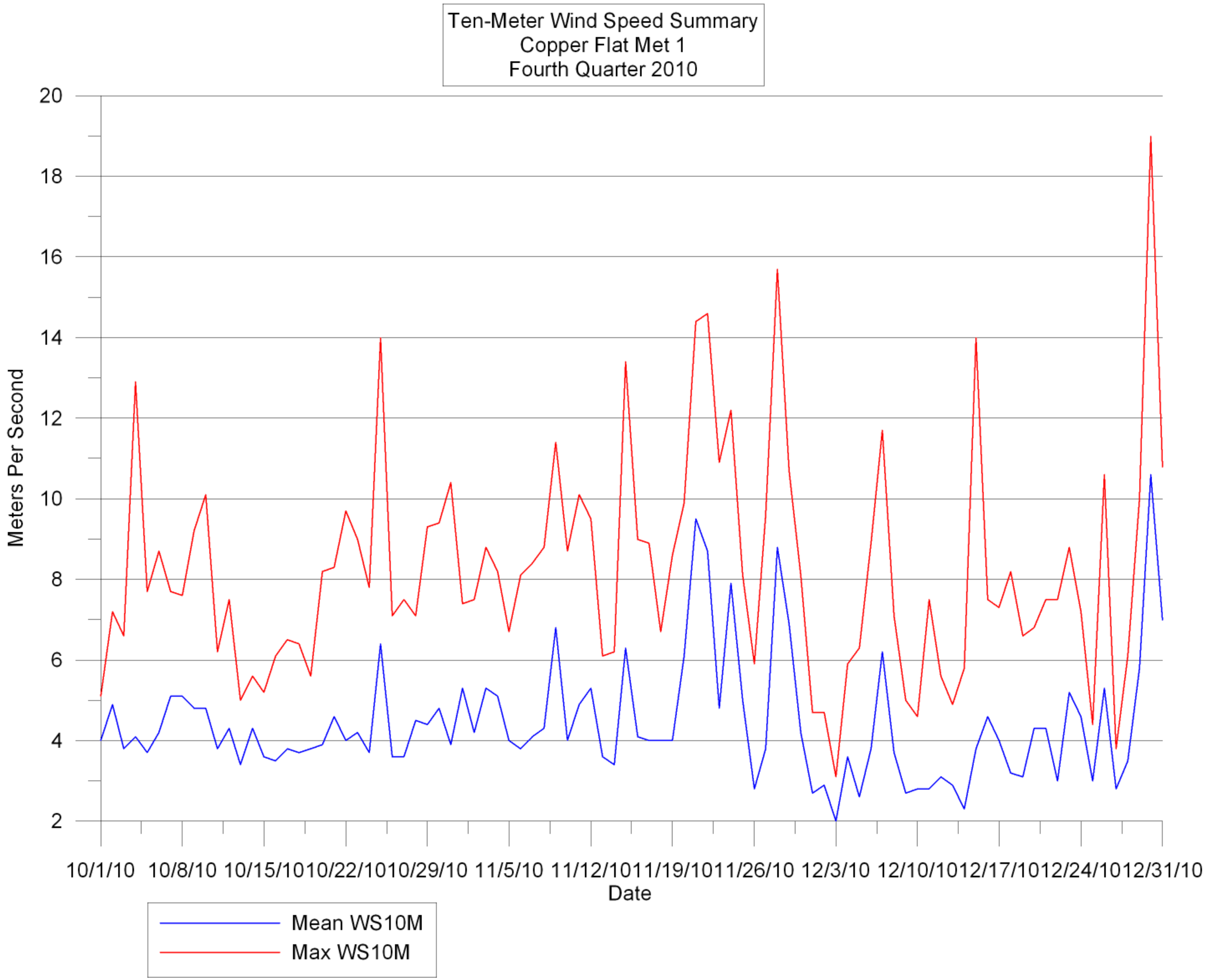
Day	October Daily Total	October Hourly Min	October Hourly Max	November Daily Total	November Hourly Min	November Hourly Max	December Daily Total	December Hourly Min	December Hourly Max
1	0.229	-0.002	0.033	0.146	-0.002	0.020			
2	0.222	-0.002	0.037	0.080	-0.003	0.015			
3	0.039	-0.002	0.007	0.130	-0.001	0.021			
4	0.078	-0.015	0.023	0.134	-0.002	0.021			
5	-0.041	-0.083	0.020	0.108	-0.002	0.018			
6	0.167	-0.001	0.038	0.134	-0.003	0.027			
7	0.206	-0.003	0.038	0.143	-0.002	0.027			
8	0.208	-0.001	0.039	0.145	-0.002	0.028			
9	0.190	-0.002	0.032	0.106	-0.031	0.015			
10	0.165	-0.001	0.021	-0.083	-0.078	0.000			
11	0.137	-0.002	0.025						
12	0.165	-0.003	0.023						
13	0.129	-0.004	0.023						
14	0.166	-0.001	0.023						
15	0.149	-0.002	0.026						
16	0.142	-0.001	0.026						
17	0.100	-0.005	0.025						
18	0.152	-0.002	0.026						
19	0.120	-0.002	0.020						
20	0.088	-0.002	0.024						
21	0.082	-0.002	0.018						
22	0.053	-0.001	0.018						
23	0.075	-0.003	0.016						
24	0.083	-0.002	0.015						
25	0.087	-0.003	0.021						
26	0.079	-0.002	0.016						
27	0.110	-0.002	0.017						
28	0.102	-0.001	0.014						
29	0.124	-0.005	0.026						
30	0.204	-0.001	0.033						
31	0.144	-0.001	0.015						
Monthly Total	3.954			1.043					
Monthly Min		-0.083			-0.078				
Monthly Max			0.039			0.028			
Quarterly Total	4.997								
Quarterly Min	-0.083								
Quarterly Max	0.039								

6.0 Graphical Summaries

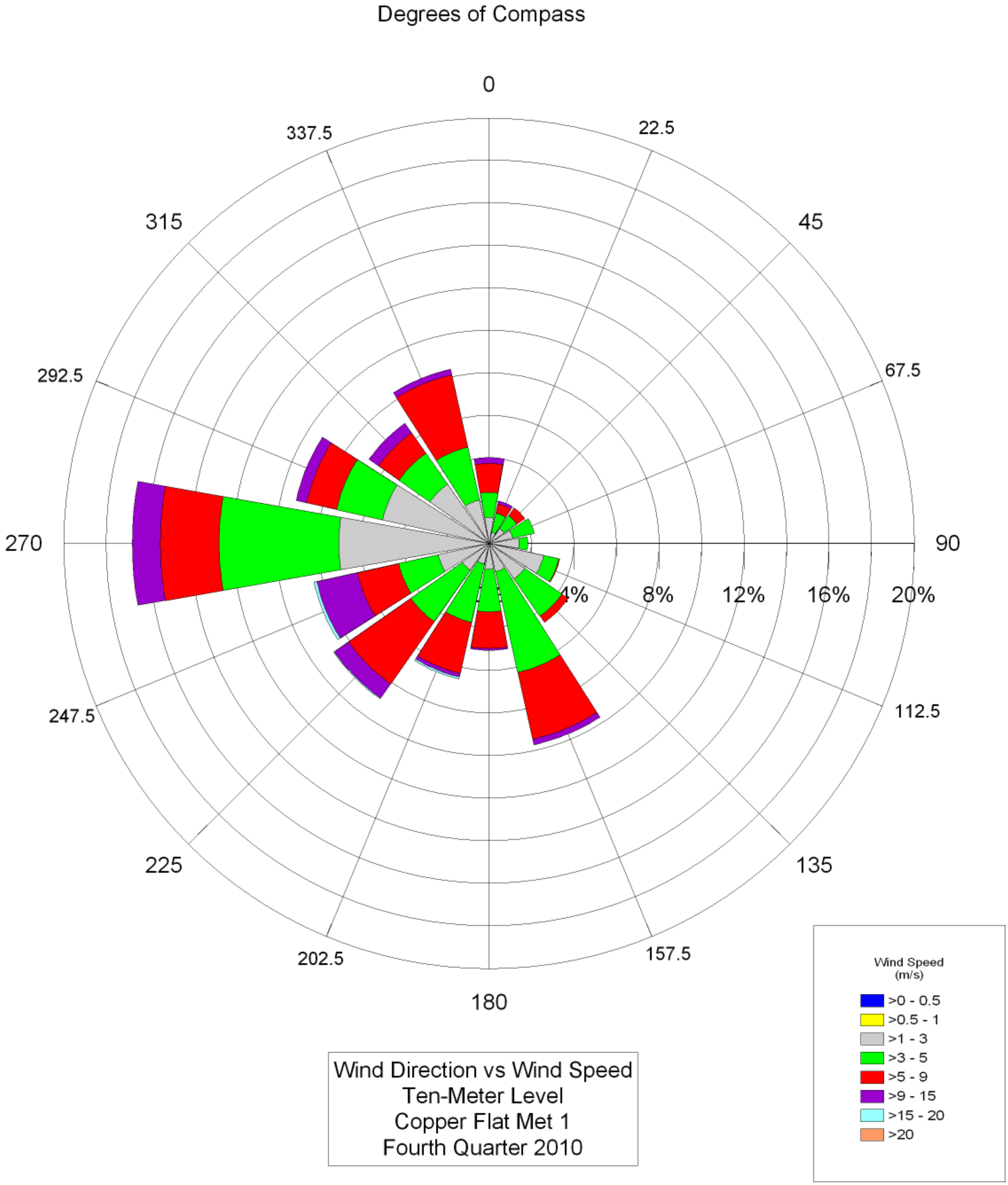
Copper Flat Met 1

Fourth Quarter 2010

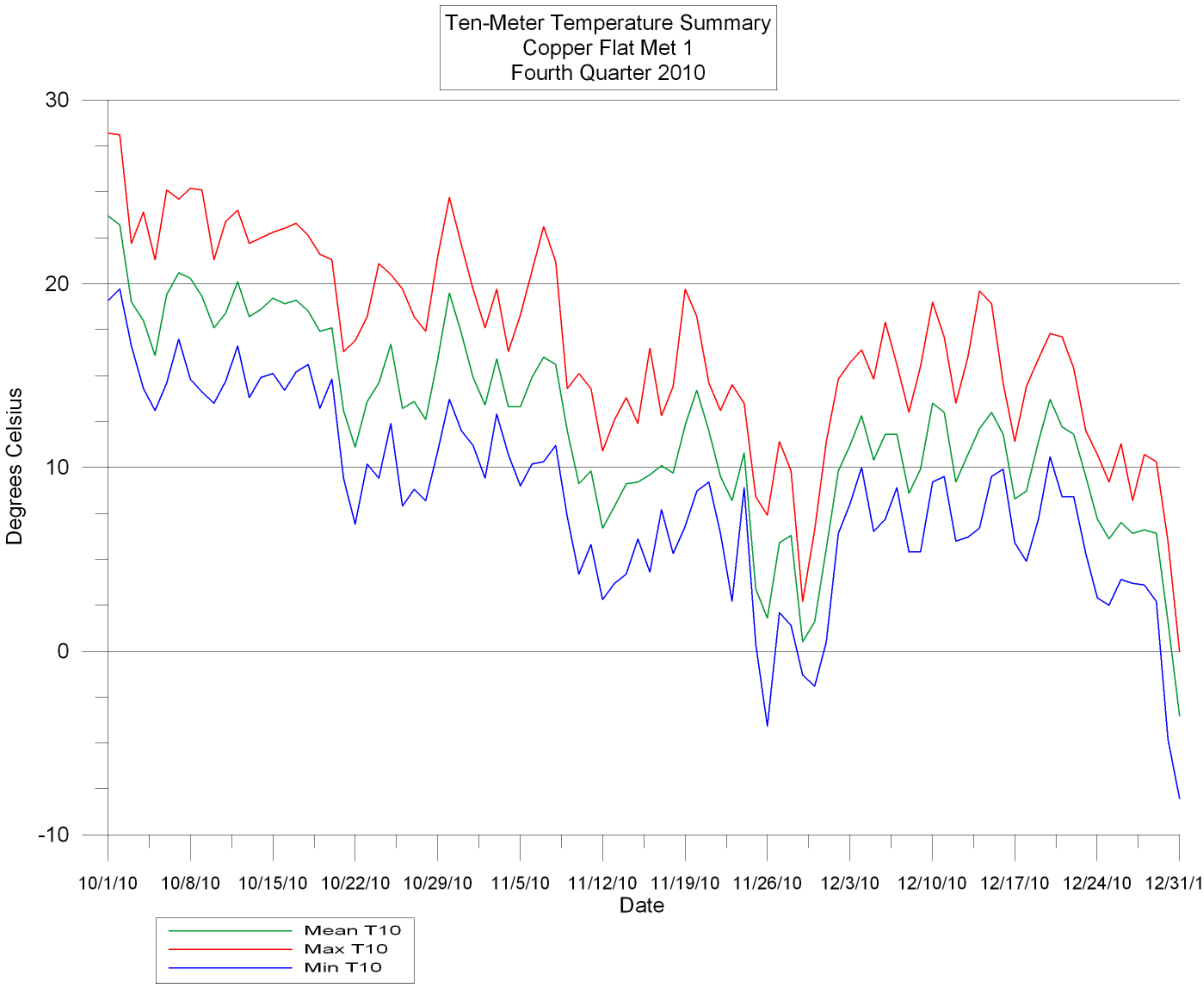

Data Capture Summary
Copper Flat Met 1
Fourth Quarter 2010
Percent
100
90
80
70
60
50
40
30
20
10
0
Wind Speed 10m
Wind Direction 10m
Sigma Theta 10m
Temp 10m
Temp 2m
Delta Temp
Relative Humidity
Net Radiation
Precip
Evaporation
Barometric Pressure
Parameter
October
November
December
Quarter

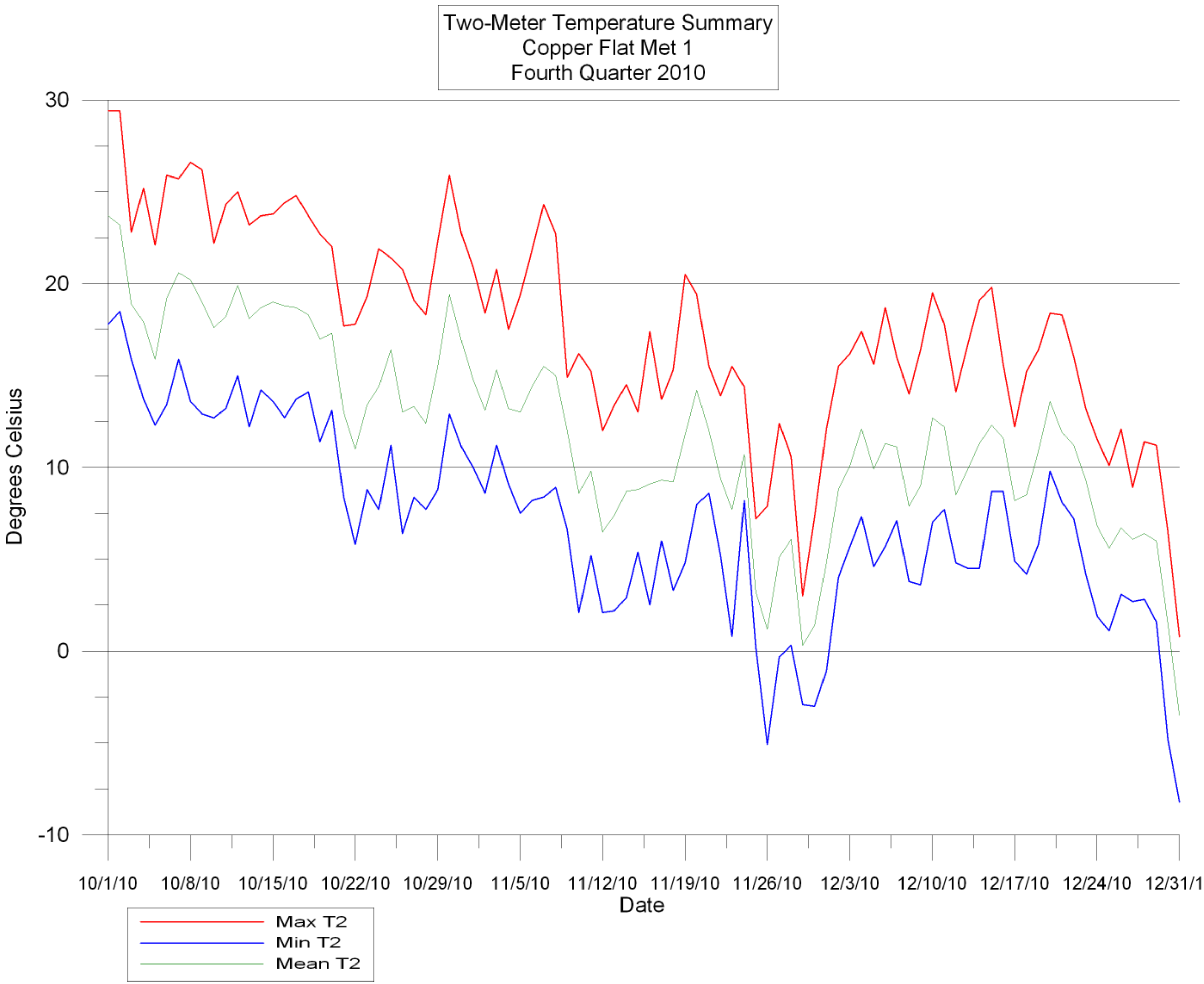


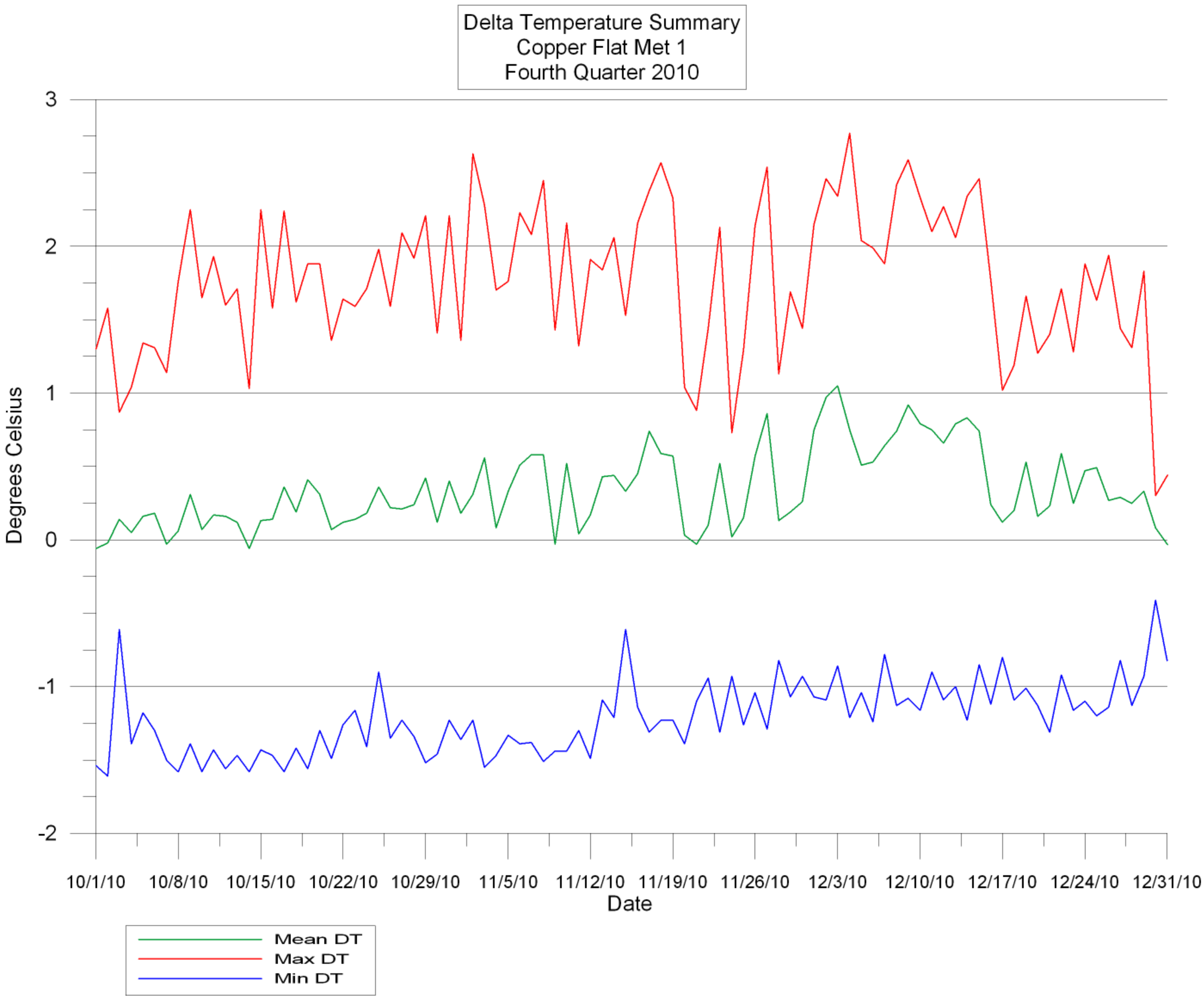
Ten-Meter Wind Speed Summary
Copper Flat Met 1
Fourth Quarter 2010
Meters Per Second
20
18
16
14
12
10
8
6
4
2
10/1/10
10/8/10
10/15/10
10/22/10
10/29/10
11/5/10
11/12/10
11/19/10
11/26/10
12/3/10
12/10/10
12/17/10
12/24/10
12/31/10
Date
Mean WS10M
Max WS10M



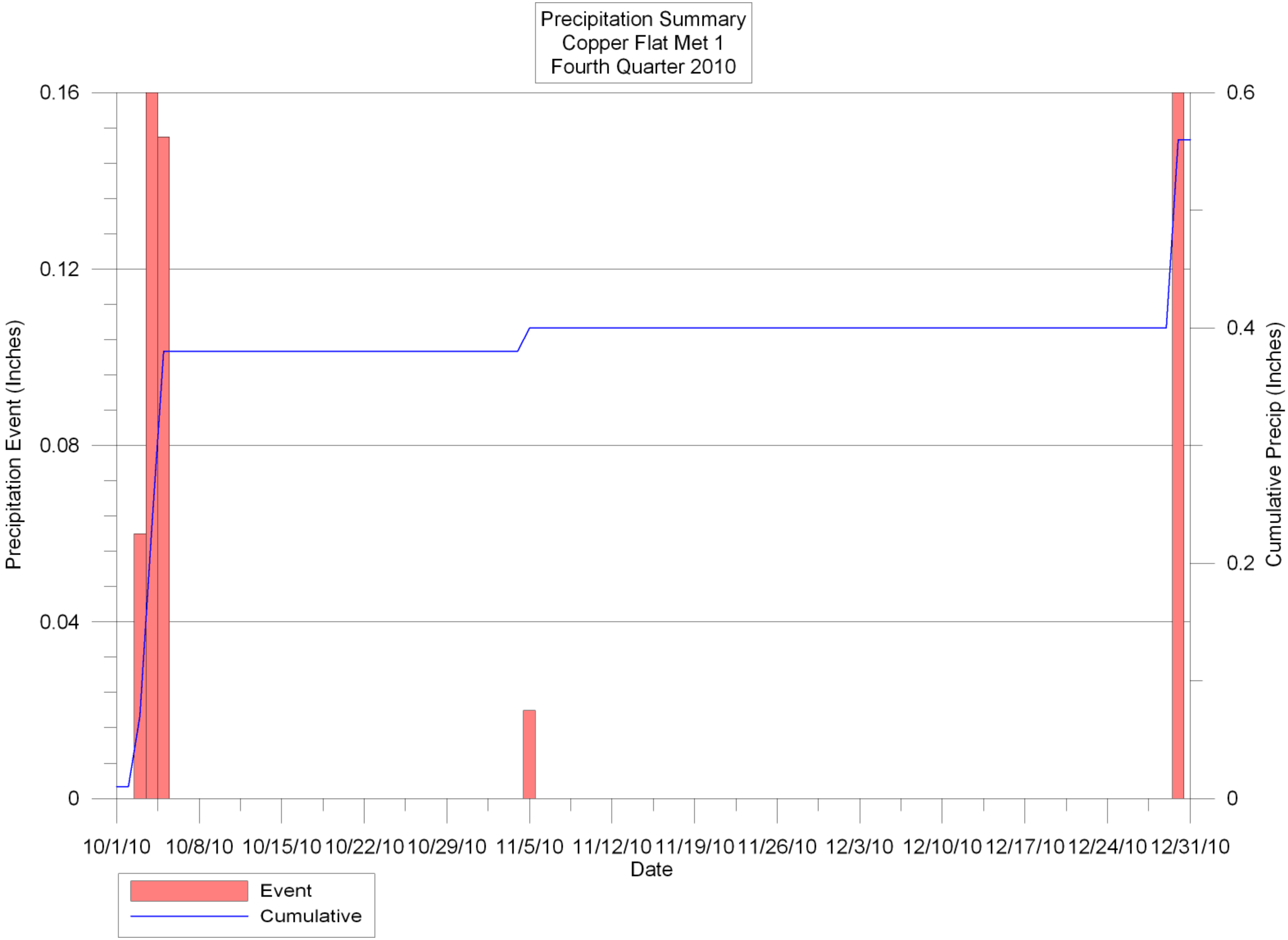
Wind Direction vs Wind Speed
Ten-Meter Level
Copper Flat Met 1
Fourth Quarter 2010


Ten-Meter Temperature Summary
Copper Flat Met 1
Fourth Quarter 2010
30
20
10
0
-10
Degrees Celsius
10/1/10
10/8/10
10/15/10
10/22/10
10/29/10
11/5/10
11/12/10
11/19/10
11/26/10
12/3/10
12/10/10
12/17/10
12/24/10
12/31/10
Date
Mean T10
Max T10
Min T10

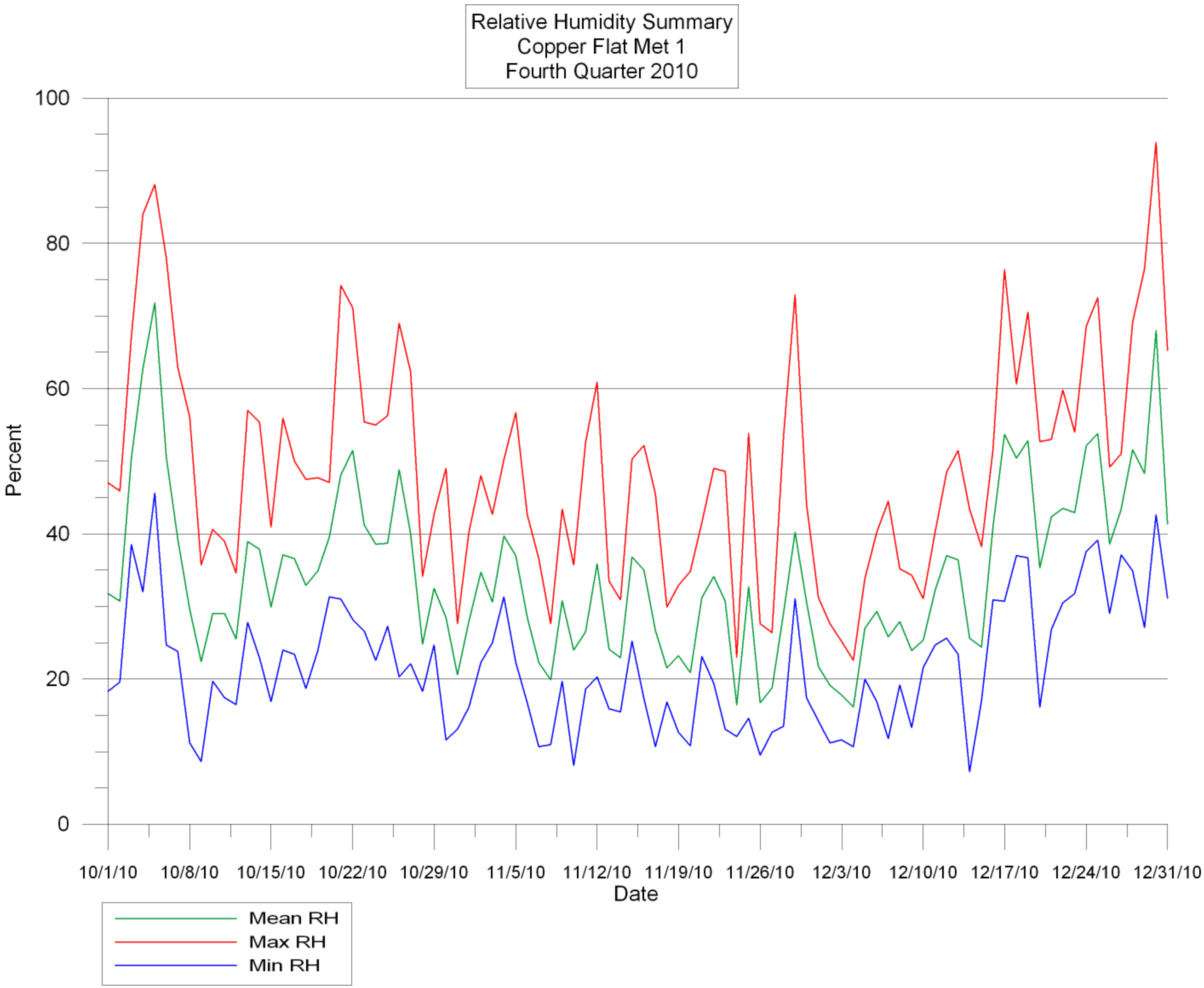

Two-Meter Temperature Summary
Copper Flat Met 1
Fourth Quarter 2010
30
20
10
0
-10
Degrees Celsius
10/1/10
10/8/10
10/15/10
10/22/10
10/29/10
11/5/10
11/12/10
11/19/10
11/26/10
12/3/10
12/10/10
12/17/10
12/24/10
12/31/10
Date
Max T2
Min T2
Mean T2


Delta Temperature Summary
Copper Flat Met 1
Fourth Quarter 2010
Degrees Celsius
3
2
1
0
-1
-2
10/1/10
10/8/10
10/15/10
10/22/10
10/29/10
11/5/10
11/12/10
11/19/10
11/26/10
12/3/10
12/10/10
12/17/10
12/24/10
12/31/10
Date
Mean DT
Max DT
Min DT

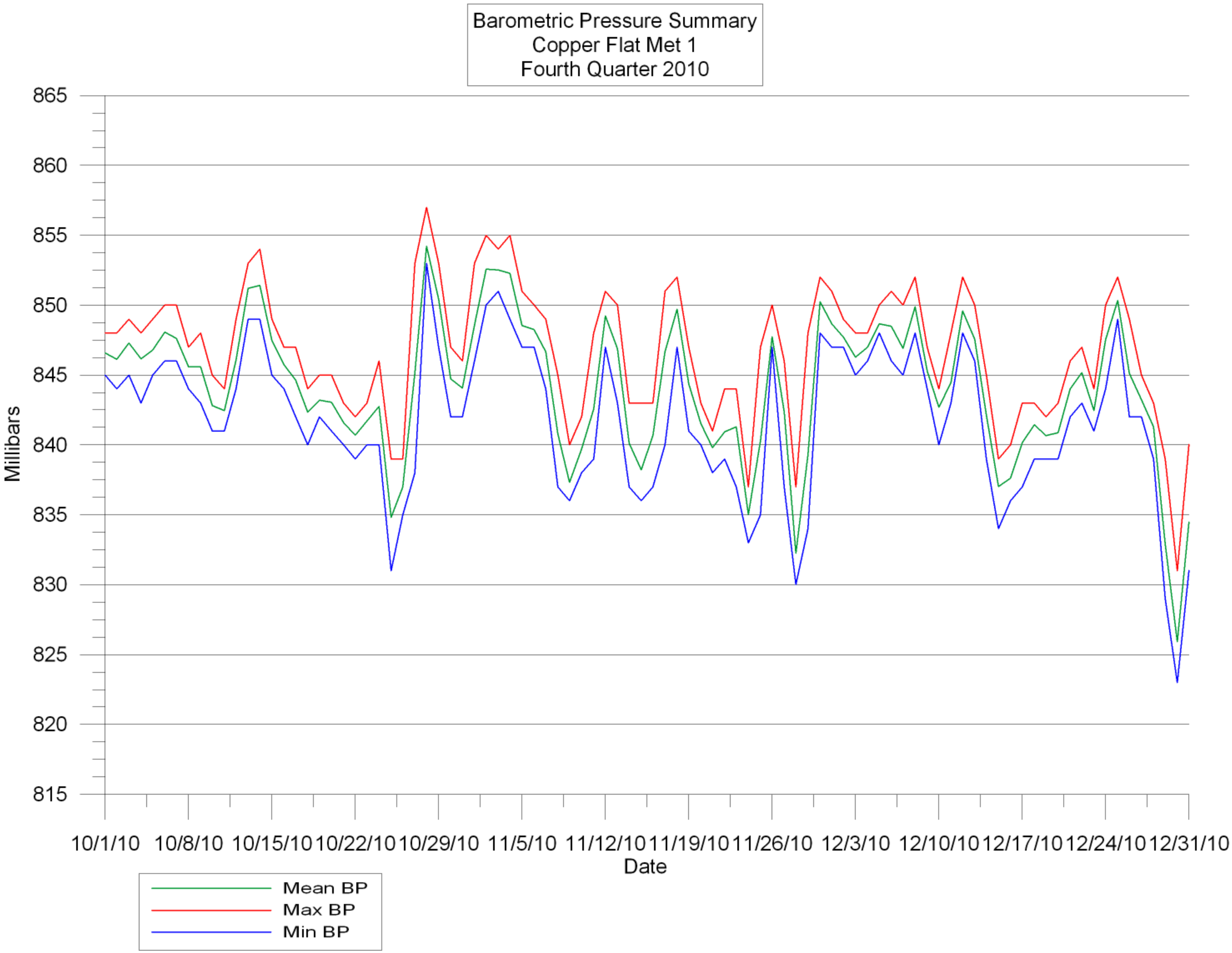

Net Radiation Summary
Navajo Met 3
Third Quarter 2010
600
400
200
0
-200
Watts Per Square Meter
10/1/10
10/8/10
10/15/10
10/22/10
10/29/10
11/5/10
11/12/10
11/19/10
11/26/10
12/3/10
12/10/10
12/17/10
12/24/10
12/31/10
Date
Mean NR
Max NR
Min NR



Precipitation Summary
Copper Flat Met 1
Fourth Quarter 2010
Precipitation Event (Inches)
Cumulative Precip (Inches)
0.16
0.12
0.08
0.04
0
0.6
0.4
0.2
0
10/1/10
10/8/10
10/15/10
10/22/10
10/29/10
11/5/10
11/12/10
11/19/10
11/26/10
12/3/10
12/10/10
12/17/10
12/24/10
12/31/10
Date
Event
Cumulative



Relative Humidity Summary
Copper Flat Met 1
Fourth Quarter 2010
100
80
60
40
20
0
Percent
10/1/10
10/8/10
10/15/10
10/22/10
10/29/10
11/5/10
11/12/10
11/19/10
11/26/10
12/3/10
12/10/10
12/17/10
12/24/10
12/31/10
Date
Mean RH
Max RH
Min RH


Barometric Pressure Summary
Copper Flat Met 1
Fourth Quarter 2010
865
860
855
850
845
840
835
830
825
820
815
Millibars
10/1/10
10/8/10
10/15/10
10/22/10
10/29/10
11/5/10
11/12/10
11/19/10
11/26/10
12/3/10
12/10/10
12/17/10
12/24/10
12/31/10
Date
Mean BP
Max BP
Min BP

New Mexico Copper Corporation

Copper Flat Mine

Meteorological Quarterly Summary Report
Copper Flat Met 1

First Quarter 2011
(January through March 2011)

Prepared By:

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Albuquerque, New Mexico
87107

September 9, 2011

Table of Contents

1.0 INTRODUCTION

This report is a summary of the basic meteorological data collected at Copper Flat Mine 10-meter meteorological tower for the First quarter of 2011. Data reduction and performance audits during this quarter were performed by Class One Technical Services. The most recent field performance audit was conducted on January 13, 2011.

The Copper Flat meteorological tower is located on the Copper Flat Mine. The site coordinates in the UTM Coordinate System are:

Site - Met 1

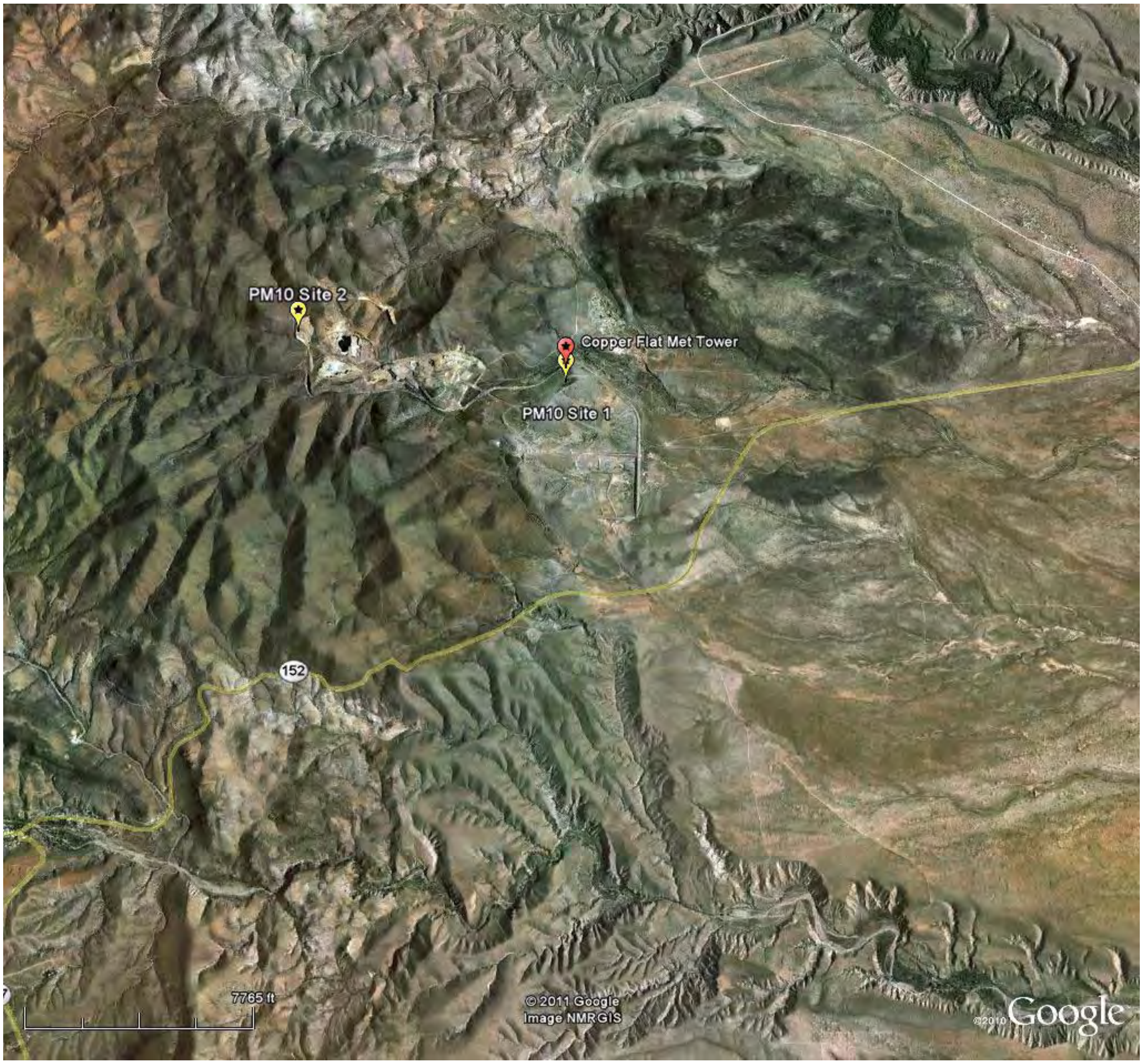
North: 3,650,579
East: 265,718

The tower location and general environs of the tower are shown in Figure 1. The tower site includes the following instrumentation:

Instrument	Manufacture	Model	Range
Wind Speed (10m)	Climatronics	F460	0-50 m/s
Wind Direction (10m)	Climatronics	F460	0-360 deg
Temperature (10m)	Climatronics	100093	-30 ^{o}C to +50 ^{o}C
Temperature (2m)	Climatronics	100093	-30 ^{o}C to +50 ^{o}C
Relative Humidity	Rotronic	MP801A	0-100%
Precipitation	Climatronics	100508-G0	0.01 in (per tip)
Net Radiation	Kipp & Zonen (Wavelength)	NR LITE	0.20 - 100 micron
Barometric Pressure	Climatronics	102663-G1	17.72 to 32.49 in. Hg
Evaporation Pan	NovaLynx	255-100	0 to 9 inches water
Data Logger	Campbell CR1000		

The wind speed, wind direction, temperature, and relative humidity sensors are mounted at ten (10) meters above ground level. The wind speed and wind direction sensors are mounted at three (3) meters. The temperature, solar radiation, and barometric pressure sensors are mounted at two (2) meters above ground level. The precipitation gauge is located at ground level.

Figure 1: Map of Copper Flat PM_{10} Sampler Locations



2.0 REPORTING CRITERIA

The following criteria have been used in preparing the quarterly summaries for the El Segundo meteorological data for this report:

a. Temperature Summaries (10-m temperature, 2-m temperature, delta temperature, and temperature lapse rate)

For each day of each month in the quarter the mean, maximum and minimum temperature, in degrees, Celsius are reported. The maxima and the minima are based on one-hour averages. For a 24-hour mean value to be *valid*, at least 18 hourly values must have been present during the 24-hour period. If less than 18 hours of valid data are available, the mean *is calculated, but data may not be representative and should be used with care*. Similarly, maxima and minima are *included* for these periods. Even though some data may have been available on these days, the maxima and minima may be misleading if the missing data happened to occur during the hottest or coldest part of the day.

For each month in the quarter the mean temperature for the month is calculated from all the hourly data, including data on those days which did not have enough data to calculate a 24-hour mean. Monthly averages *are calculated for months with less than* 4 valid 24-hour means in the month. *The* monthly maximum *and* minimum are reported as well. While 4 valid days are *considered valid* to report a mean, means for months with less than 18 days of valid data may not be representative and should be used with care.

Means, maxima and minima are reported for the entire quarter if there is at least one valid month of data in the quarter. As such, these values may not be truly representative of the entire quarter if significant amounts of data are missing. The validity of the quarterly values depends on their intended use and care should be taken with quarters with low data capture.

b. Wind Speed Summary

For each day of each month the 24-hour mean wind speed and the maximum hourly wind speed has been reported in units of meters per second. The criterion for valid 24-hour means is the same as that described above for mean temperatures.

For each month, the mean wind speed and the maximum wind speed are reported. The criteria for determining the monthly values are the same as those described above for monthly temperature values. For each quarter, the mean for the entire quarter and the maximum hourly value in the quarter is reported. The criteria for reporting quarterly values are the same as those described above for quarterly temperature values.

c. Wind Data Summary

The Wind Data Summary report gives a JFD (Joint Frequency Distribution) of wind direction and wind speed. Wind directions are divided into 16 sectors, each 22.5 degrees wide. The north sector covers 348.75 degrees to 11.25 degrees (i.e. it is symmetrical about zero degrees). Wind speeds are divided into 8 categories. The data in each wind speed/wind direction category are given as a fraction of the total month to the nearest 1 percent. The total fraction for each wind direction sector and each wind speed category is also given.

A quarterly JFD is printed if at least one valid month of data existed in the quarter. As such, it is possible that the quarterly JFD may not be truly representative of the full quarter if only one month of data is available.

d. Precipitation Summary

For each day in the quarter, the total precipitation in inches is reported along with a running precipitation total beginning at the first day of the quarter. Precipitation for a day is reported if at least one hour of data is available during the day.

For each quarter, the total precipitation for the quarter is reported along with the total number of hours during which precipitation occurred. A quarterly precipitation value is reported if there is any valid precipitation during the quarter. Care must be taken in use of the quarterly precipitation values if there were significant missing data during the quarter.

e. Relative Humidity Summaries

For each day in the quarter the mean, maximum and minimum relative humidity, in percent, is reported. The maxima and the minima are based on one-hour averages. For a 24-hour mean value to be *valid*, at least 18 hourly values must have been present during the 24-hour period. If less than 18 hours of valid data are available, the mean i*s calculated*, *but data may not be representative and should be used with care*. Similarly, maxima and minima are *included* for these periods. Even though some data may have been available on these days, the maxima and minima may be misleading if the missing data happened to occur during the hottest or coldest part of the day.

For each month in the quarter the mean temperature for the month is calculated from all the hourly data, including data on those days which did not have enough data to calculate a 24-hour mean. Monthly averages *are calculated for months with less than* 4 valid 24-hour means in the month. *The* monthly maximum *and* minimum are reported as well. While 4 valid days are *considered valid* to report a mean, means for months with less than 18 days of valid data may not be representative and should be used with care.

Means, maxima and minima are reported for the entire quarter if there is at least one valid month of data in the quarter. As such, these values may not be truly representative of the entire quarter if significant amounts of data are missing.

f. Data Capture Summary

For each month and each parameter the percent of valid data, based on hourly values, is reported as well as the average data capture for the entire month. Also, the percent of valid data for the quarter for each parameter and the average data capture for the quarter are given.

g. Barometric Pressure Summary

Barometric pressure is summarized in inches of Mercury (in. Hg). The pressure data are the actual site pressures; they have not been "corrected" to sea level as is typically done with National Weather Service data. The reporting requirements for valid averages, maxima, and minima are the same as those for temperature and relative humidity summaries.

h. Net Radiation Summary

For each day in the quarter the daily maximum net radiation in watts per square meter is reported. The maxima are based on one-hour averages.

i. Evaporation Summary

For each day of the quarter, the total, minimum, and maximum evaporation values are reported in inches. Minima and maxima are based on one-hour averages. Positive values indicate evaporation, or loss of water from the evaporation pan, whereas negative values indicate precipitation or addition of water to the evaporation pan by other means.

For a 24-hour total value to be *valid*, at least 18 hourly values must have been present during the 24-hour period. If less than 18 hours of valid data are available, the total is *calculated*, *but data may not be representative and should be used with care*. Similarly, maxima and minima are *included* for these periods. Even though some data may have been available on these days, the maxima and minima may be misleading if the missing data happened to occur during the hottest or coldest part of the day, or during a precipitation event.

For each month in the quarter, the total evaporation is calculated from all the hourly data, including data on those days which did not have enough data to calculate a 24-hour total. The monthly maximum and minimum are reported as well.

3.0 Meteorological Data Summary

The Copper Flat Met 1 meteorological data for First quarter 2011 is presented in section 5.0 Numerical Summaries, on pages 14-24. The following text and tables represent the summarized data in section 5.0 Numerical Summaries.

Wind Speed

The average ten-meter wind speed for the First quarter was 4.9 m/s. The maximum hourly ten-meter wind speed for the meteorological tower was 17.5 m/s and was recorded March 21, 2010 at 1600 MST. Thirty-three percent of the hourly wind speeds at the ten-meter level were observed in the >1.0 to 3.0 m/s wind speed class, while twenty-eight percent were in the >3.0 to 5.0 m/s wind speed class.

Table 1 below summarizes the monthly hourly average and maximum wind speeds in meters per second (m/s).

Table 1: Monthly Wind Speed Summary

Month	Mean Hourly Wind Speed (meters/second)	Maximum Hourly Wind Speed (meters/second)	Date of Maximum Hourly Wind Speed
January	3.8	12.5	Apr. 24 @ 1600
February	5.5	16.3	May 20 @ 0500
March	5.4	17.5	Mar. 21 @ 1600

Wind Direction

The prevailing wind direction for the quarter was from the West sector. Winds from this sector occurred approximately fifteen percent of the time. Winds from the west occurred five percent of the time in both the >1.0 to 3.0 m/s and >3.0 to 5.0 m/s wind speed classes.

The next most common wind direction was from the North-northwest (NNW) occurring ten percent of the time. Winds from the NNW occurred four percent of the time in the >5.0 to 9.0 m/s class.

Temperature

The mean quarterly 10-meter temperature was 8.9 degrees Celsius (^{o}C). The maximum hourly temperature of 25.5^{o}C was recorded on March 16, 2011 at 1600 MST. The minimum temperature of -20.9^{o}C was recorded on February 3, 2011 at 0600 MST.

The mean quarterly 2-meter temperature was 8.6^{o}C. The maximum hourly temperature of 26.6^{o}C was recorded on March 16, 2011 at 1600 MST. The minimum hourly temperature of -21.9^{o}C was recorded on February 3, 2011 at 0600 MST.

Table 2 below represents the monthly mean, minimum, and maximum temperatures for the 10 and 2-meter levels of the meteorological tower.

Table 2: Monthly Temperature Summary

10-Meter Temperature

Month	Max Hrly Temp ^{o}C	Date of Max Temp	Min Hrly Temp ^{o}C	Date of Min Temp	Mean Hrly Temp ^{o}C
January	21.1	Jan. 17 @ 1700	-10.0	Jan. 1 @ 07-0800	5.6
February	20.9	Feb. 16 @ 1400	-20.9	Feb. 3 @ 0600	6.0
March	25.5	Mar. 16 @ 1600	2.7	Mar. 5 @ 0500	15.0

2-Meter Temperature

Month	Max Hrly Temp ^{o}C	Date of Max Temp	Min Hrly Temp ^{o}C	Date of Min Temp	Mean Hrly Temp ^{o}C
January	21.0	Jan. 17 @ 1700	-10.9	Jan. 1 @ 0700	5.0
February	22.4	Feb. 16 @ 13-1400	-21.9	Feb. 3 @ 0600	5.7
March	26.6	Mar. 16 @ 1600	2.0	Mar. 5 @ 0500	14.8

Net Radiation

The maximum hourly net radiation for the First Quarter 2011 was 559 w/m^2 and occurred on March 31, 2011 at 1200 MST. Table 4 below summarizes the monthly maximum net radiation in watts per square meter (w/m^2).

Table 4: Monthly Net Radiation Summary

Month	Maximum Hrly Net Radiation (w/m^2)	Date of Maximum Hourly Net Radiation
January	432	Jan. 23 @ 1300
February	494	Feb. 28 @ 1200
March	559	Mar. 31 @ 1200

Precipitation

The total precipitation for First Quarter 2011 was 0.02 inches, with a duration of 1 hour. All of the observed precipitation fell in the month of February. The largest single day precipitation amount was 0.02 inches was recorded on February 3, 2011. Table 5 summarizes the total monthly precipitation for January, February, and March 2011.

Table 5: Monthly Precipitation Summary

Month	Total Precipitation (inches)	Percent Of Total (%)	Max. Daily Precipitation Event (inches)	Date of Max Daily Precip Event
January	0.00	0	---	---
February	0.02	100	0.02	Feb. 3
March	0.00	0	---	---

Relative Humidity

The mean relative humidity for the quarter was 28 percent. The maximum hourly relative humidity of 83 percent was recorded on February 1, 2011. The minimum hourly relative humidity value of 2 percent was recorded on March 23, 2011. Table 6 below represents the monthly mean, minimum and maximum relative humidity values for the meteorological tower.

Table 6: Monthly Relative Humidity Summary

Month	Mean Hrly Relative Humidity (%)	Minimum Hrly Relative Humidity (%)	Maximum Hrly Relative Humidity (%)
January	34	10	69
February	32	3	83
March	19	2	61

Barometric Pressure

The mean barometric pressure for the First Quarter 2011 was 843 milibars. The maximum hourly barometric pressure value of 854 mbars occurred on February 12, 2011. Table 7 below represents the monthly mean, minimum and maximum barometric pressure values for the meteorological tower.

Table 7: Monthly Barometric Pressure Summary

Month	Mean Hrly Barometric Pressure (mbars)	Minimum Hrly Barometric Pressure (mbars)	Maximum Hrly Barometric Pressure (mbars)
January	844	833	853
February	842	830	854
March	843	830	853

Evaporation

Table 8 represents the monthly net sum, minimum and maximum evaporation values for the meteorological tower. The evaporation gauge was disconnected for the season on November 11, 2010.

Table 8: Monthly Evaporation Summary

Month	Total Monthly Net Evaporation (inches)	Minimum Hourly Evaporation (inches)	Maximum Hourly Evaporation (inches)
January	---	---	---
February	---	---	---
March	---	---	---

4.0 DATA CAPTURE DESCRIPTION

Overall data capture for the First quarter of 2011 was approximately ninety-nine (99) percent (excluding Evaporation data and edits).

January 2011

Overall data capture for the month was approximately ninety-nine (99) percent for all parameters. All data loss is attributed to the performance audit that occurred on January 13, 2011

February 2011

Overall data capture for the month was one hundred (100) percent for all parameters.

March 2011

Overall data capture for the month was one hundred (100) percent for all parameters.

5.0 Numerical Summaries

Copper Flat Met 1

First Quarter 2011

Copper Flat - Met 1

Q1 - 2011 Quarterly Data Capture Report
(percentages)
01/01/2011 to 03/31/2011

Parameter	January Values Count	January Capture Pct	February Values Count	February Capture Pct	March Values Count	March Capture Pct	Qtr Total Count	Qtr Total Capture Pct
Wind Speed 10m	742	99.73	672	100.00	744	100.00	2158	99.91
Wind Direction 10m	742	99.73	672	100.00	744	100.00	2158	99.91
Sigma Theta 10m	742	99.73	672	100.00	744	100.00	2158	99.91
Temp 10m	742	99.73	672	100.00	744	100.00	2158	99.91
Temp 2m	742	99.73	672	100.00	744	100.00	2158	99.91
Delta Temp	742	99.73	672	100.00	744	100.00	2158	99.91
Relative Humidity	744	100.00	672	100.00	744	100.00	2160	100.00
Net Radiation	744	100.00	672	100.00	744	100.00	2160	100.00
Precipitation	744	100.00	672	100.00	744	100.00	2160	100.00
Evaporation	744	100.00	672	100.00	744	100.00	2160	100.00
Barometric Pressure	744	100.00	672	100.00	744	100.00	2160	100.00
Station AVERAGE	742	99.73	672	100.00	744	100.00	2158	99.91

Report Date
09/09/2011

Copper Flat - Met 1

Q1 - 2011 Quarterly Summary Report For Wind Speed 10m (m/s)

01/01/2011 to 03/31/2011

DAY	January Mean	January Min	January Max	February Mean	February Min	February Max	March Mean	March Min	March Max
1	2.5	1.0	5.1	4.8	2.5	9.2	4.3	1.2	10.3
2	2.9	1.2	4.7	8.2	5.9	10.0	4.0	1.2	9.6
3	2.8	1.5	5.5	5.4	1.1	11.0	4.0	0.9	9.1
4	2.6	1.1	6.0	2.3	1.3	4.1	6.1	2.0	10.4
5	3.1	1.5	4.4	3.7	1.1	9.5	5.5	3.0	8.8
6	3.0	1.1	6.3	6.5	2.7	11.6	5.3	1.4	10.6
7	2.4	1.3	3.5	4.7	1.8	10.6	7.5	2.1	15.8
8	3.6	1.4	8.9	6.9	1.9	12.5	4.9	1.9	8.2
9	3.7	1.0	7.1	5.1	1.1	9.6	3.7	1.5	6.5
10	3.2	1.5	8.3	2.5	1.2	5.2	5.1	3.7	8.8
11	4.2	1.3	9.1	3.2	1.9	4.7	4.6	0.8	8.3
12	3.2	0.9	5.5	4.0	2.3	9.2	4.3	1.3	9.4
13	2.8	1.5	5.2	2.5	1.0	4.5	3.5	1.3	6.4
14	4.2	1.3	8.5	4.2	1.0	8.8	6.0	2.3	9.9
15	4.7	1.0	8.3	4.1	1.9	7.8	4.5	1.6	9.8
16	3.4	1.2	5.9	6.2	2.3	9.5	4.6	0.8	8.7
17	4.2	2.0	9.2	7.3	1.8	13.9	4.5	2.2	8.5
18	4.6	1.6	8.1	5.6	1.4	9.8	4.5	1.6	9.2
19	4.6	1.3	10.9	8.1	0.7	15.6	5.4	2.2	9.4
20	4.7	1.2	8.6	11.8	3.2	16.3	6.5	1.2	10.9
21	2.6	1.3	4.5	5.0	1.8	11.1	11.5	4.7	17.5
22	2.9	1.2	6.1	5.2	1.5	11.7	8.5	3.0	16.0
23	5.2	1.7	10.4	6.2	1.6	11.6	4.1	1.1	7.7
24	4.6	1.6	12.5	5.8	1.4	12.5	6.9	1.8	12.7
25	4.7	1.2	9.2	4.9	1.6	9.6	5.0	1.8	11.4
26	6.2	2.3	9.4	7.4	1.3	11.7	4.6	1.4	10.4
27	3.5	2.1	5.1	8.9	1.6	15.9	5.7	2.0	9.8
28	3.0	0.9	7.0	3.6	2.0	6.0	5.9	1.9	9.7
29	3.9	1.7	9.3				5.5	2.6	7.7
30	3.8	1.8	6.7				5.1	2.0	10.0
31	5.4	1.2	10.5				6.6	2.0	12.9
Monthly Mean	3.8			5.5			5.4		
Monthly Min		0.9			0.7			0.8	
Monthly Max			12.5			16.3			17.5
Quarterly Mean	4.9								
Quarterly Min	0.7								
Quarterly Max	17.5								

Copper Flat - Met 1

Q1 - 2011 Quarterly Wind Summary Report
(Wind Direction 10m vs Wind Speed 10m)
01/01/2011 to 03/31/2011

WS CLASS	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTALS
CALM	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
0.5 TO 1.0	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.0046
>1.0 TO 3.0	0.015	0.010	0.009	0.016	0.017	0.020	0.023	0.016	0.009	0.010	0.008	0.023	0.053	0.051	0.025	0.024	0.3285
>3.0 TO 5.0	0.023	0.015	0.011	0.007	0.008	0.012	0.025	0.027	0.006	0.009	0.011	0.011	0.050	0.015	0.018	0.034	0.2822
>5.0 TO 9.0	0.038	0.017	0.002	0.000	0.001	0.003	0.005	0.019	0.005	0.017	0.039	0.028	0.035	0.016	0.013	0.040	0.2780
>9.0 TO 15.0	0.008	0.002	0.000	0.000	0.000	0.000	0.000	0.003	0.006	0.013	0.024	0.020	0.014	0.003	0.004	0.003	0.1010
>15.0 TO 20.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.001	0.000	0.000	0.000	0.0056
>20.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
TOTAL	0.085	0.045	0.022	0.024	0.027	0.035	0.054	0.064	0.026	0.051	0.084	0.084	0.153	0.086	0.059	0.101	

Report Date
09/09/2011

Copper Flat - Met 1

Q1 - 2011 Quarterly Summary Report For Temp 10m
(deg C)
01/01/2011 to 03/31/2011

DAY	January Mean	January Min	January Max	February Mean	February Min	February Max	March Mean	March Min	March Max
1	-5.7	-10.0	-1.0	-3.4	-12.1	2.2	10.9	4.8	17.7
2	-2.7	-7.2	2.6	-16.3	-19.2	-12.5	15.5	9.7	22.4
3	2.1	-2.7	9.1	-15.2	-20.9	-9.1	16.2	11.9	22.0
4	4.1	0.6	9.7	-5.9	-12.6	1.1	12.0	7.6	16.9
5	2.7	-1.7	7.7	3.6	-2.5	8.7	7.3	2.7	12.1
6	3.9	0.4	7.8	5.2	1.5	8.4	11.0	4.3	19.3
7	5.9	1.8	11.2	4.3	-0.3	11.1	13.5	9.9	17.1
8	5.6	2.8	9.9	8.5	1.9	14.5	9.9	6.8	14.5
9	6.5	2.9	12.1	-1.6	-5.7	1.9	10.0	3.5	16.9
10	5.4	-2.3	9.9	-0.4	-4.9	5.3	13.9	9.2	19.5
11	-1.4	-5.8	3.4	3.5	-1.6	9.2	17.4	12.3	23.6
12	2.7	0.0	6.0	7.6	2.3	14.1	17.3	13.3	21.8
13	4.4	0.5	10.0	10.4	5.2	16.6	16.6	10.8	21.0
14	6.8	2.4	11.2	13.9	7.7	20.8	16.1	11.3	21.4
15	8.8	5.1	12.9	15.4	9.9	20.6	17.5	12.2	22.7
16	8.3	3.6	13.9	16.5	13.0	20.9	18.6	13.9	25.5
17	13.5	6.2	21.1	13.9	11.3	16.5	19.1	14.0	24.2
18	12.4	9.2	16.4	13.1	7.2	17.9	18.0	13.3	22.7
19	11.7	7.0	17.7	14.3	10.3	18.6	17.6	14.5	21.2
20	6.0	2.6	12.1	10.7	6.9	13.9	16.9	10.7	20.9
21	6.2	1.6	12.6	7.3	1.3	13.5	17.1	13.6	20.4
22	8.9	3.6	16.3	10.6	3.8	15.9	11.9	8.3	17.3
23	5.7	2.4	8.0	10.5	5.5	14.8	11.6	4.7	20.1
24	4.7	1.0	10.4	7.7	4.0	12.6	15.4	11.6	19.2
25	2.7	-0.9	7.8	9.8	3.3	17.2	13.8	8.7	19.1
26	4.6	1.5	7.4	12.0	4.2	15.9	13.7	7.6	19.6
27	6.0	1.4	10.7	5.1	0.2	12.1	15.1	9.7	21.3
28	7.4	2.6	13.2	5.5	-1.5	12.3	17.3	12.2	22.7
29	9.4	5.3	15.3				16.5	12.8	20.7
30	9.6	5.8	14.9				16.8	11.6	22.8
31	6.4	1.6	9.4				18.7	11.3	24.7
Monthly Mean	5.6			6.0			15.0		
Monthly Min		-10.0			-20.9			2.7	
Monthly Max			21.1			20.9			25.5
Quarterly Mean	8.9								
Quarterly Min	-20.9								
Quarterly Max	25.5								

Report Date
09/09/2011

Copper Flat - Met 1

Q1 - 2011 Quarterly Summary Report For Temp 2m
(deg C)
01/01/2011 to 03/31/2011

DAY	January Mean	January Min	January Max	February Mean	February Min	February Max	March Mean	March Min	March Max
1	-5.9	-10.9	-0.4	-3.4	-11.9	0.8	10.3	2.7	18.5
2	-3.3	-8.4	3.2	-16.2	-19.7	-12.3	15.0	8.0	23.4
3	1.4	-4.2	9.2	-15.6	-21.9	-9.0	15.7	10.7	23.0
4	3.3	-1.2	10.1	-6.4	-14.0	1.6	11.9	7.1	18.1
5	2.1	-2.9	8.4	3.2	-3.7	8.6	7.5	2.0	13.0
6	3.4	0.1	8.2	4.7	0.5	9.2	10.8	2.8	20.3
7	5.1	0.2	11.8	4.0	-2.0	11.5	13.4	9.5	18.4
8	4.9	1.1	11.0	8.4	1.9	15.4	10.0	6.0	15.2
9	6.0	1.1	13.2	-1.3	-5.3	2.5	9.8	2.3	17.7
10	5.1	-2.5	10.5	-0.6	-5.9	5.9	13.6	7.4	20.6
11	-1.5	-6.3	3.9	2.9	-2.8	9.9	17.3	11.6	25.0
12	2.2	-0.7	6.6	7.0	0.1	15.0	17.1	12.3	22.7
13	3.6	-1.4	10.8	9.6	2.9	17.2	16.4	9.6	22.1
14	6.1	1.4	11.8	13.4	7.2	21.7	16.1	10.6	22.7
15	8.3	3.4	13.6	14.6	7.9	21.2	17.3	10.7	23.6
16	7.7	2.4	14.6	16.3	11.7	22.4	18.4	12.1	26.6
17	13.1	5.7	21.0	13.9	10.9	17.5	18.6	11.7	26.0
18	11.9	8.2	17.3	12.9	6.0	19.1	17.6	12.3	24.3
19	11.2	5.7	18.6	14.4	9.4	19.7	17.3	13.0	23.1
20	5.8	2.1	11.3	11.0	6.5	15.2	16.9	9.6	22.0
21	5.6	0.0	13.3	7.4	0.7	14.6	17.3	12.6	21.9
22	8.1	1.6	16.5	10.4	3.5	17.3	12.2	8.0	18.7
23	5.4	2.3	8.9	10.3	3.5	16.2	11.6	3.8	21.0
24	4.3	0.0	11.2	7.9	2.9	13.4	15.5	10.7	20.6
25	2.6	-2.1	8.5	9.6	1.9	18.3	13.8	7.6	20.9
26	4.1	0.5	8.3	12.2	3.8	17.5	13.9	6.2	21.4
27	5.3	0.6	11.6	5.2	-1.2	11.9	15.3	8.8	22.3
28	6.6	0.5	13.8	5.2	-2.7	13.0	17.2	10.6	24.1
29	8.6	2.7	16.1				16.3	11.3	21.5
30	9.0	3.6	15.8				17.0	10.8	23.7
31	6.2	0.6	10.1				18.9	10.3	25.6
Monthly Mean	5.0			5.7			14.8		
Monthly Min		-10.9			-21.9			2.0	
Monthly Max			21.0			22.4			26.6
Quarterly Mean	8.6								
Quarterly Min	-21.9								
Quarterly Max	26.6								

Report Date
09/09/2011

Copper Flat - Met 1

Q1 - 2011 Quarterly Summary Report For Delta Temp
(deg C)
01/01/2011 to 03/31/2011

DAY	January Mean	January Min	January Max	February Mean	February Min	February Max	March Mean	March Min	March Max
1	0.29	-1.17	1.64	0.07	-1.17	1.87	0.60	-1.58	2.50
2	0.60	-0.92	2.13	-0.04	-0.36	0.47	0.49	-1.53	2.25
3	0.72	-1.01	2.02	0.38	-0.71	1.96	0.45	-1.37	2.74
4	0.76	-0.93	2.11	0.45	-0.80	1.71	0.09	-1.25	1.84
5	0.57	-0.88	2.14	0.37	-1.10	1.61	-0.15	-1.32	1.30
6	0.47	-0.76	1.57	0.51	-0.90	2.00	0.20	-1.37	1.79
7	0.88	-0.94	2.30	0.31	-1.42	1.85	0.18	-1.34	1.73
8	0.67	-1.09	2.24	0.10	-0.97	1.07	-0.16	-1.59	0.89
9	0.53	-1.12	2.20	-0.33	-1.40	0.68	0.24	-1.34	1.88
10	0.29	-1.07	1.54	0.23	-1.13	1.64	0.33	-1.43	2.03
11	0.10	-1.05	1.41	0.60	-1.18	2.33	0.08	-1.66	1.52
12	0.46	-1.13	1.96	0.59	-1.31	2.22	0.18	-1.29	2.14
13	0.78	-1.22	2.10	0.80	-1.11	2.60	0.27	-1.50	2.37
14	0.65	-1.20	2.39	0.52	-1.35	2.58	-0.01	-1.77	1.60
15	0.43	-0.99	1.70	0.80	-1.35	2.72	0.26	-1.61	2.02
16	0.60	-1.12	2.03	0.23	-1.55	2.30	0.27	-1.67	2.41
17	0.38	-1.25	2.48	0.01	-1.20	1.41	0.48	-1.81	2.74
18	0.51	-1.35	2.64	0.18	-1.49	1.70	0.39	-1.87	2.59
19	0.57	-0.99	2.52	-0.04	-1.46	1.39	0.29	-1.84	2.33
20	0.23	-1.28	1.58	-0.31	-1.52	0.37	-0.03	-1.78	1.69
21	0.60	-1.12	1.92	-0.13	-1.41	0.77	-0.21	-1.66	1.01
22	0.79	-0.97	2.37	0.15	-1.64	1.45	-0.29	-1.58	1.41
23	0.23	-1.28	1.75	0.20	-1.60	1.98	0.05	-1.57	1.56
24	0.42	-1.41	2.00	-0.13	-1.28	1.08	-0.05	-1.45	1.40
25	0.12	-1.43	1.33	0.21	-1.26	2.02	-0.02	-1.81	1.55
26	0.42	-1.21	1.68	-0.12	-1.66	0.88	-0.15	-1.79	1.52
27	0.62	-1.20	2.13	-0.03	-1.22	1.47	-0.14	-1.60	1.37
28	0.84	-1.24	2.47	0.33	-1.28	2.02	0.03	-1.60	1.92
29	0.80	-1.27	2.96				0.16	-1.50	2.52
30	0.54	-1.20	2.21				-0.17	-1.50	0.97
31	0.21	-1.60	1.30				-0.27	-1.69	0.98
Monthly Mean	0.52			0.21			0.11		
Monthly Min		-1.60			-1.66			-1.87	
Monthly Max			2.96			2.72			2.74
Quarterly Mean	0.28								
Quarterly Min	-1.87								
Quarterly Max	2.96								

Report Date
09/09/2011

Copper Flat - Met 1

Q1 - 2011 Quarterly Summary Report For Net Radiation
(W/m2)
01/01/2011 to 03/31/2011

DAY	January Mean	January Min	January Max	February Mean	February Min	February Max	March Mean	March Min	March Max
1	23	-89	349	31	-71	397	74	-86	470
2	31	-86	359	9	-64	133	78	-92	464
3	28	-85	339	7	-63	192	67	-110	473
4	28	-90	340	34	-75	289	67	-111	475
5	19	-74	314	43	-79	360	76	-98	492
6	12	-67	273	53	-84	412	51	-81	391
7	34	-88	337	58	-81	409	58	-90	410
8	25	-72	333	54	-88	394	66	-106	501
9	30	-83	325	76	-91	445	81	-105	507
10	25	-87	338	60	-95	432	79	-98	499
11	35	-73	351	57	-94	442	76	-111	475
12	19	-78	321	57	-93	434	59	-91	436
13	37	-82	348	59	-94	427	84	-113	508
14	36	-81	380	62	-93	426	79	-96	479
15	32	-85	356	56	-106	437	85	-87	534
16	26	-84	348	55	-89	407	86	-106	497
17	31	-94	342	28	-88	299	86	-106	512
18	29	-91	360	59	-77	407	91	-104	521
19	35	-77	352	60	-83	419	84	-105	482
20	38	-88	362	58	-86	415	81	-106	494
21	36	-95	360	74	-90	465	80	-98	485
22	37	-91	361	58	-100	434	93	-107	549
23	35	-95	432	62	-91	442	99	-113	543
24	35	-95	369	67	-94	467	80	-111	506
25	38	-81	357	67	-104	459	94	-99	495
26	39	-87	373	51	-99	422	98	-99	532
27	37	-99	378	53	-92	448	98	-114	535
28	36	-100	369	77	-103	494	94	-106	513
29	35	-94	368				103	-110	544
30	37	-95	366				98	-100	521
31	36	-77	351				101	-110	559
Monthly Mean	31			53			82		
Monthly Min		-100			-106			-114	
Monthly Max			432			494			559
Quarterly Mean	56								
Quarterly Min	-114								
Quarterly Max	559								

Report Date
09/09/2011

Copper Flat - Met 1

Q1 - 2011 Quarterly Precipitation Summary
(inches)
01/01/2011 to 03/31/2011

Day of Month	January Precip (inches)	January Sum	January Duration (hours)	February Precip (inches)	February Sum	February Duration (hours)	March Precip (inches)	March Sum	March Duration (hours)
1	0.00	0.00		0.00	0.00		0.00	0.00	
2	0.00	0.00		0.00	0.00		0.00	0.00	
3	0.00	0.00		0.02	0.02	1:00	0.00	0.00	
4	0.00	0.00		0.00	0.02		0.00	0.00	
5	0.00	0.00		0.00	0.02		0.00	0.00	
6	0.00	0.00		0.00	0.02		0.00	0.00	
7	0.00	0.00		0.00	0.02		0.00	0.00	
8	0.00	0.00		0.00	0.02		0.00	0.00	
9	0.00	0.00		0.00	0.02		0.00	0.00	
10	0.00	0.00		0.00	0.02		0.00	0.00	
11	0.00	0.00		0.00	0.02		0.00	0.00	
12	0.00	0.00		0.00	0.02		0.00	0.00	
13	0.00	0.00		0.00	0.02		0.00	0.00	
14	0.00	0.00		0.00	0.02		0.00	0.00	
15	0.00	0.00		0.00	0.02		0.00	0.00	
16	0.00	0.00		0.00	0.02		0.00	0.00	
17	0.00	0.00		0.00	0.02		0.00	0.00	
18	0.00	0.00		0.00	0.02		0.00	0.00	
19	0.00	0.00		0.00	0.02		0.00	0.00	
20	0.00	0.00		0.00	0.02		0.00	0.00	
21	0.00	0.00		0.00	0.02		0.00	0.00	
22	0.00	0.00		0.00	0.02		0.00	0.00	
23	0.00	0.00		0.00	0.02		0.00	0.00	
24	0.00	0.00		0.00	0.02		0.00	0.00	
25	0.00	0.00		0.00	0.02		0.00	0.00	
26	0.00	0.00		0.00	0.02		0.00	0.00	
27	0.00	0.00		0.00	0.02		0.00	0.00	
28	0.00	0.00		0.00	0.02		0.00	0.00	
29	0.00	0.00					0.00	0.00	
30	0.00	0.00					0.00	0.00	
31	0.00	0.00					0.00	0.00	
Monthly Total:	0.00		0:00	0.02		1:00	0.00		0:00
Qtrly Total:	0.02		1:00						

Report Date
09/09/2011

Copper Flat - Met 1

Q1 - 2011 Quarterly Summary Report For Relative Humidity (%)

01/01/2011 to 03/31/2011

DAY	January Mean	January Min	January Max	February Mean	February Min	February Max	March Mean	March Min	March Max
1	41.8	25.4	59.2	67.4	55.2	82.5	17.0	9.4	25.2
2	35.7	21.3	49.4	68.1	53.2	82.0	16.1	9.6	27.1
3	34.7	24.1	44.3	51.5	39.8	62.7	23.3	4.9	38.5
4	41.6	19.1	59.3	49.6	37.9	60.5	21.1	9.7	38.3
5	36.4	23.1	50.5	44.4	31.4	58.8	32.4	18.1	61.3
6	32.9	23.4	43.0	32.4	19.4	44.1	25.0	11.1	37.2
7	32.9	19.4	45.0	36.4	22.3	51.0	22.9	12.3	30.0
8	41.3	26.6	59.5	31.4	17.3	60.3	29.3	18.0	43.9
9	42.6	25.0	58.5	42.3	23.3	64.2	21.4	9.8	35.8
10	37.0	24.4	50.2	35.6	22.9	49.3	16.5	7.6	26.0
11	32.1	21.0	44.4	26.1	15.0	39.1	10.6	4.8	15.7
12	24.9	15.9	32.2	20.5	9.3	32.7	12.3	7.9	17.0
13	37.5	25.8	57.5	15.7	8.4	22.9	14.9	8.1	24.1
14	40.5	27.2	51.9	13.0	4.9	22.0	14.1	9.5	18.8
15	37.6	25.1	53.0	11.1	3.1	23.0	17.8	9.4	26.0
16	32.2	20.2	43.2	13.9	8.6	25.0	15.6	6.2	20.6
17	33.4	12.6	56.0	30.7	19.9	46.0	16.2	7.4	23.4
18	30.6	20.7	41.4	32.2	20.3	47.5	17.5	8.1	27.4
19	32.8	16.4	41.5	38.4	20.1	58.3	18.0	7.3	28.0
20	40.3	27.1	57.9	37.2	24.7	51.2	10.1	5.3	17.6
21	32.4	17.0	47.3	33.5	14.9	54.0	11.4	6.8	19.9
22	27.8	14.6	39.3	18.9	6.0	33.6	27.9	8.9	54.7
23	32.7	22.8	47.7	18.9	14.0	33.2	19.8	2.4	30.3
24	30.1	12.8	61.1	29.4	17.6	41.6	13.2	7.2	18.1
25	43.5	27.8	58.5	23.0	9.7	40.1	18.4	9.9	24.9
26	28.7	21.0	40.5	11.6	3.7	25.5	24.3	13.9	35.0
27	26.6	14.4	37.0	31.5	13.8	73.8	22.9	8.7	37.7
28	22.2	10.6	33.4	27.2	14.3	40.6	17.6	8.3	26.2
29	15.9	9.8	22.5				19.0	12.6	31.4
30	23.0	13.0	32.7				15.5	10.7	21.1
31	38.4	23.0	68.5				20.8	12.1	35.7
Monthly Mean	33.5			31.8			18.8		
Monthly Min		9.8			3.1			2.4	
Monthly Max			68.5			82.5			61.3
Quarterly Mean	27.9								
Quarterly Min	2.4								
Quarterly Max	82.5								

Report Date
09/09/2011

Copper Flat - Met 1

Q1 - 2011 Quarterly Summary Report For Barometric Pressure (mbars)

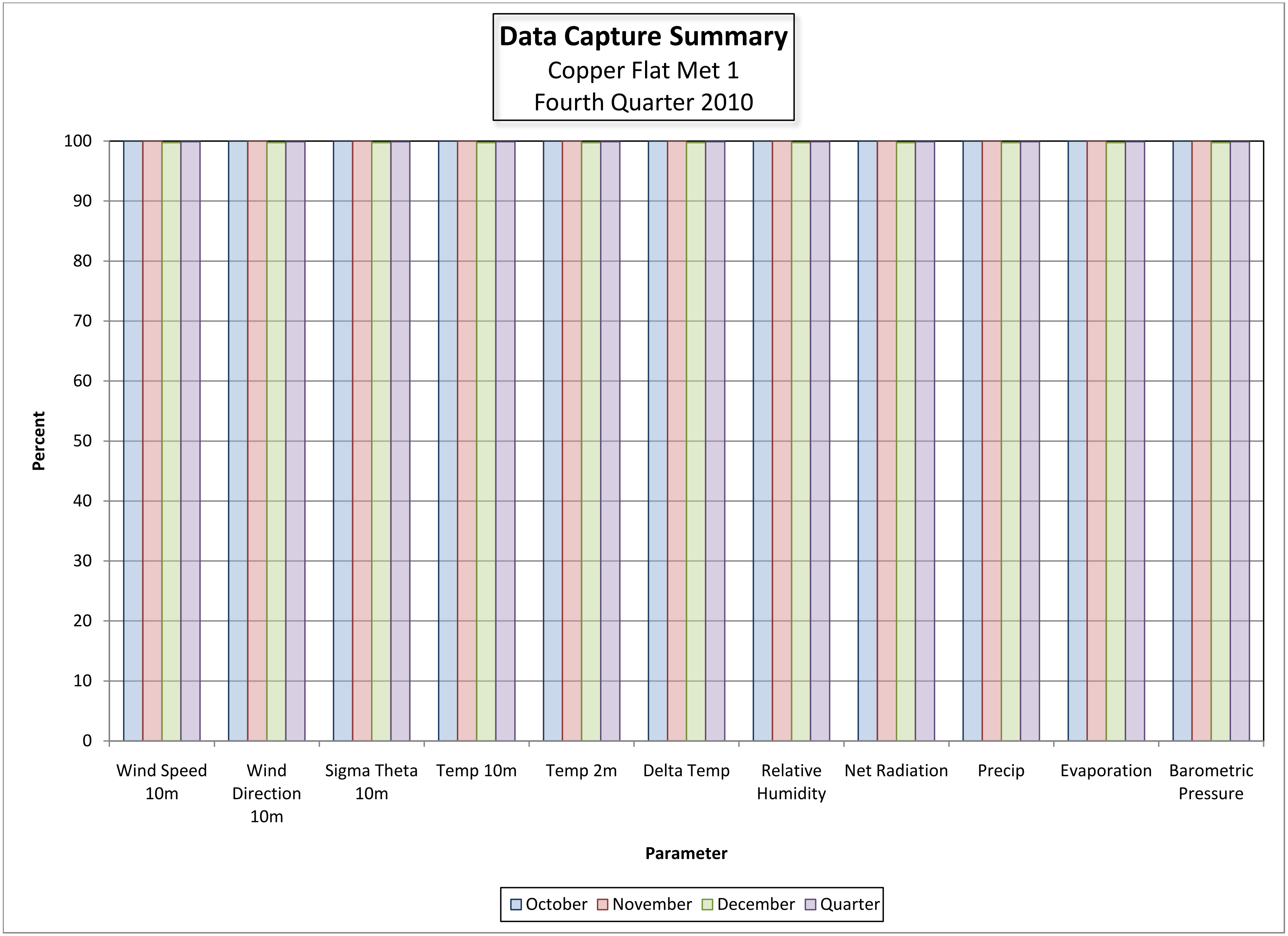
01/01/2011 to 03/31/2011

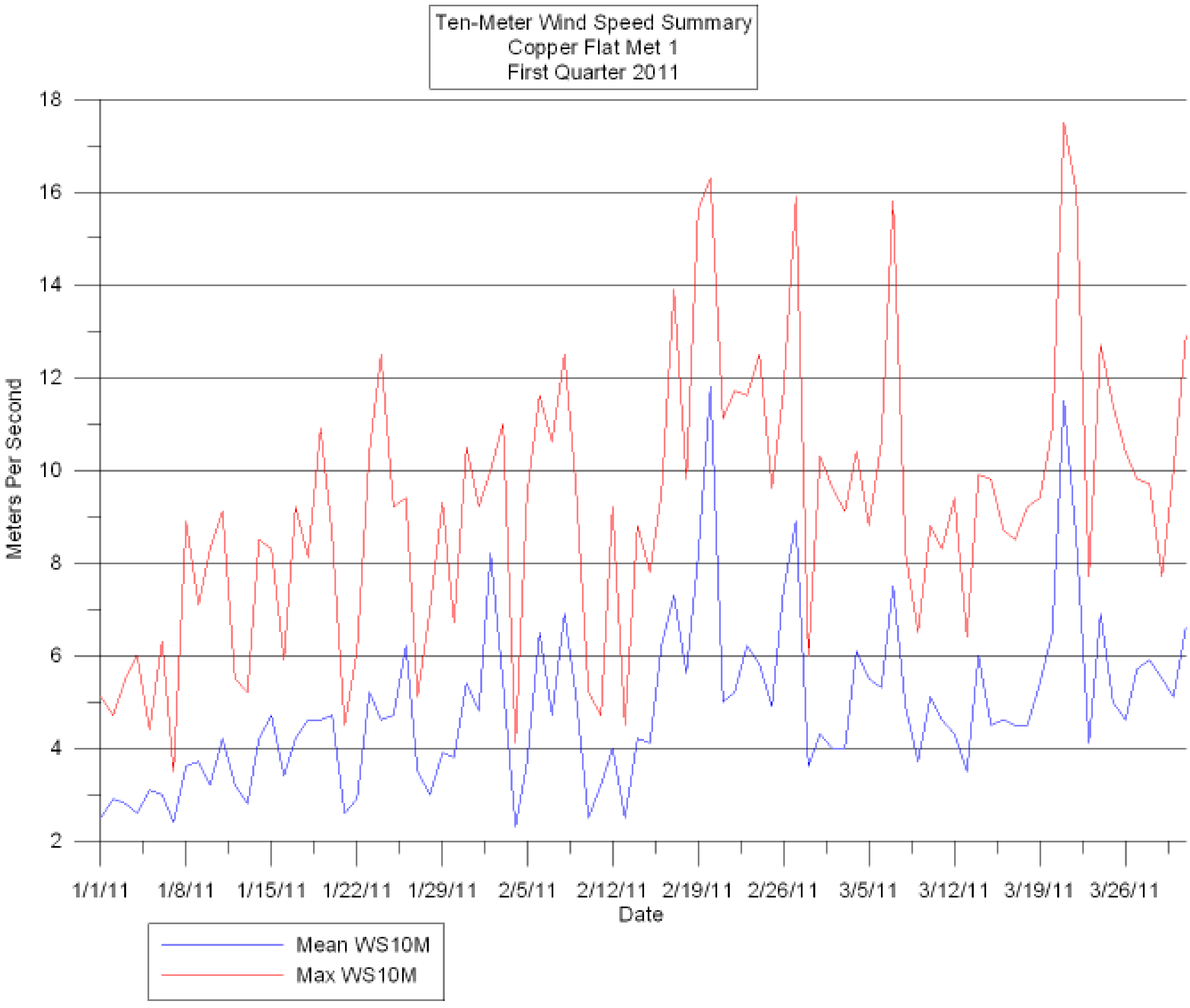
DAY	January Mean	January Min	January Max	February Mean	February Min	February Max	March Mean	March Min	March Max
1	845	841	848	838	836	841	847	844	849
2	847	844	849	846	841	850	846	843	848
3	842	841	844	848	846	850	843	840	846
4	844	842	846	845	844	847	844	841	849
5	847	846	849	839	836	844	850	847	853
6	848	845	849	842	838	848	841	836	847
7	842	838	845	845	838	850	834	830	837
8	836	833	838	835	831	839	838	834	845
9	835	834	837	844	840	847	850	845	852
10	840	836	847	844	843	845	850	847	853
11	850	848	852	848	845	851	845	842	847
12	851	850	853	852	850	854	843	841	845
13	850	848	853	849	846	851	846	844	849
14	846	844	849	847	845	850	847	844	849
15	847	844	849	845	843	848	845	842	847
16	843	842	845	841	839	844	844	842	846
17	840	838	842	841	838	844	846	844	848
18	842	840	845	844	843	846	846	844	849
19	838	835	841	841	837	845	843	841	845
20	845	840	848	836	834	837	843	841	846
21	844	843	845	839	837	841	840	837	843
22	839	835	844	840	838	842	839	838	842
23	842	838	845	839	837	842	842	839	845
24	842	840	847	840	837	843	839	838	841
25	845	842	847	840	838	843	839	836	841
26	846	843	849	836	834	839	838	835	840
27	848	847	850	835	830	844	838	836	840
28	846	843	848	848	845	851	839	837	841
29	842	840	843				842	840	844
30	842	840	845				842	840	844
31	837	834	841				842	840	844
Monthly Mean	844			842			843		
Monthly Min		833			830			830	
Monthly Max			853			854			853
Quarterly Mean	843								
Quarterly Min	830								
Quarterly Max	854								

6.0 Graphical Summaries

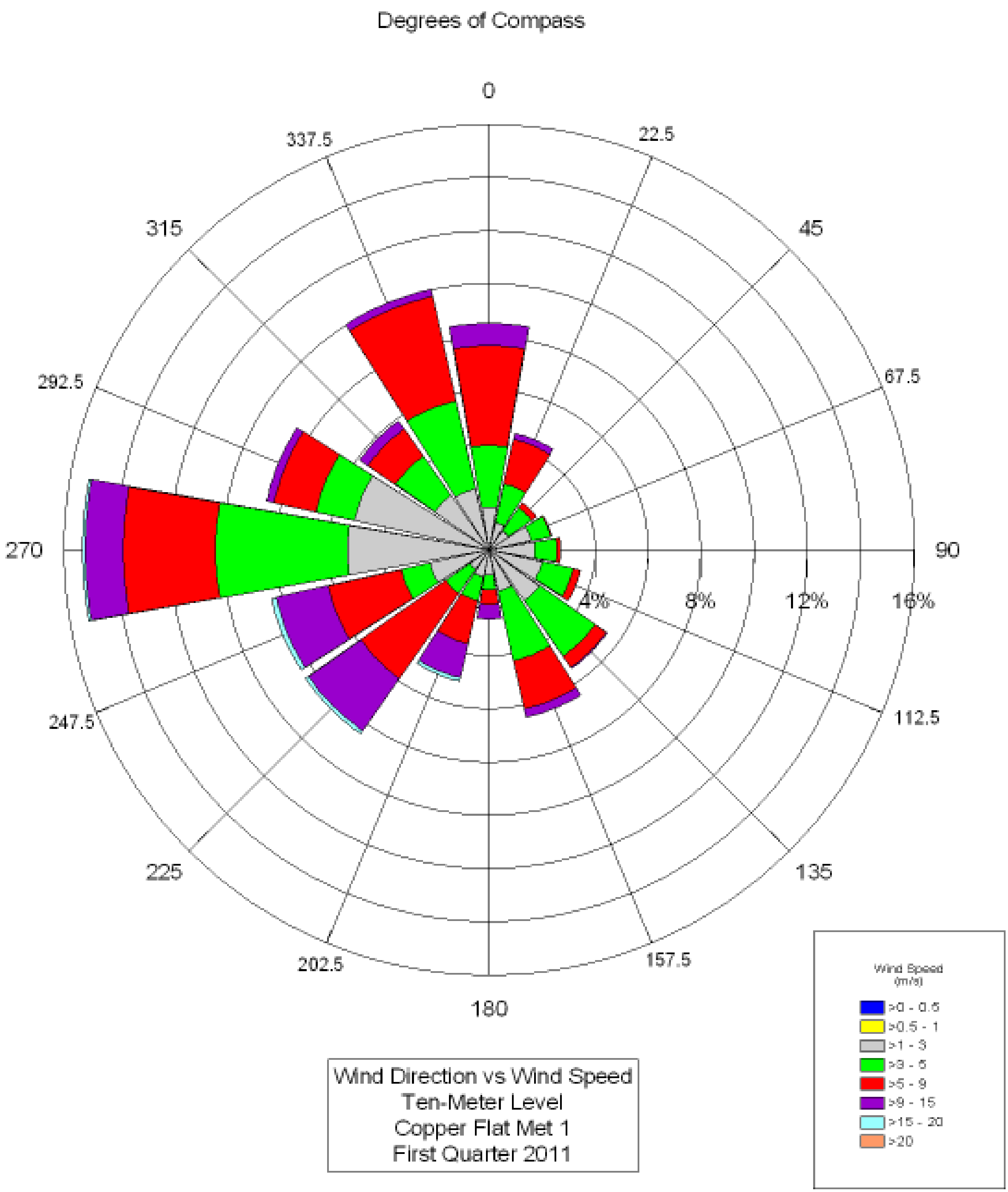
Copper Flat Met 1

First Quarter 2011

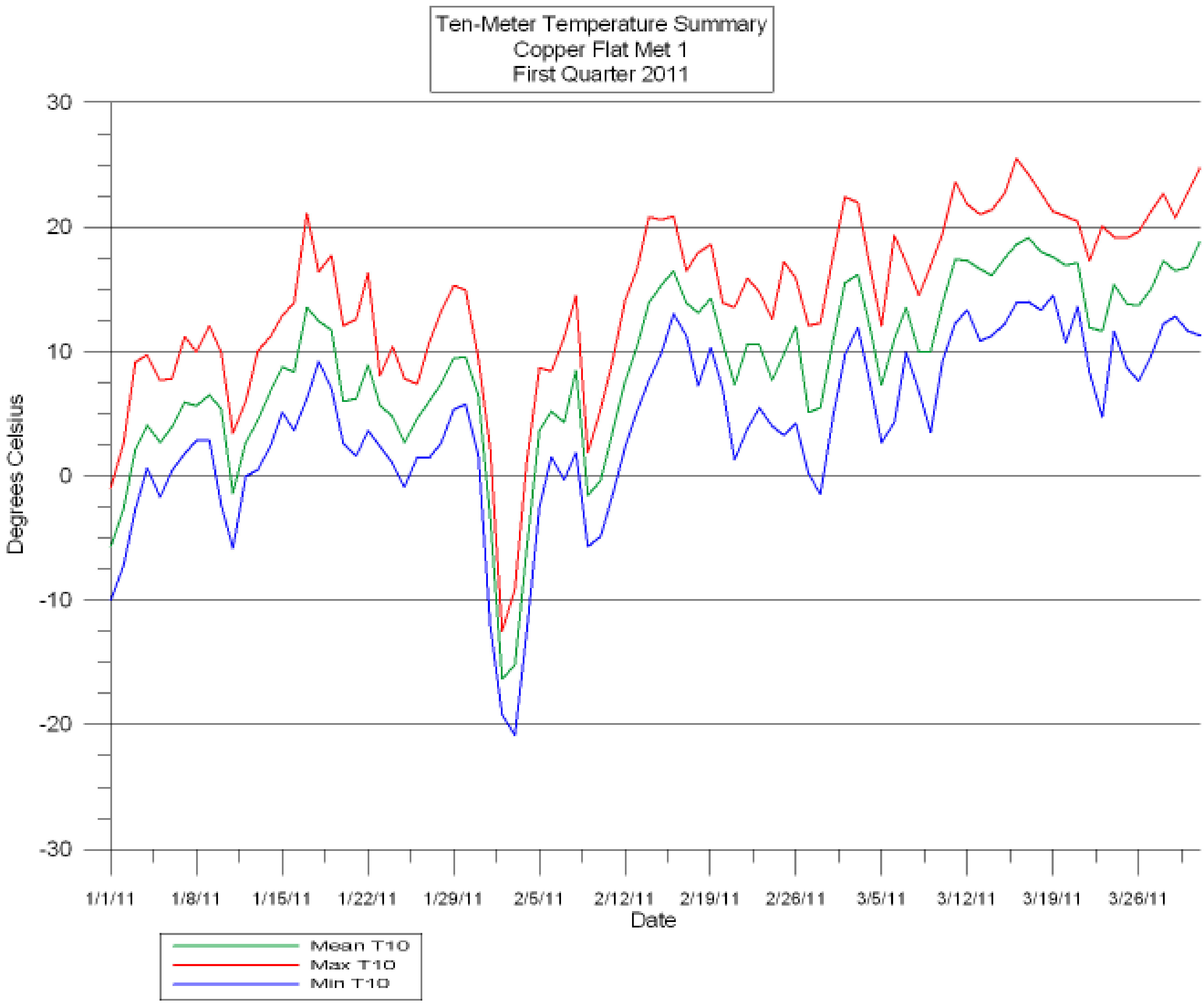

Data Capture Summary
Copper Flat Met 1
Fourth Quarter 2010
Percent
100
90
80
70
60
50
40
30
20
10
0
Wind Speed 10m
Wind Direction 10m
Sigma Theta 10m
Temp 10m
Temp 2m
Delta Temp
Relative Humidity
Net Radiation
Precip
Evaporation
Barometric Pressure
Parameter
October
November
December
Quarter



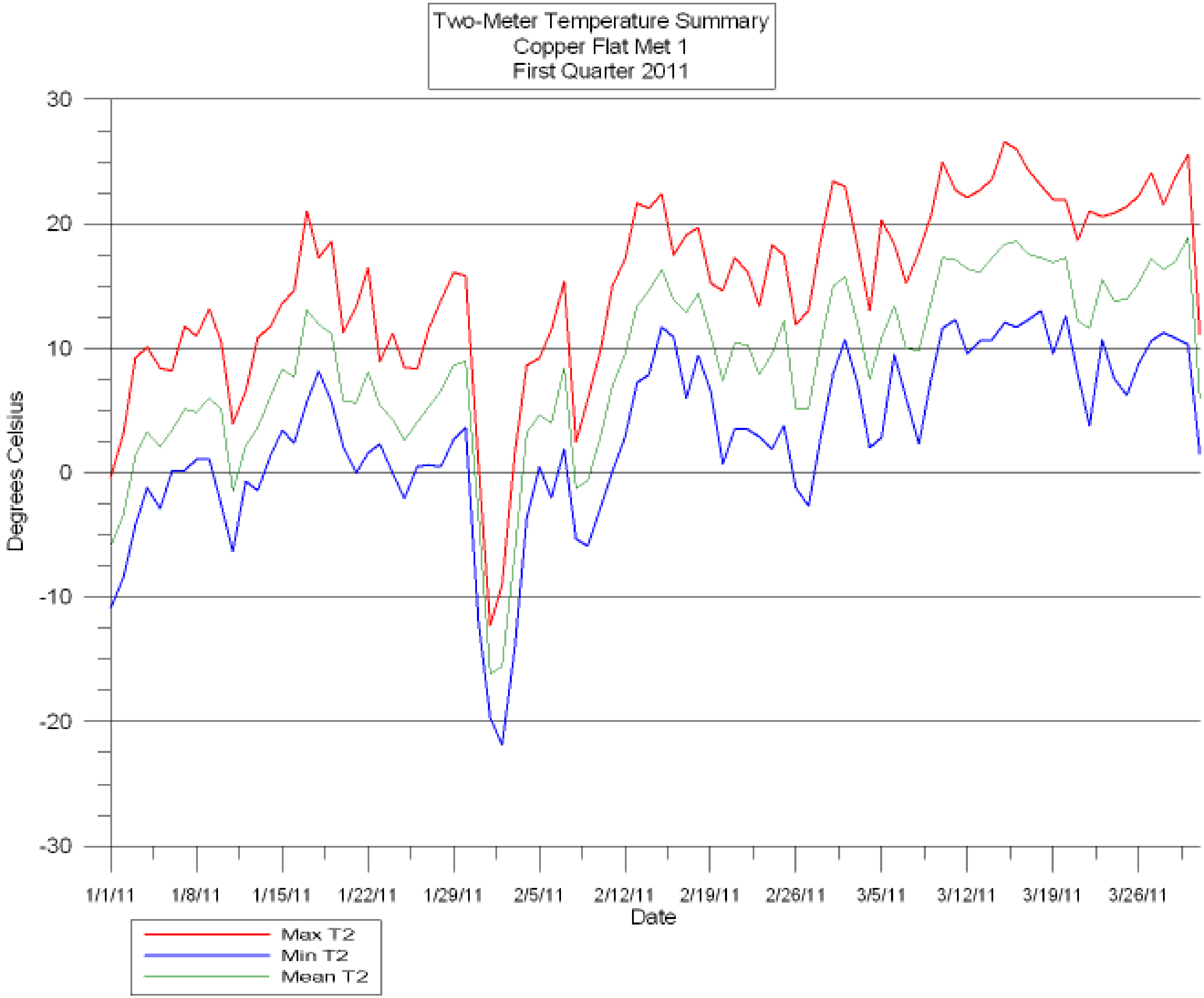
Ten-Meter Wind Speed Summary
Copper Flat Met 1
First Quarter 2011
Meters Per Second
18
16
14
12
10
8
6
4
2
1/1/11
1/8/11
1/15/11
1/22/11
1/29/11
2/5/11
2/12/11
2/19/11
2/26/11
3/5/11
3/12/11
3/19/11
3/26/11
Date
Mean WS10M
Max WS10M

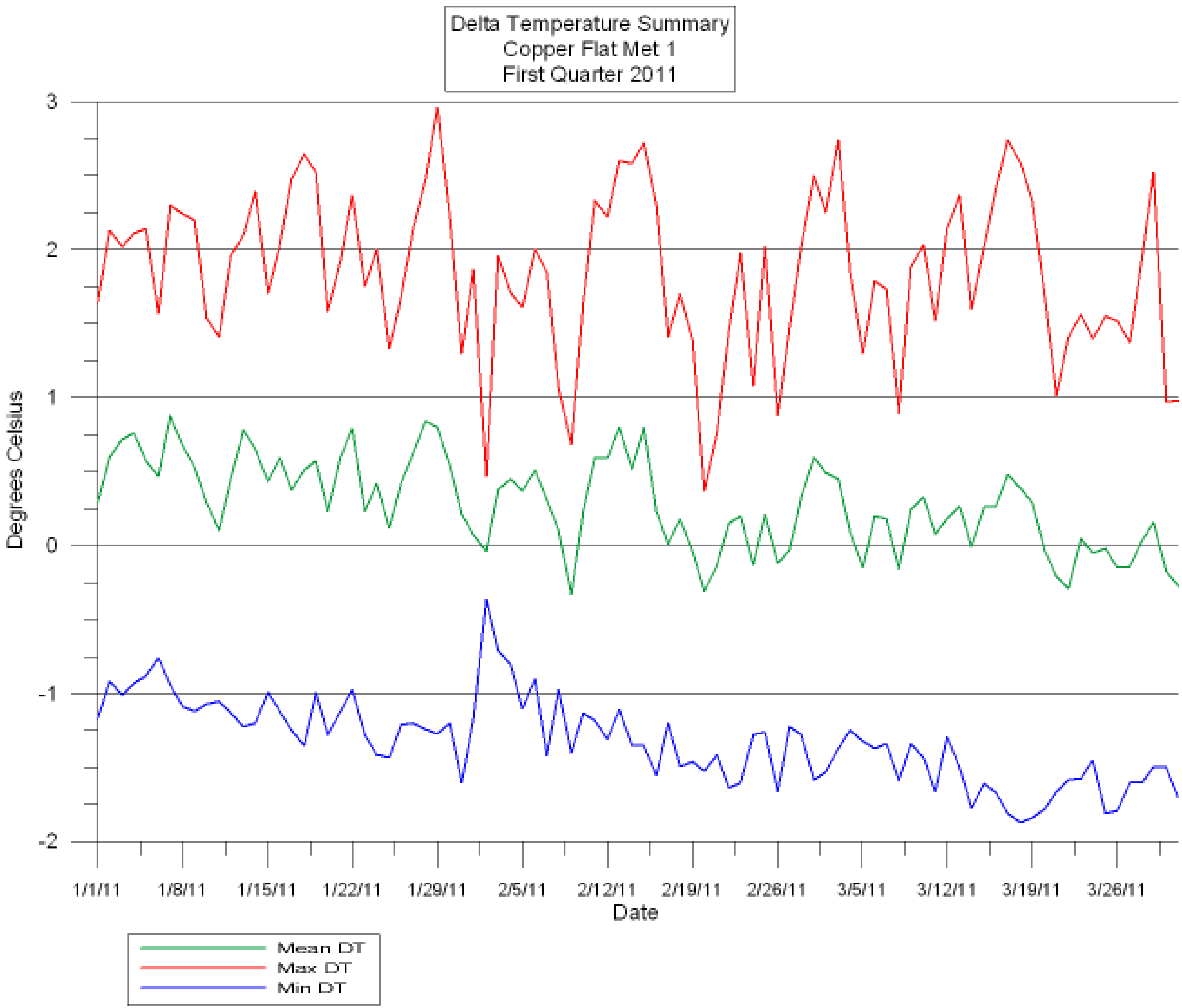


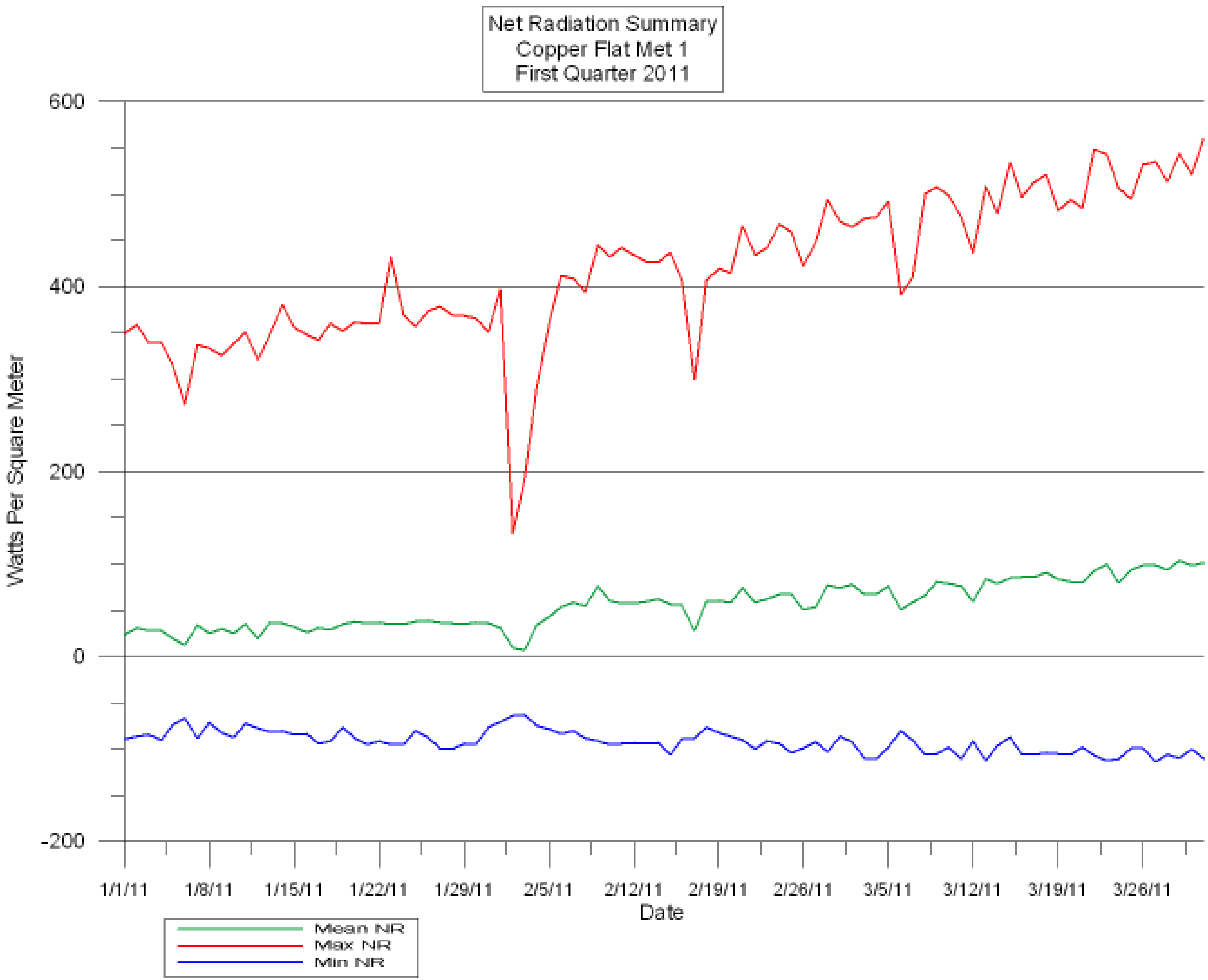
Wind Direction vs Wind Speed
Ten-Meter Level
Copper Flat Met 1
First Quarter 2011

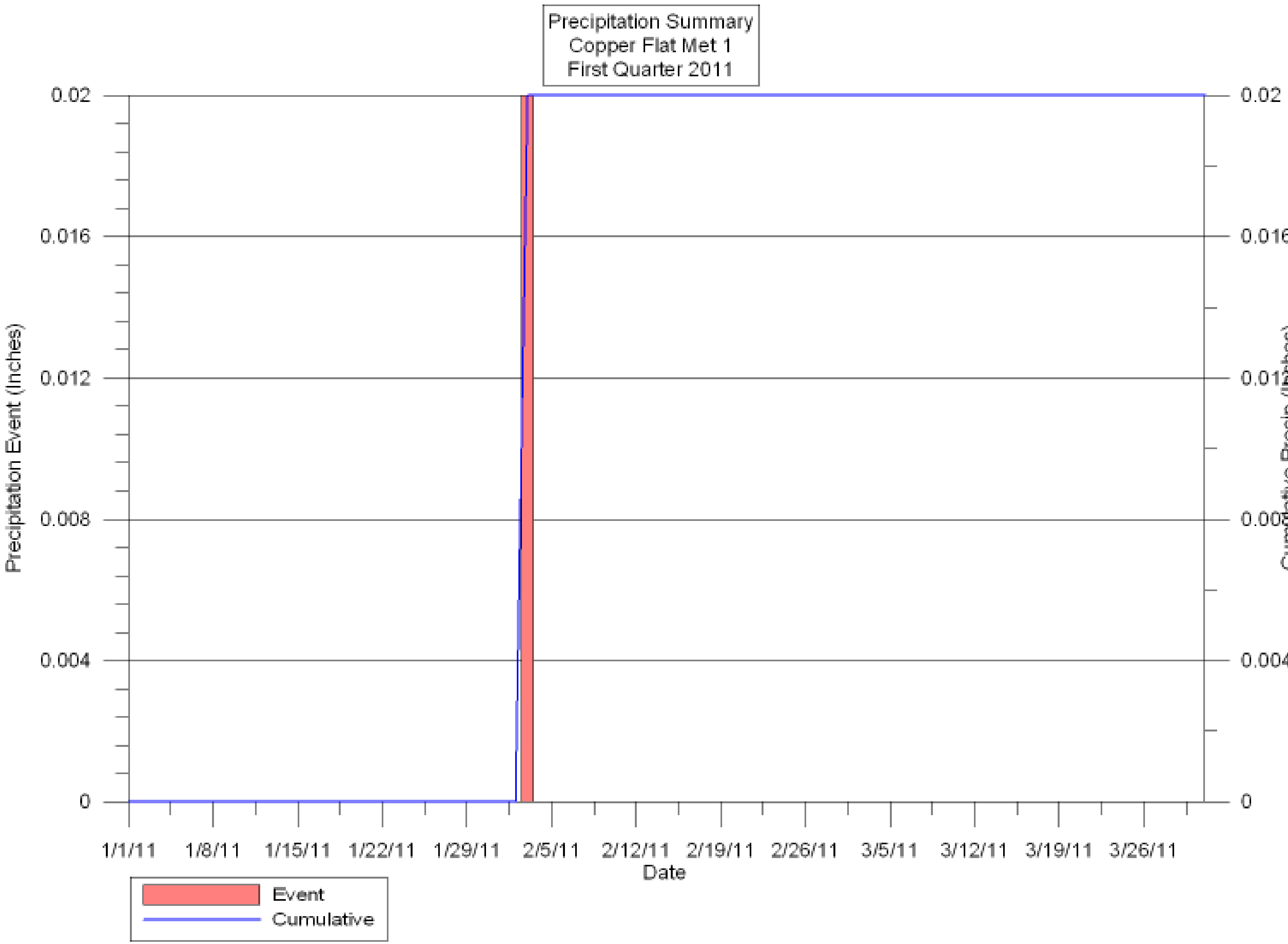


Ten-Meter Temperature Summary
Copper Flat Met 1
First Quarter 2011
30
20
10
0
-10
-20
-30
Degrees Celsius
1/1/11
1/8/11
1/15/11
1/22/11
1/29/11
2/5/11
2/12/11
2/19/11
2/26/11
3/5/11
3/12/11
3/19/11
3/26/11
Date
Mean T10
Max T10
Min T10

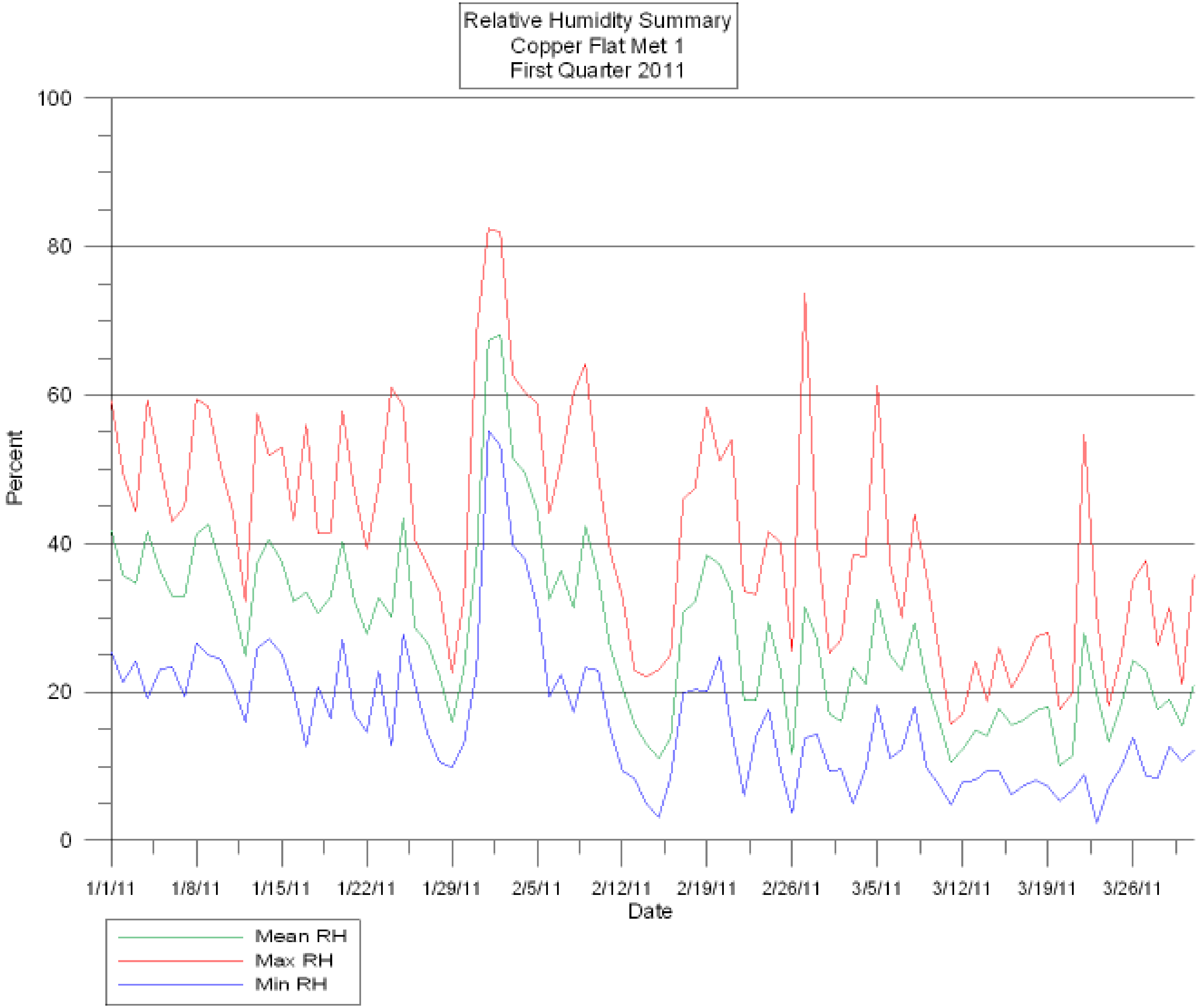

Two-Meter Temperature Summary
Copper Flat Met 1
First Quarter 2011
30
20
10
0
-10
-20
-30
Degrees Celsius
1/1/11
1/8/11
1/15/11
1/22/11
1/29/11
2/5/11
2/12/11
2/19/11
2/26/11
3/5/11
3/12/11
3/19/11
3/26/11
Date
Max T2
Min T2
Mean T2


Delta Temperature Summary
Copper Flat Met 1
First Quarter 2011
Degrees Celsius
3
2
1
0
-1
-2
1/1/11
1/8/11
1/15/11
1/22/11
1/29/11
2/5/11
2/12/11
2/19/11
2/26/11
3/5/11
3/12/11
3/19/11
3/26/11
Date
Mean DT
Max DT
Min DT

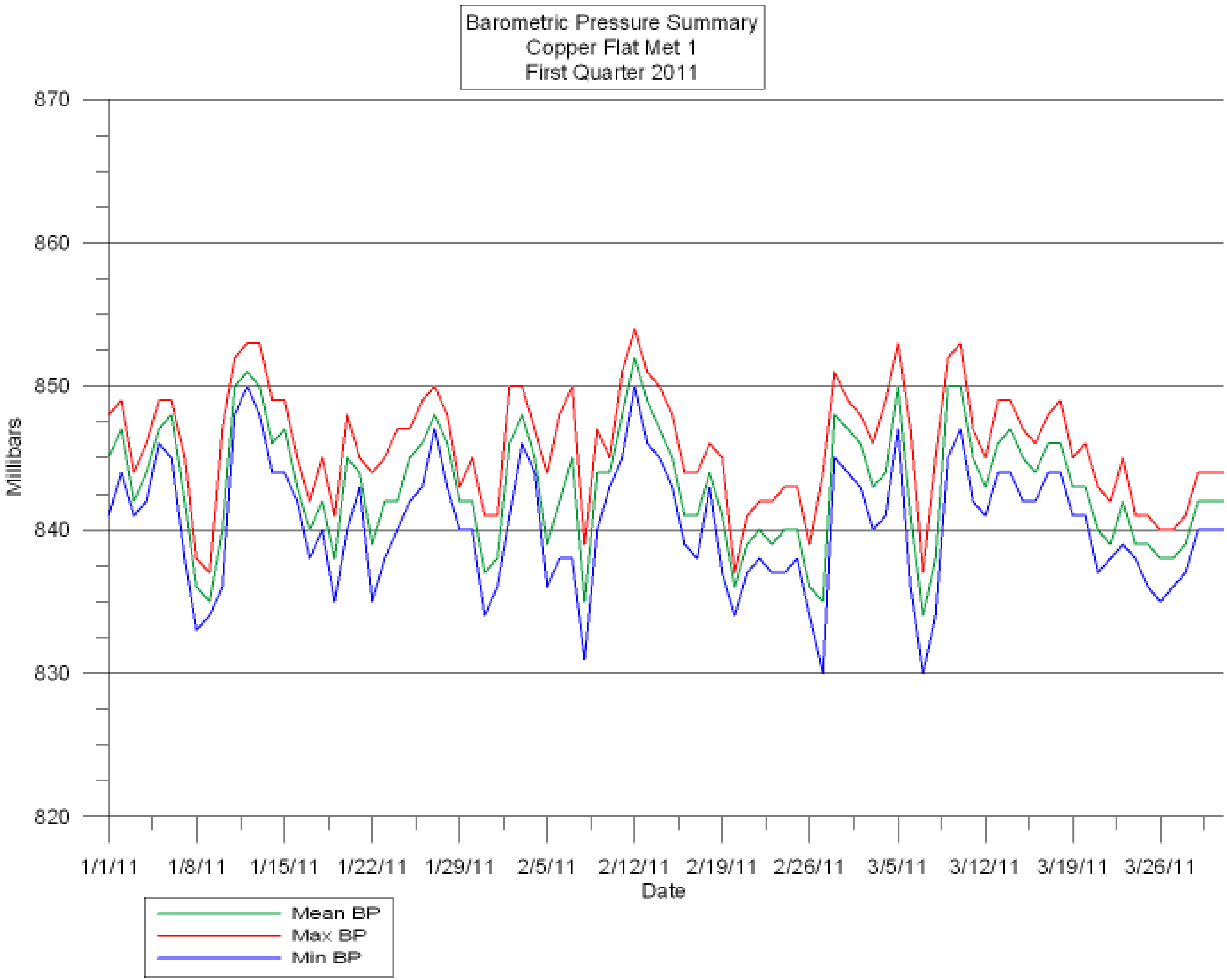

Net Radiation Summary
Copper Flat Met 1
First Quarter 2011
600
400
200
0
-200
Watts Per Square Meter
1/1/11
1/8/11
1/15/11
1/22/11
1/29/11
2/5/11
2/12/11
2/19/11
2/26/11
3/5/11
3/12/11
3/19/11
3/26/11
Date
Mean NR
Max NR
Min NR



Precipitation Summary
Copper Flat Met 1
First Quarter 2011
Precipitation Event (Inches)
Cumulative Precip (Inches)
0.02
0.016
0.012
0.008
0.004
0
1/1/11
1/8/11
1/15/11
1/22/11
1/29/11
2/5/11
2/12/11
2/19/11
2/26/11
3/5/11
3/12/11
3/19/11
3/26/11
Date
Event
Cumulative



Relative Humidity Summary
Copper Flat Met 1
First Quarter 2011
100
80
60
40
20
0
Percent
1/1/11
1/8/11
1/15/11
1/22/11
1/29/11
2/5/11
2/12/11
2/19/11
2/26/11
3/5/11
3/12/11
3/19/11
3/26/11
Date
Mean RH
Max RH
Min RH


Barometric Pressure Summary
Copper Flat Met 1
First Quarter 2011
870
860
850
840
830
820
Millibars
1/1/11
1/8/11
1/15/11
1/22/11
1/29/11
2/5/11
2/12/11
2/19/11
2/26/11
3/5/11
3/12/11
3/19/11
3/26/11
Date
Mean BP
Max BP
Min BP

New Mexico Copper Corporation

Copper Flat Mine

Meteorological Quarterly Summary Report
Copper Flat Met 1

Second Quarter 2011
(April through June 2011)

Prepared By:

Class One Technical Services, Inc.
3500 Comanche N.E. Suite G
Albuquerque, New Mexico
87107

September 13, 2011

Table of Contents

1.0 INTRODUCTION

This report is a summary of the basic meteorological data collected at Copper Flat Mine 10-meter meteorological tower for the Second quarter of 2011. Data reduction and performance audits during this quarter were performed by Class One Technical Services. The most recent field performance audit was conducted on January 13, 2011.

The Copper Flat meteorological tower is located on the Copper Flat Mine. The site coordinates in the UTM Coordinate System are:

Site - Met 1

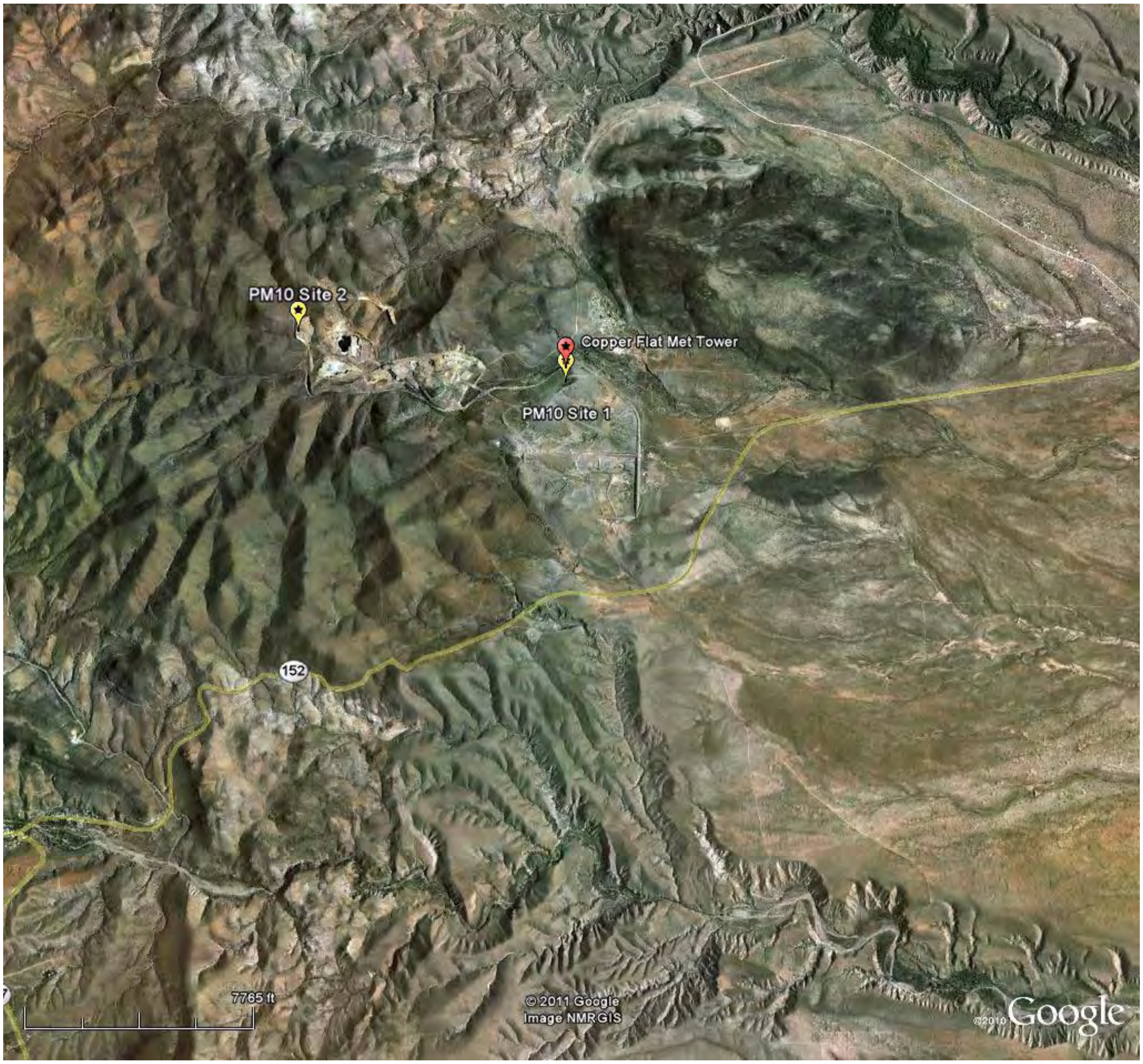
North: 3,650,579
East: 265,718

The tower location and general environs of the tower are shown in Figure 1. The tower site includes the following instrumentation:

Instrument	Manufacture	Model	Range
Wind Speed (10m)	Climatronics	F460	0-50 m/s
Wind Direction (10m)	Climatronics	F460	0-360 deg
Temperature (10m)	Climatronics	100093	-30 ^{o}C to +50 ^{o}C
Temperature (2m)	Climatronics	100093	-30 ^{o}C to +50 ^{o}C
Relative Humidity	Rotronic	MP801A	0-100%
Precipitation	Climatronics	100508-G0	0.01 in (per tip)
Net Radiation	Kipp & Zonen (Wavelength)	NR LITE	0.20 - 100 micron
Barometric Pressure	Climatronics	102663-G1	17.72 to 32.49 in. Hg
Evaporation Pan	NovaLynx	255-100	0 to 9 inches water
Data Logger	Campbell CR1000		

The wind speed, wind direction, temperature, and relative humidity sensors are mounted at ten (10) meters above ground level. The wind speed and wind direction sensors are mounted at three (3) meters. The temperature, solar radiation, and barometric pressure sensors are mounted at two (2) meters above ground level. The precipitation gauge is located at ground level.

Figure 1: Map of Copper Flat PM_{10} Sampler Locations



2.0 REPORTING CRITERIA

The following criteria have been used in preparing the quarterly summaries for the El Segundo meteorological data for this report:

a. Temperature Summaries (10-m temperature, 2-m temperature, delta temperature, and temperature lapse rate)

For each day of each month in the quarter the mean, maximum and minimum temperature, in degrees, Celsius are reported. The maxima and the minima are based on one-hour averages. For a 24-hour mean value to be *valid*, at least 18 hourly values must have been present during the 24-hour period. If less than 18 hours of valid data are available, the mean *is calculated, but data may not be representative and should be used with care*. Similarly, maxima and minima are *included* for these periods. Even though some data may have been available on these days, the maxima and minima may be misleading if the missing data happened to occur during the hottest or coldest part of the day.

For each month in the quarter the mean temperature for the month is calculated from all the hourly data, including data on those days which did not have enough data to calculate a 24-hour mean. Monthly averages *are calculated for months with less than* 4 valid 24-hour means in the month. *The* monthly maximum *and* minimum are reported as well. While 4 valid days are *considered valid* to report a mean, means for months with less than 18 days of valid data may not be representative and should be used with care.

Means, maxima and minima are reported for the entire quarter if there is at least one valid month of data in the quarter. As such, these values may not be truly representative of the entire quarter if significant amounts of data are missing. The validity of the quarterly values depends on their intended use and care should be taken with quarters with low data capture.

b. Wind Speed Summary

For each day of each month the 24-hour mean wind speed and the maximum hourly wind speed has been reported in units of meters per second. The criterion for valid 24-hour means is the same as that described above for mean temperatures.

For each month, the mean wind speed and the maximum wind speed are reported. The criteria for determining the monthly values are the same as those described above for monthly temperature values. For each quarter, the mean for the entire quarter and the maximum hourly value in the quarter is reported. The criteria for reporting quarterly values are the same as those described above for quarterly temperature values.

c. Wind Data Summary

The Wind Data Summary report gives a JFD (Joint Frequency Distribution) of wind direction and wind speed. Wind directions are divided into 16 sectors, each 22.5 degrees wide. The north sector covers 348.75 degrees to 11.25 degrees (i.e. it is symmetrical about zero degrees). Wind speeds are divided into 8 categories. The data in each wind speed/wind direction category are given as a fraction of the total month to the nearest 1 percent. The total fraction for each wind direction sector and each wind speed category is also given.

A quarterly JFD is printed if at least one valid month of data existed in the quarter. As such, it is possible that the quarterly JFD may not be truly representative of the full quarter if only one month of data is available.

d. Precipitation Summary

For each day in the quarter, the total precipitation in inches is reported along with a running precipitation total beginning at the first day of the quarter. Precipitation for a day is reported if at least one hour of data is available during the day.

For each quarter, the total precipitation for the quarter is reported along with the total number of hours during which precipitation occurred. A quarterly precipitation value is reported if there is any valid precipitation during the quarter. Care must be taken in use of the quarterly precipitation values if there were significant missing data during the quarter.

e. Relative Humidity Summaries

For each day in the quarter the mean, maximum and minimum relative humidity, in percent, is reported. The maxima and the minima are based on one-hour averages. For a 24-hour mean value to be *valid*, at least 18 hourly values must have been present during the 24-hour period. If less than 18 hours of valid data are available, the mean is *calculated*, *but data may not be representative and should be used with care*. Similarly, maxima and minima are *included* for these periods. Even though some data may have been available on these days, the maxima and minima may be misleading if the missing data happened to occur during the hottest or coldest part of the day.

For each month in the quarter the mean temperature for the month is calculated from all the hourly data, including data on those days which did not have enough data to calculate a 24-hour mean. Monthly averages *are calculated for months with less than* 4 valid 24-hour means in the month. *The* monthly maximum *and* minimum are reported as well. While 4 valid days are *considered valid* to report a mean, means for months with less than 18 days of valid data may not be representative and should be used with care.

Means, maxima and minima are reported for the entire quarter if there is at least one valid month of data in the quarter. As such, these values may not be truly representative of the entire quarter if significant amounts of data are missing.

f. Data Capture Summary

For each month and each parameter the percent of valid data, based on hourly values, is reported as well as the average data capture for the entire month. Also, the percent of valid data for the quarter for each parameter and the average data capture for the quarter are given.

g. Barometric Pressure Summary

Barometric pressure is summarized in inches of Mercury (in. Hg). The pressure data are the actual site pressures; they have not been "corrected" to sea level as is typically done with National Weather Service data. The reporting requirements for valid averages, maxima, and minima are the same as those for temperature and relative humidity summaries.

h. Net Radiation Summary

For each day in the quarter the daily maximum net radiation in watts per square meter is reported. The maxima are based on one-hour averages.

i. Evaporation Summary

For each day of the quarter, the total, minimum, and maximum evaporation values are reported in inches. Minima and maxima are based on one-hour averages. Positive values indicate evaporation, or loss of water from the evaporation pan, whereas negative values indicate precipitation or addition of water to the evaporation pan by other means.

For a 24-hour total value to be *valid*, at least 18 hourly values must have been present during the 24-hour period. If less than 18 hours of valid data are available, the total i*s calculated, but data may not be representative and should be used with care*. Similarly, maxima and minima are *included* for these periods. Even though some data may have been available on these days, the maxima and minima may be misleading if the missing data happened to occur during the hottest or coldest part of the day, or during a precipitation event.

For each month in the quarter, the total evaporation is calculated from all the hourly data, including data on those days which did not have enough data to calculate a 24-hour total. The monthly maximum and minimum are reported as well.

3.0 Meteorological Data Summary

The Copper Flat Met 1 meteorological data for Second quarter 2011 is presented in section 5.0 Numerical Summaries, on pages 14-24. The following text and tables represent the summarized data in section 5.0 Numerical Summaries.

Wind Speed

The average ten-meter wind speed for the Second quarter was 6.2 m/s. The maximum hourly ten-meter wind speed for the meteorological tower was 19.2 m/s and was recorded April 3, 2011 at 1400 MST. Thirty-nine percent of the hourly wind speeds at the ten-meter level were observed in the >5.0 to 9.0 m/s wind speed class, while twenty-seven percent were in the >3.0 to 5.0 m/s wind speed class.

Table 1 below summarizes the monthly hourly average and maximum wind speeds in meters per second (m/s).

Table 1: Monthly Wind Speed Summary

Month	Mean Hourly Wind Speed (meters/second)	Maximum Hourly Wind Speed (meters/second)	Date of Maximum Hourly Wind Speed
April	6.7	19.2	Apr. 3 @ 1400
May	6.2	16.6	May 10 @ 1700
June	5.8	16.2	Jun. 19 @ 1900

Wind Direction

The prevailing wind direction for the quarter was from the West-southwest (WSW) sector. Winds from this sector occurred approximately sixteen percent of the time. Winds from the WSW occurred seven percent of the time in the >5.0 to 9.0 m/s wind speed classes.

The next most common wind direction was from the Southwest (SW) occurring ten percent of the time. Winds from the SW occurred sixpercent of the time in the >5.0 to 9.0 m/s class.

Temperature

The mean quarterly 10-meter temperature was 21.6 degrees Celsius (^oC). The maximum hourly temperature of 36.1^oC was recorded on June 23, 2011 at 1700 MST. The minimum temperature of -2.5^oC was recorded on May 2, 2011 at 0600 MST.

The mean quarterly 2-meter temperature was 21.8^oC. The maximum hourly temperature of 37.7^oC was recorded on June 25, 2011 at 1500 MST. The minimum hourly temperature of 2.3^oC was recorded on May 2, 2011 from 0500 to 0600 MST.

Table 2 below represents the monthly mean, minimum, and maximum temperatures for the 10 and 2-meter levels of the meteorological tower.

Table 2: Monthly Temperature Summary

10-Meter Temperature

Month	Max Hrly Temp ^oC	Date of Max Temp	Min Hrly Temp ^oC	Date of Min Temp	Mean Hrly Temp ^oC
April	27.8	Apr. 2 @ 1400	3.1	Apr. 10 @ 0700	17.7
May	32.7	May 27 @ 1400	2.5	May 2 @ 0600	19.6
June	36.1	Jun. 23 @ 1700	16.9	Jun. 20 @ 0600	27.6

2-Meter Temperature

Month	Max Hrly Temp ^oC	Date of Max Temp	Min Hrly Temp ^oC	Date of Min Temp	Mean Hrly Temp ^oC
April	29.6	Apr. 2 @ 1400	3.3	Apr. 10 @ 0700	18.0
May	34.4	May 27 @ 1400	2.3	May 2 @ 05-0600	19.8
June	37.7	Jun. 25 @ 1500	16.2	Jun. 20 @ 0600	27.8

Net Radiation

The maximum hourly net radiation for the Second Quarter 2011 was 628 w/m^2 and occurred on May 2, 2011 at 1200 MST. Table 4 below summarizes the monthly maximum net radiation in watts per square meter (w/m^2).

Table 4: Monthly Net Radiation Summary

Month	Maximum Hrly Net Radiation (w/m^2)	Date of Maximum Hourly Net Radiation
April	605	Apr. 30 @ 1200
May	628	May 2 @ 1200
June	610	Jun. 27 @ 1200

Precipitation

The total precipitation for Second Quarter 2011 was 0.02 inches, with a duration of 1 hour. All of the observed precipitation fell in the month of June. The largest single day precipitation amount was 0.02 inches was recorded on June 5, 2011. Table 5 summarizes the total monthly precipitation for April, May, and June 2011.

Table 5: Monthly Precipitation Summary

Month	Total Precipitation (inches)	Percent Of Total (%)	Max. Daily Precipitation Event (inches)	Date of Max Daily Precip Event
April	0.00	0	---	---
May	0.00	0	---	---
June	0.02	100	0.02	Jun. 5

Relative Humidity

The mean relative humidity for the quarter was 15 percent. The maximum hourly relative humidity of 62 percent was recorded on May 2, 2011. The minimum hourly relative humidity value of 0 percent was recorded on May 8, 2011. Table 6 below represents the monthly mean, minimum and maximum relative humidity values for the meteorological tower.

Table 6: Monthly Relative Humidity Summary

Month	Mean Hrly Relative Humidity (%)	Minimum Hrly Relative Humidity (%)	Maximum Hrly Relative Humidity (%)
April	16	2	55
May	16	0	62
June	13	0	55

Barometric Pressure

The mean barometric pressure for the Second Quarter 2011 was 844 milibars. The maximum hourly barometric pressure value of 855 mbars occurred on May 3, 2011. Table 7 below represents the monthly mean, minimum and maximum barometric pressure values for the meteorological tower.

Table 7: Monthly Barometric Pressure Summary

Month	Mean Hrly Barometric Pressure (mbars)	Minimum Hrly Barometric Pressure (mbars)	Maximum Hrly Barometric Pressure (mbars)
April	842	833	853
May	843	832	855
June	847	838	853

Evaporation

Table 8 represents the monthly net sum, minimum and maximum evaporation values for the meteorological tower. The evaporation gauge was activated on April 2, 2011.

The net sum evaporation for the quarter was 36.31 inches. The minimum hour evaporation for the quarter was -0.004 and occurred on June 5, 2011. The maximum evaporation for the quarter was 0.09 inches and occurred on April 3, 2011.

Table 8: Monthly Evaporation Summary

Month	Total Monthly Net Evaporation (inches)	Minimum Hourly Evaporation (inches)	Maximum Hourly Evaporation (inches)
April	9.912	-0.003	0.091
May	11.659	-0.003	0.074
June	14.735	-0.004	0.073

4.0 DATA CAPTURE DESCRIPTION

Overall data capture for the Second quarter of 2011 was approximately ninety-nine (99) percent (excluding Evaporation data and edits).

April 2011

Overall data capture for the month was approximately ninety-nine (99) percent for all parameters. All data loss is attributed one to three hours of invalid data per day for evaporation at the time the evaporation pan is filled.

May 2011

Overall data capture for the month was approximately ninety-nine (99) percent for all parameters. All data loss is attributed one to three hours of invalid data per day for evaporation at the time the evaporation pan is filled.

June 2011

Overall data capture for the month was approximately ninety-nine (99) percent for all parameters. All data loss is attributed one to three hours of invalid data per day for evaporation at the time the evaporation pan is filled.

5.0 Numerical Summaries

Copper Flat Met 1

Second Quarter 2011

Copper Flat - Met 1

Q2 - 2011 Quarterly Data Capture Report

(percentages)

04/01/2011 to 06/30/2011

Parameter	April Values Count	April Capture Pct	May Values Count	May Capture Pct	June Values Count	June Capture Pct	Qtr Total Count	Qtr Total Capture Pct
Wind Speed 10m	720	100.00	744	100.00	720	100.00	2184	100.00
Wind Direction 10m	720	100.00	744	100.00	720	100.00	2184	100.00
Sigma Theta 10m	720	100.00	744	100.00	720	100.00	2184	100.00
Temp 10m	720	100.00	744	100.00	720	100.00	2184	100.00
Temp 2m	720	100.00	744	100.00	720	100.00	2184	100.00
Delta Temp	720	100.00	744	100.00	720	100.00	2184	100.00
Relative Humidity	720	100.00	737	99.06	718	99.72	2175	99.59
Net Radiation	720	100.00	744	100.00	720	100.00	2184	100.00
Precipitation	720	100.00	744	100.00	720	100.00	2184	100.00
Evaporation	660	91.67	668	89.78	664	92.22	1992	91.21
Barometric Pressure	720	100.00	744	100.00	720	100.00	2184	100.00
Station AVERAGE	714	99.17	736	98.92	714	99.17	2164	99.08

Report Date
11/29/2011

Copper Flat - Met 1

Q2 - 2011 Quarterly Summary Report For Wind Speed 10m (m/s)

04/01/2011 to 06/30/2011

DAY	April Mean	April Min	April Max	May Mean	May Min	May Max	June Mean	June Min	June Max
1	6.4	2.1	13.1	6.1	2.4	12.5	6.9	1.6	12.4
2	4.9	1.3	10.3	5.8	2.8	9.0	7.0	3.0	11.1
3	10.7	5.1	19.2	4.3	1.5	6.9	6.9	1.1	11.3
4	5.8	1.2	11.2	5.6	1.1	8.4	4.8	2.1	7.7
5	5.3	1.5	10.3	5.9	3.3	8.4	6.0	3.4	11.4
6	6.8	1.8	11.9	5.6	1.4	9.3	6.6	3.5	10.9
7	9.0	3.1	12.0	4.7	1.0	9.0	6.9	2.3	13.2
8	10.4	6.8	14.0	6.1	1.1	10.8	7.1	2.3	12.4
9	10.7	4.3	17.8	10.1	5.2	14.4	5.7	1.7	9.4
10	6.5	2.4	13.1	10.6	6.5	16.6	4.7	1.2	9.0
11	5.4	2.8	8.5	5.2	1.6	8.9	4.9	0.9	9.6
12	5.8	1.6	10.3	5.7	2.1	10.0	6.0	1.9	11.1
13	5.9	1.4	11.4	5.0	3.2	8.1	5.2	1.4	10.9
14	6.5	1.5	11.0	6.1	3.8	9.4	4.3	1.7	7.8
15	5.6	3.7	10.0	5.1	1.6	9.5	5.4	1.7	9.2
16	5.7	3.0	10.1	6.1	1.0	10.9	6.5	1.0	12.6
17	7.1	1.5	11.7	6.1	1.6	8.8	6.1	1.6	11.0
18	5.5	1.1	10.1	6.7	1.6	13.4	6.7	1.1	12.0
19	5.8	2.2	10.8	8.0	2.6	10.8	8.9	3.1	16.2
20	4.8	1.2	11.0	4.9	1.9	9.4	4.1	1.6	7.5
21	5.2	1.6	11.2	4.5	2.5	8.0	4.9	1.6	7.6
22	4.4	1.9	9.4	5.0	1.5	10.3	4.9	3.5	6.2
23	5.6	1.8	9.4	5.8	1.2	10.6	5.3	1.6	9.8
24	7.5	2.5	13.4	9.1	2.4	13.3	4.8	1.3	10.1
25	5.6	1.9	9.9	4.6	1.7	7.2	5.9	1.3	9.2
26	10.2	3.5	15.6	5.2	0.9	9.8	5.3	1.8	8.2
27	6.3	1.8	10.3	5.6	1.0	11.4	5.1	2.8	8.6
28	5.9	3.2	10.4	5.8	1.7	10.6	5.4	1.2	9.1
29	8.3	2.9	14.0	10.1	3.6	13.1	6.0	1.4	10.1
30	6.2	1.2	12.6	8.4	3.6	13.8	5.5	1.5	12.4
31				4.8	2.1	7.3			
Monthly Mean	6.7			6.2			5.8		
Monthly Min		1.1			0.9			0.9	
Monthly Max			19.2			16.6			16.2
Quarterly Mean	6.2								
Quarterly Min	0.9								
Quarterly Max	19.2								

Copper Flat - Met 1

Q2 - 2011 Quarterly Wind Summary Report
(Wind Direction 10m vs Wind Speed 10m)
04/01/2011 to 06/30/2011

WS CLASS	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTALS
CALM	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
0.5 TO 1.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0014
>1.0 TO 3.0	0.007	0.006	0.005	0.006	0.010	0.010	0.010	0.004	0.004	0.007	0.005	0.014	0.019	0.015	0.009	0.006	0.1383
>3.0 TO 5.0	0.012	0.009	0.010	0.009	0.010	0.016	0.022	0.024	0.010	0.014	0.023	0.022	0.040	0.015	0.013	0.024	0.2715
>5.0 TO 9.0	0.016	0.011	0.007	0.002	0.002	0.005	0.014	0.030	0.020	0.029	0.059	0.072	0.056	0.032	0.014	0.022	0.3924
>9.0 TO 15.0	0.003	0.002	0.000	0.000	0.000	0.000	0.000	0.005	0.005	0.027	0.054	0.050	0.024	0.010	0.002	0.005	0.1886
>15.0 TO 20.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.003	0.000	0.000	0.000	0.000	0.0073
>20.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
TOTAL	0.039	0.028	0.022	0.018	0.022	0.031	0.046	0.063	0.038	0.078	0.145	0.161	0.140	0.072	0.039	0.058	

Report Date
11/29/2011

Copper Flat - Met 1

Q2 - 2011 Quarterly Summary Report For Temp 10m
(deg C)
04/01/2011 to 06/30/2011

DAY	April Mean	April Min	April Max	May Mean	May Min	May Max	June Mean	June Min	June Max
1	21.5	15.6	26.3	10.9	6.1	16.6	26.3	20.6	32.6
2	22.7	17.1	27.8	8.3	2.5	13.5	26.4	20.5	31.1
3	20.3	16.6	22.8	12.6	7.1	18.0	26.3	20.7	30.7
4	11.9	5.9	16.2	18.8	11.7	24.9	26.1	20.2	31.5
5	17.2	9.5	25.0	21.2	16.8	25.9	25.3	21.4	31.3
6	19.4	13.8	23.6	22.1	15.2	28.0	25.8	18.7	31.5
7	15.7	12.3	19.2	23.6	19.0	28.4	27.0	20.4	30.6
8	16.0	12.2	19.9	22.6	17.6	26.4	27.0	23.0	30.5
9	13.6	8.5	17.1	20.7	15.7	25.2	25.5	20.4	30.6
10	9.1	3.1	14.4	17.0	11.3	21.5	24.9	19.7	29.6
11	11.0	6.0	16.9	13.8	7.1	20.0	26.0	21.2	30.9
12	17.0	10.2	23.2	18.5	13.2	24.1	26.5	21.6	31.1
13	17.5	13.0	21.5	20.4	15.3	25.6	27.0	21.5	31.7
14	16.3	12.2	22.5	20.9	16.4	25.4	27.5	21.4	32.6
15	14.3	8.2	19.9	21.2	16.6	26.4	28.7	23.5	33.7
16	18.8	12.6	25.6	21.4	16.5	25.3	28.7	24.5	32.4
17	21.5	15.8	26.2	19.0	15.4	22.3	27.4	23.6	31.6
18	21.3	15.8	25.8	17.2	13.3	22.1	28.4	23.8	32.0
19	20.4	15.5	25.9	14.2	11.0	16.7	27.8	24.6	31.8
20	21.4	16.5	25.9	14.9	8.0	21.1	24.4	16.9	30.1
21	21.0	16.4	25.2	18.6	12.1	24.8	25.4	19.4	31.2
22	20.2	14.7	24.8	21.6	16.3	26.2	28.8	24.0	33.5
23	20.1	16.4	23.1	21.5	16.0	25.5	29.9	23.4	36.1
24	18.2	15.0	20.8	19.4	14.8	23.6	30.5	24.0	36.0
25	17.3	12.0	23.6	21.0	14.9	27.2	31.1	24.1	36.0
26	17.8	14.0	22.0	24.8	18.9	30.4	31.2	25.9	35.8
27	13.9	6.7	19.6	26.4	21.5	32.7	31.4	26.9	35.4
28	17.1	9.3	25.3	26.6	21.5	31.0	30.5	26.0	33.9
29	22.1	18.3	26.3	24.9	20.2	29.0	29.0	24.7	33.0
30	18.0	14.3	22.0	21.4	16.7	25.2	27.2	23.0	32.1
31				21.7	15.9	27.7			
Monthly Mean	17.7			19.6			27.6		
Monthly Min		3.1			2.5			16.9	
Monthly Max			27.8			32.7			36.1
Quarterly Mean	21.6								
Quarterly Min	2.5								
Quarterly Max	36.1								

Report Date
11/29/2011

Copper Flat - Met 1

Q2 - 2011 Quarterly Summary Report For Temp 2m
(deg C)
04/01/2011 to 06/30/2011

DAY	April Mean	April Min	April Max	May Mean	May Min	May Max	June Mean	June Min	June Max
1	21.6	14.8	27.9	11.3	6.0	18.1	26.6	20.4	33.6
2	22.6	14.9	29.6	8.8	2.3	14.9	26.6	19.7	32.4
3	20.5	16.3	24.2	12.7	5.6	19.1	26.6	19.9	32.2
4	12.2	6.1	16.6	18.8	11.1	25.8	26.3	19.5	33.0
5	17.2	8.6	26.3	21.3	15.4	26.9	25.6	21.1	33.0
6	19.6	13.8	25.7	22.3	13.7	29.8	26.1	18.2	33.0
7	16.1	12.1	20.5	23.5	17.2	30.1	27.3	20.6	32.3
8	16.5	12.0	20.9	22.7	15.6	27.9	27.1	22.2	32.2
9	14.0	8.4	18.6	21.1	15.8	26.6	25.7	20.4	32.4
10	9.6	3.3	15.8	17.6	11.1	23.0	24.9	18.3	30.7
11	11.3	5.6	17.9	14.2	6.2	21.4	26.1	19.7	32.7
12	16.9	8.4	24.6	18.9	12.7	25.2	26.3	19.6	32.6
13	17.5	11.1	23.4	20.4	13.8	26.8	26.9	20.1	33.5
14	16.5	11.5	23.6	21.2	15.5	26.8	27.3	18.7	34.2
15	14.4	7.6	21.0	21.2	15.1	28.1	28.7	21.8	35.2
16	18.7	11.0	26.9	21.5	14.7	26.8	28.9	24.0	33.8
17	21.4	14.6	27.8	19.4	15.1	23.7	27.6	23.4	33.0
18	21.4	15.0	27.7	17.6	12.3	23.1	28.6	22.5	33.7
19	20.8	15.1	27.3	14.8	10.8	18.3	27.8	24.1	32.4
20	21.7	15.8	27.6	15.2	6.8	22.6	24.7	16.2	31.1
21	21.2	15.7	27.1	18.9	11.7	25.4	25.6	18.6	32.5
22	20.4	14.2	26.6	21.6	14.6	27.6	29.0	22.9	34.7
23	20.3	15.3	24.2	21.7	15.5	27.3	30.1	22.3	37.2
24	18.5	14.7	22.2	19.9	14.6	24.9	30.6	22.5	37.1
25	17.6	11.6	25.1	21.0	13.5	27.8	31.5	23.0	37.7
26	18.2	13.7	23.4	24.8	16.8	32.1	31.4	25.2	37.2
27	14.2	6.5	20.3	26.7	20.2	34.4	31.5	26.1	36.2
28	17.3	8.8	26.4	26.7	19.6	32.9	30.9	25.0	35.2
29	22.2	16.3	27.8	25.4	20.5	30.6	29.2	23.5	34.5
30	18.4	13.6	23.6	21.8	16.3	26.6	27.3	22.4	33.4
31				21.7	14.8	28.6			
Monthly Mean	18.0			19.8			27.8		
Monthly Min		3.3			2.3			16.2	
Monthly Max			29.6			34.4			37.7
Quarterly Mean	21.8								
Quarterly Min	2.3								
Quarterly Max	37.7								

Report Date
11/29/2011

Copper Flat - Met 1

Q2 - 2011 Quarterly Summary Report For Delta Temp (deg C)

04/01/2011 to 06/30/2011

DAY	April Mean	April Min	April Max	May Mean	May Min	May Max	June Mean	June Min	June Max
1	-0.12	-1.83	1.21	-0.38	-2.01	1.54	-0.28	-1.60	1.68
2	0.10	-1.81	2.18	-0.53	-2.28	1.04	-0.24	-1.79	0.94
3	-0.26	-1.55	0.53	-0.08	-1.67	1.87	-0.34	-1.95	0.97
4	-0.25	-1.79	1.48	0.06	-1.56	2.26	-0.22	-1.82	1.47
5	-0.01	-1.80	1.47	-0.04	-1.76	2.02	-0.34	-1.86	0.86
6	-0.25	-2.06	1.57	-0.21	-1.73	1.57	-0.35	-1.79	1.18
7	-0.45	-1.88	0.35	0.08	-1.81	2.19	-0.34	-1.96	0.86
8	-0.43	-1.77	0.37	-0.07	-1.97	2.23	-0.10	-1.86	1.73
9	-0.37	-1.73	0.76	-0.38	-1.85	0.97	-0.16	-1.97	1.85
10	-0.51	-1.70	0.29	-0.53	-1.90	0.29	0.01	-1.54	1.74
11	-0.27	-1.43	0.96	-0.38	-1.74	0.85	-0.04	-2.13	2.19
12	0.10	-1.73	2.05	-0.38	-1.67	0.82	0.19	-1.91	2.67
13	-0.02	-1.89	1.88	-0.08	-1.62	1.72	0.05	-1.89	2.56
14	-0.24	-1.53	0.69	-0.22	-1.82	1.33	0.16	-1.81	2.79
15	-0.16	-1.66	1.53	-0.01	-1.87	1.81	-0.04	-1.82	2.46
16	0.06	-1.80	1.90	-0.05	-1.89	1.90	-0.26	-1.78	1.48
17	0.03	-1.64	2.22	-0.40	-1.96	0.97	-0.20	-1.41	1.37
18	-0.14	-1.88	1.69	-0.40	-2.02	1.03	-0.14	-1.75	2.12
19	-0.41	-1.73	0.67	-0.57	-2.00	0.37	-0.10	-1.22	0.82
20	-0.32	-1.89	0.81	-0.29	-1.82	1.42	-0.27	-1.69	1.00
21	-0.21	-1.98	1.68	-0.30	-1.73	1.06	-0.22	-1.63	1.48
22	-0.21	-1.75	1.29	-0.06	-1.91	2.05	-0.16	-1.70	1.64
23	-0.14	-1.50	1.39	-0.21	-2.01	2.27	-0.23	-1.78	1.33
24	-0.35	-1.81	0.96	-0.41	-1.68	0.72	-0.08	-1.76	1.96
25	-0.34	-1.66	0.75	-0.01	-1.61	1.85	-0.37	-1.73	1.30
26	-0.34	-1.47	0.48	-0.04	-1.89	2.50	-0.27	-1.80	1.46
27	-0.33	-1.75	1.32	-0.23	-1.87	1.61	-0.14	-1.63	1.26
28	-0.20	-1.81	1.58	-0.12	-2.02	2.21	-0.34	-1.89	1.04
29	-0.10	-1.85	2.25	-0.51	-1.87	0.46	-0.24	-1.77	1.33
30	-0.41	-1.82	0.69	-0.36	-1.86	1.79	-0.06	-1.58	1.69
31				-0.05	-1.70	1.19			
Monthly Mean	-0.22			-0.23			-0.17		
Monthly Min		-2.06			-2.28			-2.13	
Monthly Max			2.25			2.50			2.79
Quarterly Mean	-0.21								
Quarterly Min	-2.28								
Quarterly Max	2.79								

Report Date
11/29/2011

Copper Flat - Met 1

Q2 - 2011 Quarterly Summary Report For Net Radiation
(W/m2)
04/01/2011 to 06/30/2011

DAY	April Mean	April Min	April Max	May Mean	May Min	May Max	June Mean	June Min	June Max
1	99	-118	552	130	-97	586	104	-79	519
2	100	-107	534	144	-112	628	100	-106	537
3	79	-100	536	131	-110	590	126	-94	542
4	112	-113	585	80	-93	545	126	-113	556
5	108	-97	525	120	-102	602	118	-180	581
6	105	-85	529	117	-120	555	123	-105	548
7	109	-94	529	118	-120	580	130	-109	562
8	101	-92	526	113	-121	548	120	-111	559
9	109	-86	535	121	-106	559	125	-125	579
10	119	-107	570	128	-99	566	125	-124	582
11	115	-110	581	134	-103	600	130	-125	578
12	109	-106	548	133	-116	585	130	-115	546
13	106	-109	534	136	-111	606	126	-113	551
14	109	-116	560	128	-112	574	129	-125	576
15	112	-110	583	131	-115	588	132	-123	592
16	112	-107	561	114	-112	520	118	-118	582
17	102	-106	565	114	-107	546	67	-106	437
18	113	-108	544	121	-91	578	133	-110	560
19	123	-95	578	135	-80	575	44	-108	385
20	122	-89	564	136	-103	594	140	-120	604
21	117	-108	557	140	-109	590	137	-118	605
22	117	-107	548	133	-109	574	136	-115	592
23	69	-97	375	132	-106	562	129	-121	572
24	115	-97	570	128	-118	570	128	-125	562
25	115	-106	558	133	-116	581	126	-114	568
26	118	-105	567	126	-116	567	120	-101	560
27	127	-110	598	137	-116	602	102	-92	610
28	127	-106	588	130	-111	553	138	-112	569
29	115	-110	551	127	-104	551	132	-99	568
30	126	-104	605	129	-127	571	62	-195	480
31				99	-105	546			
Monthly Mean	110			126			118		
Monthly Min		-118			-127			-195	
Monthly Max			605			628			610
Quarterly Mean	118								
Quarterly Min	-195								
Quarterly Max	628								

Report Date
11/29/2011

Copper Flat - Met 1

Q2 - 2011 Quarterly Precipitation Summary
(inches)
04/01/2011 to 06/30/2011

Day of Month	Apr Precip (inches)	Apr Sum	Apr Duration (hours)	May Precip (inches)	May Sum	May Duration (hours)	Jun Precip (inches)	Jun Sum	Jun Duration (hours)
1	0.00	0.00		0.00	0.00		0.00	0.00	
2	0.00	0.00		0.00	0.00		0.00	0.00	
3	0.00	0.00		0.00	0.00		0.00	0.00	
4	0.00	0.00		0.00	0.00		0.00	0.00	
5	0.00	0.00		0.00	0.00		0.02	0.02	1:00
6	0.00	0.00		0.00	0.00		0.00	0.02	
7	0.00	0.00		0.00	0.00		0.00	0.02	
8	0.00	0.00		0.00	0.00		0.00	0.02	
9	0.00	0.00		0.00	0.00		0.00	0.02	
10	0.00	0.00		0.00	0.00		0.00	0.02	
11	0.00	0.00		0.00	0.00		0.00	0.02	
12	0.00	0.00		0.00	0.00		0.00	0.02	
13	0.00	0.00		0.00	0.00		0.00	0.02	
14	0.00	0.00		0.00	0.00		0.00	0.02	
15	0.00	0.00		0.00	0.00		0.00	0.02	
16	0.00	0.00		0.00	0.00		0.00	0.02	
17	0.00	0.00		0.00	0.00		0.00	0.02	
18	0.00	0.00		0.00	0.00		0.00	0.02	
19	0.00	0.00		0.00	0.00		0.00	0.02	
20	0.00	0.00		0.00	0.00		0.00	0.02	
21	0.00	0.00		0.00	0.00		0.00	0.02	
22	0.00	0.00		0.00	0.00		0.00	0.02	
23	0.00	0.00		0.00	0.00		0.00	0.02	
24	0.00	0.00		0.00	0.00		0.00	0.02	
25	0.00	0.00		0.00	0.00		0.00	0.02	
26	0.00	0.00		0.00	0.00		0.00	0.02	
27	0.00	0.00		0.00	0.00		0.00	0.02	
28	0.00	0.00		0.00	0.00		0.00	0.02	
29	0.00	0.00		0.00	0.00		0.00	0.02	
30	0.00	0.00		0.00	0.00		0.00	0.02	
31				0.00	0.00				
Monthly Total:	0.00		0:00	0.00		0:00	0.02		1:00
Qtrly Total:	0.02		1:00						

Report Date
11/29/2011

Copper Flat - Met 1

Q2 - 2011 Quarterly Summary Report For Relative Humidity (%)

04/01/2011 to 06/30/2011

DAY	April Mean	April Min	April Max	May Mean	May Min	May Max	June Mean	June Min	June Max
1	10.8	3.9	19.4	20.9	3.4	51.1	26.2	8.8	54.7
2	9.7	5.9	14.1	36.6	18.3	62.2	15.9	4.1	36.9
3	16.3	7.3	25.2	17.8	10.6	27.1	11.1	6.2	20.2
4	16.3	6.5	32.2	10.4	3.1	18.0	15.9	5.7	32.0
5	10.8	6.5	15.9	9.6	5.6	14.9	29.5	14.3	42.3
6	21.5	11.0	47.4	13.5	1.6	29.0	26.2	8.8	53.0
7	32.1	17.8	50.7	5.2	1.2	9.5	9.0	4.4	15.5
8	25.2	15.2	37.4	5.8	1.6	10.2	9.0	4.1	16.1
9	34.6	23.5	49.6	11.8	5.4	27.6	4.5	0.4	7.4
10	29.0	8.5	54.5	24.3	10.3	35.8	5.5	2.1	10.0
11	17.2	7.0	28.9	22.4	12.6	31.7	6.6	1.3	13.1
12	11.8	5.3	20.7	21.6	11.3	34.9	7.3	3.6	9.9
13	13.0	5.1	23.0	14.5	7.9	19.5	6.8	1.4	12.2
14	10.4	3.0	21.8	16.7	5.3	27.3	5.2	2.0	8.7
15	10.6	4.0	17.5	12.0	4.2	21.6	7.9	1.8	14.2
16	6.3	2.4	10.0	8.5	3.4	13.6	7.9	2.9	15.7
17	12.2	6.9	17.6	18.1	12.7	26.8	10.0	4.8	15.0
18	14.2	6.5	25.4	29.6	21.5	40.6	13.5	7.6	26.5
19	18.9	8.7	30.6	31.6	18.7	46.0	9.4	2.0	13.6
20	14.3	3.8	22.4	24.9	14.6	40.3	15.8	7.2	30.7
21	16.0	8.0	25.2	25.3	11.4	47.2	14.5	9.0	22.9
22	16.6	9.1	22.8	15.6	7.2	25.6	10.3	5.6	16.3
23	16.7	11.4	22.3	13.1	5.9	20.7	9.0	3.1	15.7
24	21.2	15.1	30.4	12.1	3.2	25.2	7.9	1.3	14.5
25	21.3	11.3	33.5	11.8	6.8	17.7	8.9	5.0	13.6
26	18.0	10.8	25.9	8.5	1.2	16.0	10.8	6.4	17.9
27	12.9	6.1	24.0	10.0	5.0	14.5	10.8	7.2	16.4
28	11.6	5.5	18.4	12.4	5.7	20.6	16.0	10.4	25.1
29	9.5	4.2	15.5	15.1	6.7	25.0	19.5	9.5	28.2
30	15.1	9.6	22.1	18.5	4.2	37.9	25.0	16.3	37.9
31				9.3	7.1	11.6			
Monthly Mean	16.5			16.5			12.6		
Monthly Min		2.4			1.2			0.4	
Monthly Max			54.5			62.2			54.7
Quarterly Mean	15.2								
Quarterly Min	0.4								
Quarterly Max	62.2								

Report Date
11/29/2011

Copper Flat - Met 1

Q2 - 2011 Quarterly Summary Report For Barometric Pressure
(mbars)
04/01/2011 to 06/30/2011

DAY	April Mean	April Min	April Max	May Mean	May Min	May Max	June Mean	June Min	June Max
1	843	841	845	842	840	848	849	846	852
2	842	840	844	852	849	854	846	843	848
3	838	835	840	853	850	855	846	844	848
4	846	841	850	849	846	851	850	848	852
5	844	840	848	848	846	851	851	848	853
6	842	840	843	844	841	847	848	845	852
7	839	836	842	843	841	846	846	844	847
8	837	836	838	841	839	843	846	844	847
9	837	835	840	838	835	840	846	845	848
10	843	840	848	837	834	839	846	844	848
11	850	847	853	841	839	845	846	844	847
12	844	840	847	846	845	848	846	845	847
13	842	840	845	848	845	850	848	847	850
14	841	839	845	844	840	846	848	846	850
15	846	844	848	844	842	846	846	843	848
16	843	839	846	843	841	845	844	842	845
17	841	839	842	840	838	841	845	844	847
18	839	837	841	836	832	840	847	845	848
19	840	838	842	838	836	842	842	838	846
20	843	842	845	843	841	845	843	841	844
21	842	840	844	844	842	846	846	845	848
22	840	839	842	843	841	845	848	847	850
23	840	839	841	842	840	845	847	845	850
24	840	838	842	842	840	845	847	844	849
25	839	837	842	846	845	848	846	845	848
26	835	833	838	845	842	847	847	845	849
27	844	839	848	843	841	845	848	847	850
28	847	844	851	840	838	842	850	848	853
29	840	836	843	838	836	839	850	847	852
30	839	836	841	842	838	849	849	847	850
31				851	849	853			
Monthly Mean	842			843			847		
Monthly Min		833			832			838	
Monthly Max			853			855			853
Quarterly Mean	844								
Quarterly Min	832								
Quarterly Max	855								

Copper Flat Met I

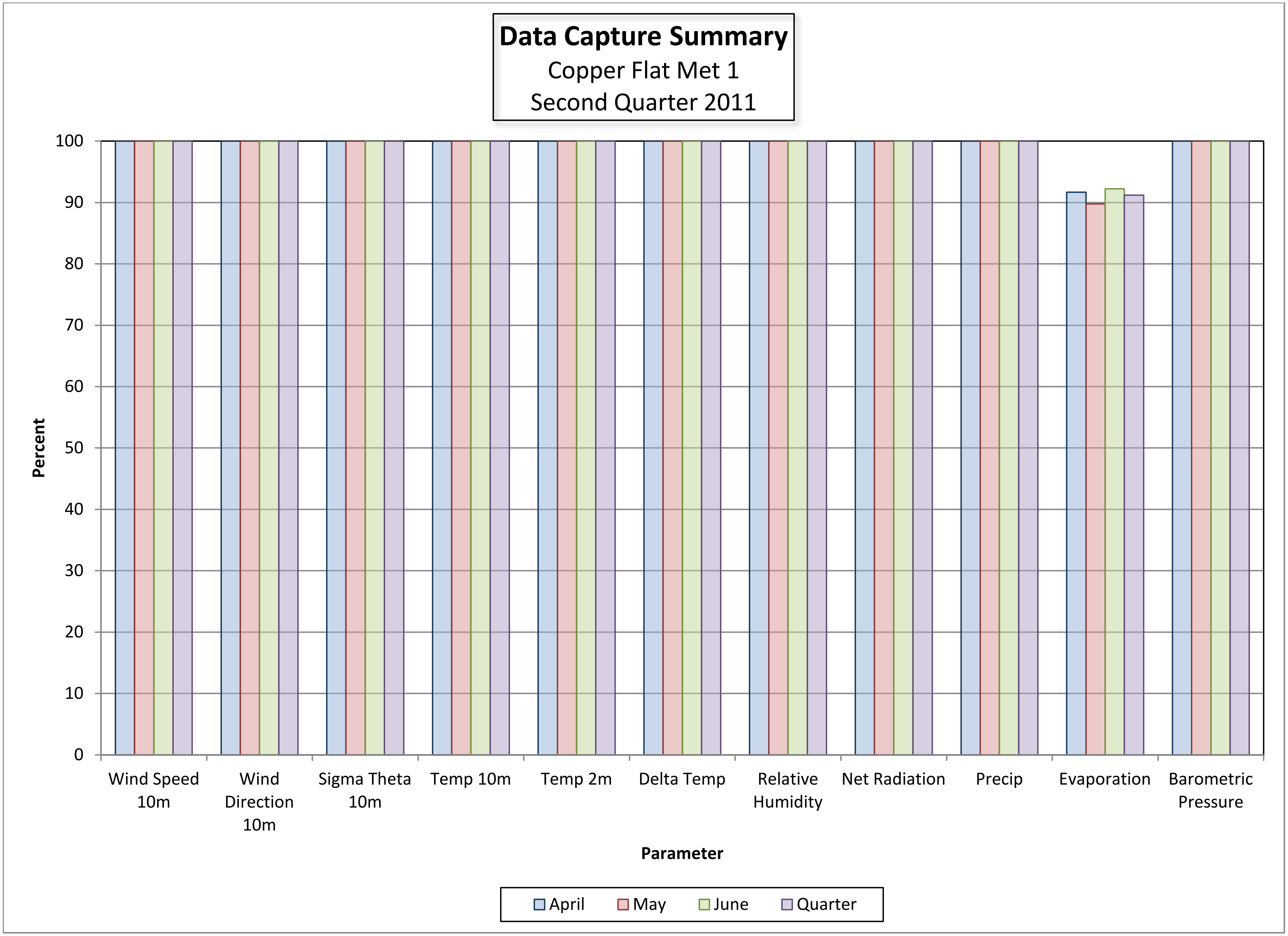
Q2 - 2011 Quarterly Summary Report for Daily Total Net Evaporation
Positive Values Indicate Evaporation
(Inches)
04/01/2011 to 06/30/2011

Day	April Daily Total	April Hourly Min	April Hourly Max	May Daily Total	May Hourly Min	May Hourly Max	June Daily Total	June Hourly Min	June Hourly Max
1	--	--	--	0.316	0.001	0.033	0.542	0.005	0.051
2	0.233	1	0.046	0.215	0	0.025	0.494	0.005	0.056
3	0.436	0.004	0.091	0.305	0	0.028	0.547	0.002	0.062
4	0.28	0.001	0.02	0.283	-0.003	0.036	0.395	-0.001	0.056
5	0.353	0.002	0.038	0.434	0.005	0.037	0.397	-0.004	0.063
6	0.392	0.003	0.053	0.363	0	0.047	0.401	0	0.047
7	0.356	-0.003	0.048	0.357	0	0.045	0.521	0.006	0.066
8	0.407	0.002	0.066	0.432	0.001	0.049	0.555	0.005	0.073
9	0.387	0.003	0.079	0.633	0	0.074	0.469	0.003	0.047
10	0.235	0.001	0.038	0.557	0.006	0.061	0.415	0	0.064
11	0.185	0	0.023	0.239	0	0.03	0.453	0	0.056
12	0.256	-0.001	0.033	0.272	0	0.034	0.493	0.003	0.058
13	0.343	0.002	0.051	0.325	0	0.045	0.464	0.001	0.058
14	0.33	-0.003	0.041	0.383	0.005	0.051	0.391	-0.003	0.039
15	0.289	0.002	0.035	0.355	-0.001	0.05	0.486	0.002	0.053
16	0.317	0.002	0.04	0.404	0	0.053	0.477	0	0.058
17	0.358	0.002	0.04	0.327	0.004	0.03	0.482	0.004	0.052
18	0.31	0.001	0.045	0.331	0.001	0.053	0.581	0.002	0.066
19	0.319	0	0.033	0.302	0.005	0.031	0.598	0.007	0.054
20	0.345	0.001	0.058	0.22	-0.002	0.034	0.43	-0.001	0.038
21	0.337	0.001	0.046	0.254	0	0.031	0.453	0	0.045
22	0.281	0.003	0.042	0.374	0	0.045	0.555	0.006	0.049
23	0.272	0.002	0.029	0.4	0.002	0.055	0.434	0.005	0.051
24	0.389	0.002	0.045	0.435	0.005	0.055	0.596	0.005	0.063
25	0.345	-0.001	0.036	0.304	0	0.038	0.628	0.003	0.052
26	0.486	0.004	0.048	0.43	0.003	0.056	0.435	0.003	0.044
27	0.351	0.005	0.031	0.431	0	0.051	0.555	0.011	0.045
28	0.413	0.002	0.062	0.452	0.002	0.049	0.642	0.004	0.052
29	0.522	0.002	0.063	0.616	0.001	0.057	0.505	-0.002	0.061
30	0.385	-0.001	0.043	0.529	0.004	0.056	0.341	-0.003	0.054
31				0.381	0.007	0.042			
Monthly Total	9.912			11.659			14.735		
Monthly Min		-0.003			-0.003			-0.004	
Monthly Max			0.091			0.074			0.073
Quarterly Total	36.306								
Quarterly Min	-0.004								
Quarterly Max	0.091								

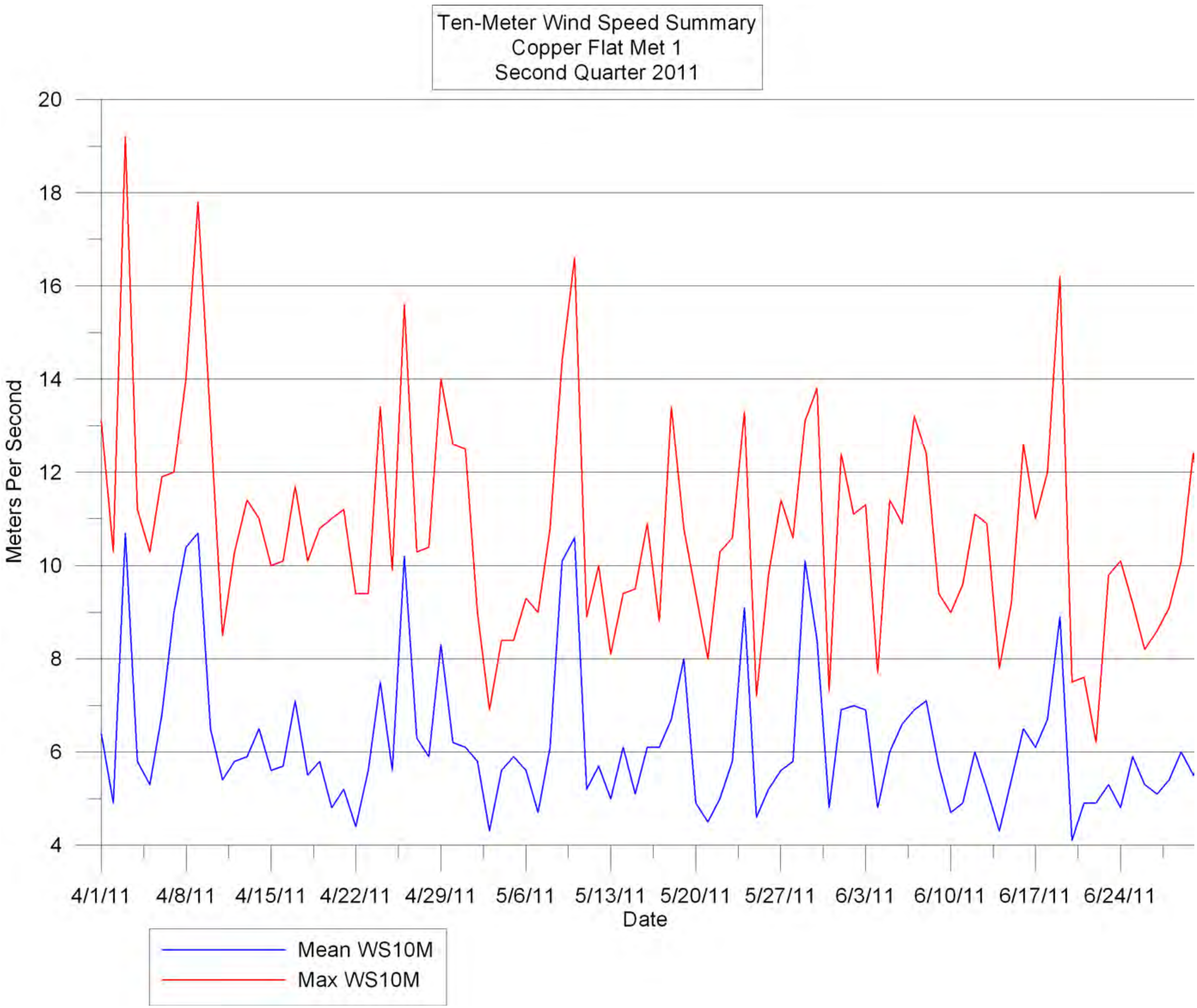
6.0 Graphical Summaries

Copper Flat Met 1

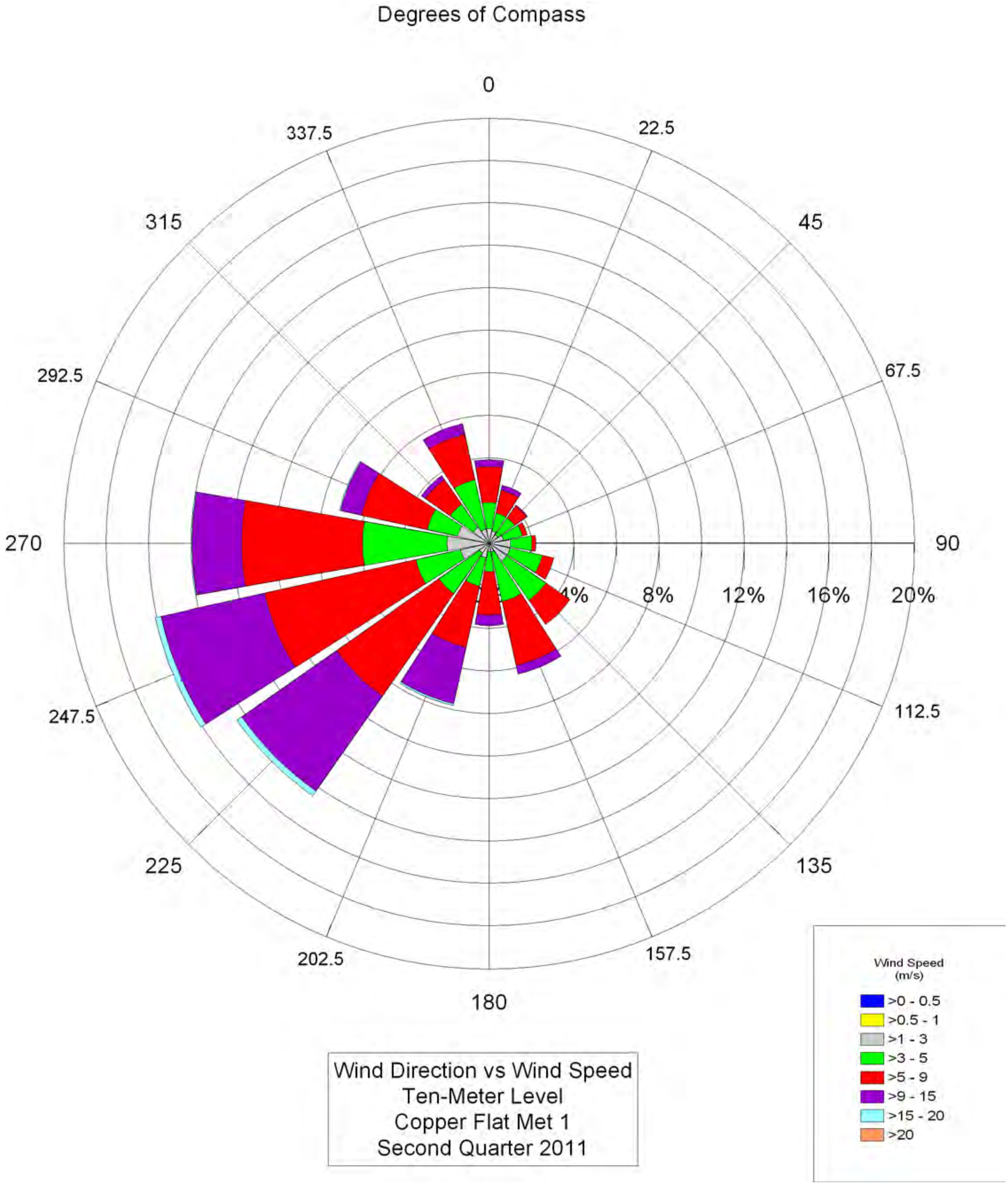
Second Quarter 2011



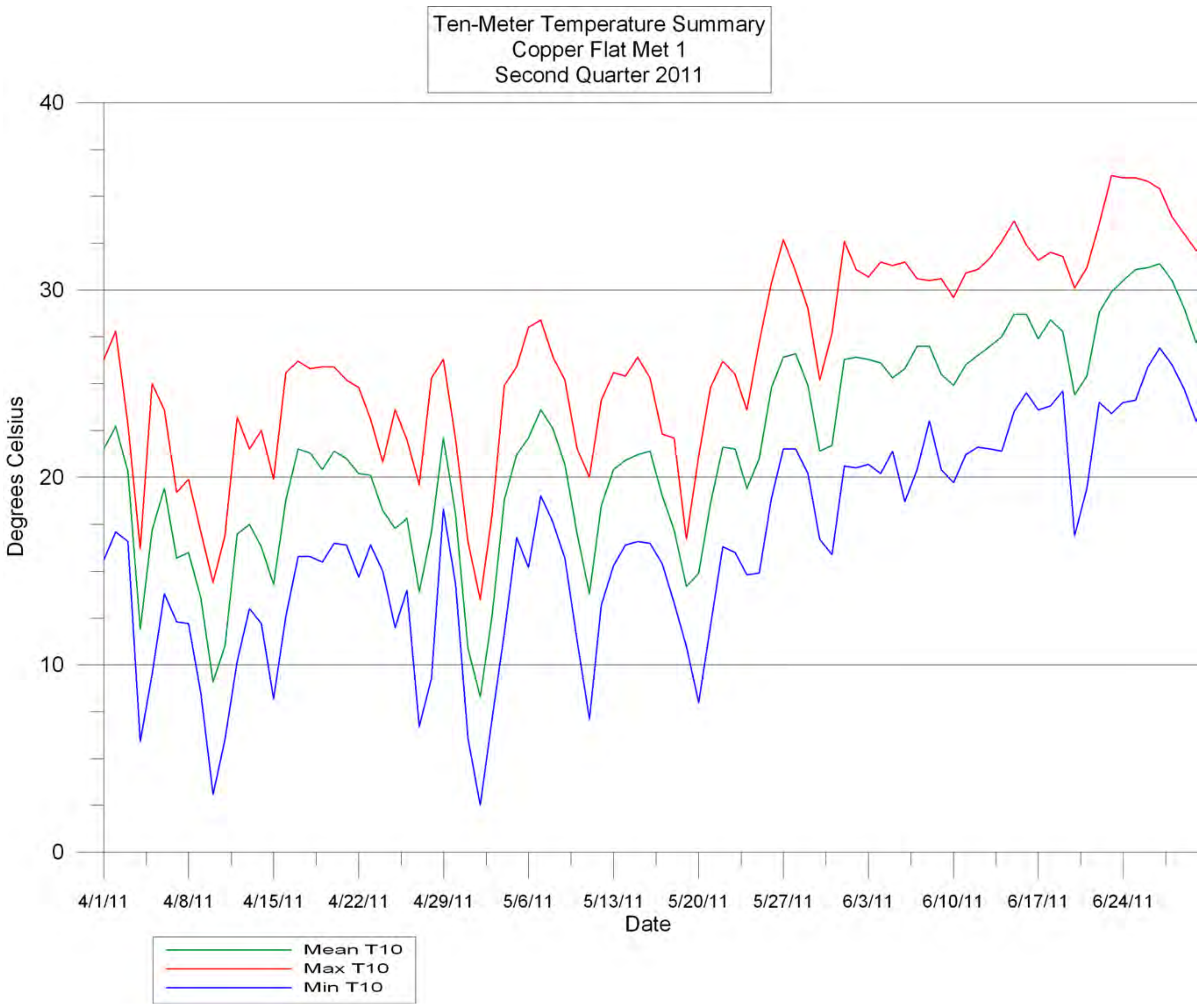
Data Capture Summary
Copper Flat Met 1
Second Quarter 2011
100
90
80
70
60
50
40
30
20
10
0
Percent
Wind Speed 10m
Wind Direction 10m
Sigma Theta 10m
Temp 10m
Temp 2m
Delta Temp
Relative Humidity
Net Radiation
Precip
Evaporation
Barometric Pressure
Parameter
April
May
June
Quarter



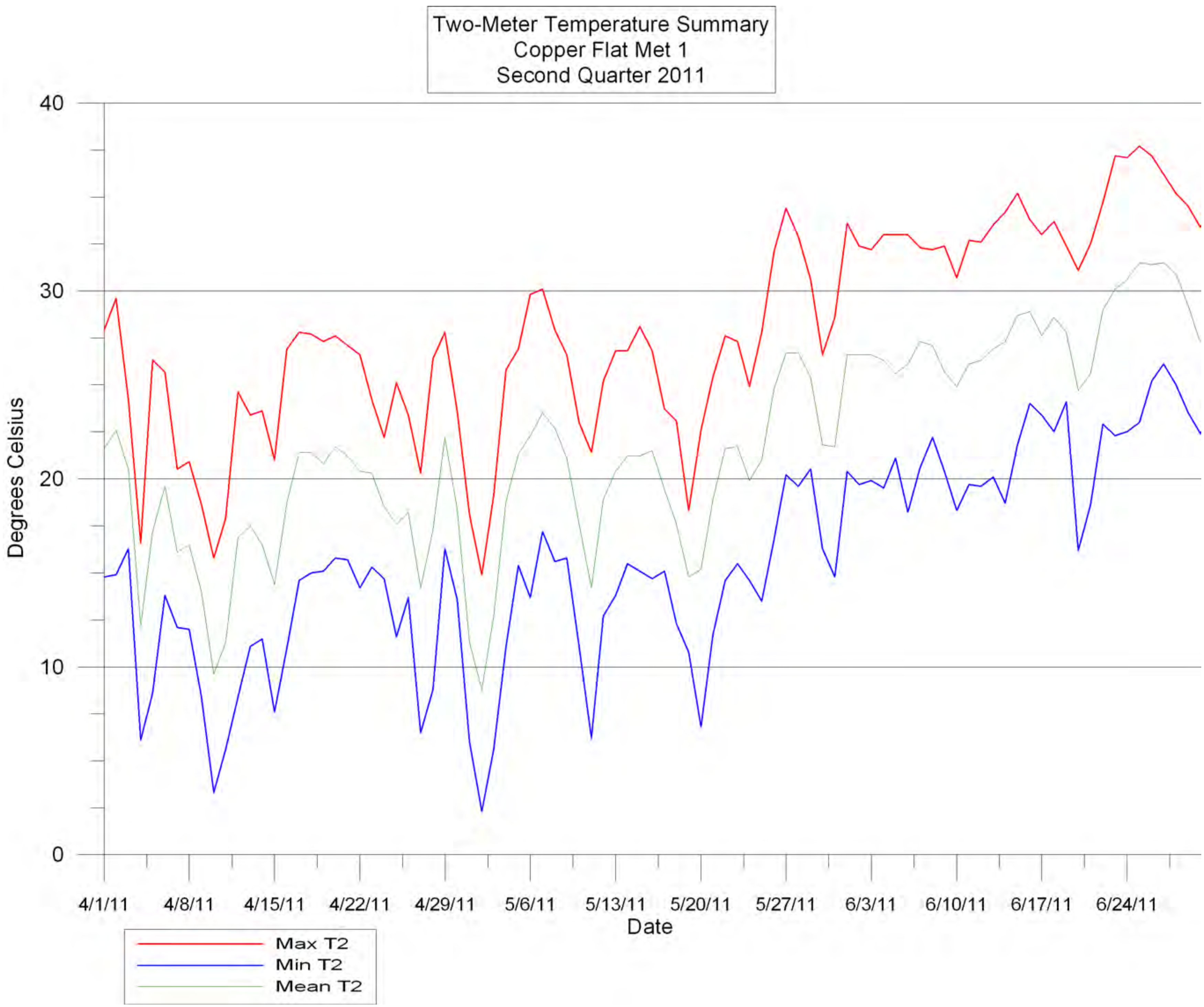
Ten-Meter Wind Speed Summary
Copper Flat Met 1
Second Quarter 2011
Meters Per Second
20
18
16
14
12
10
8
6
4
4/1/11
4/8/11
4/15/11
4/22/11
4/29/11
5/6/11
5/13/11
5/20/11
5/27/11
6/3/11
6/10/11
6/17/11
6/24/11
Date
Mean WS10M
Max WS10M



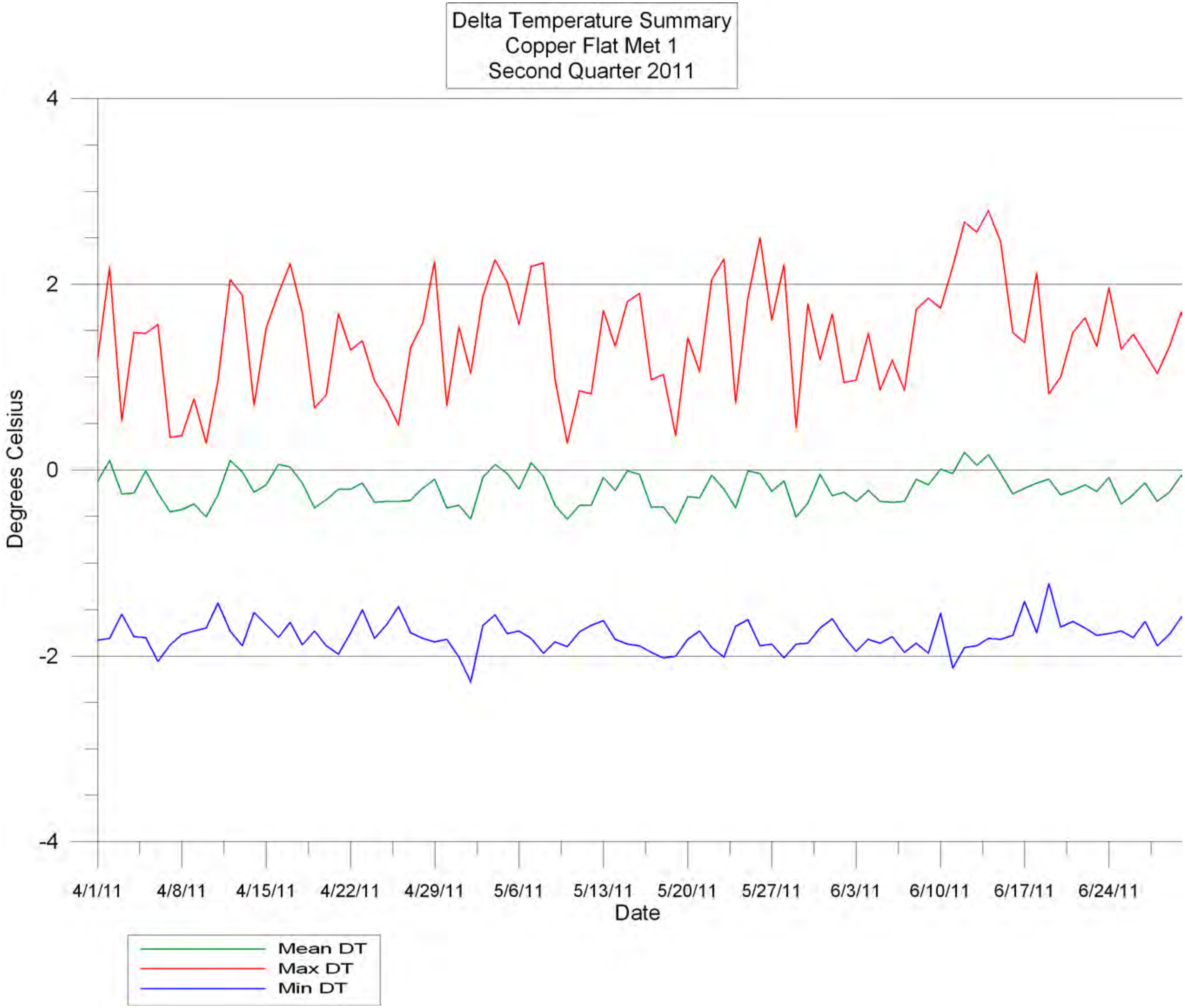
Wind Direction vs Wind Speed
Ten-Meter Level
Copper Flat Met 1
Second Quarter 2011



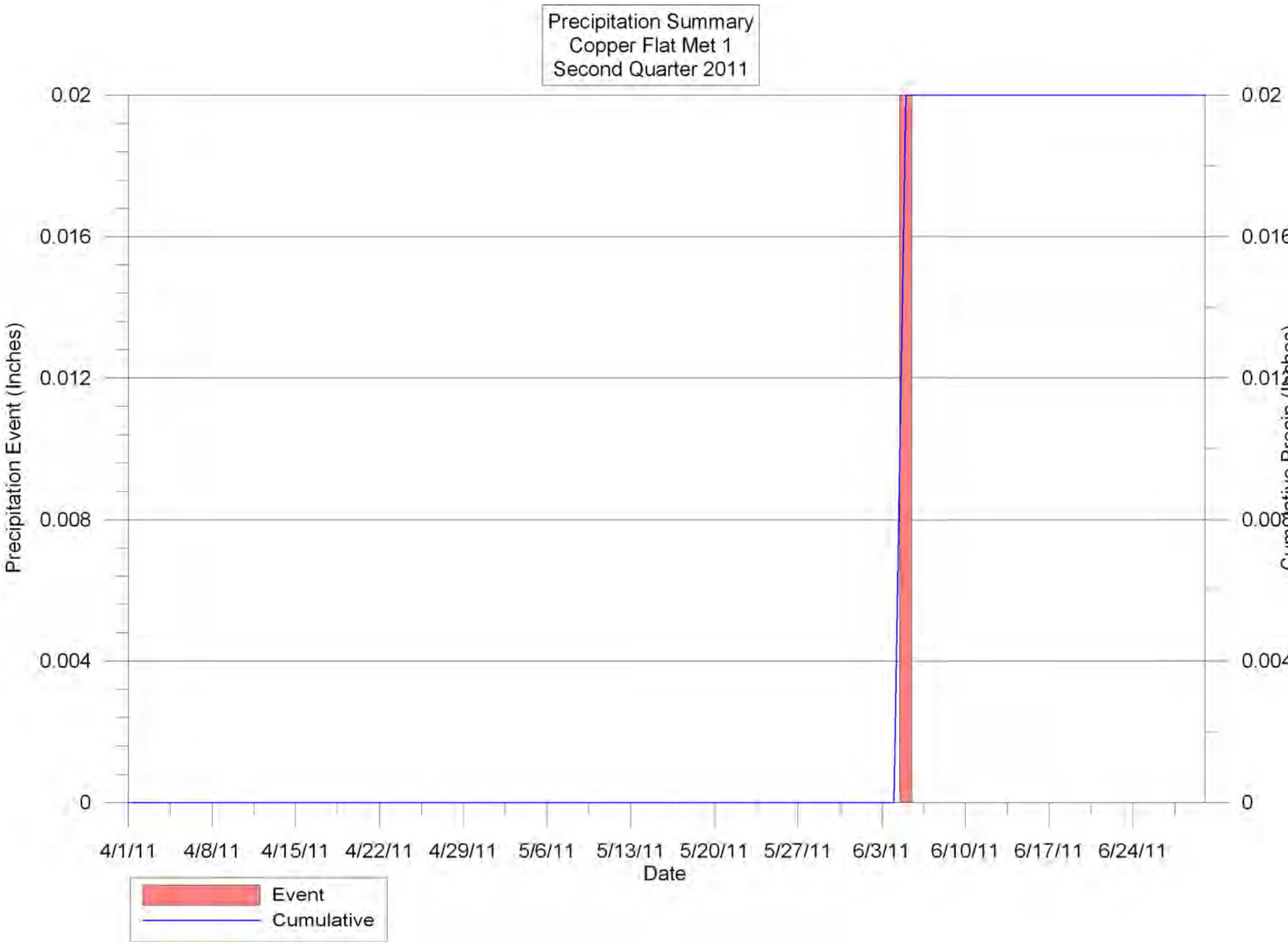
Ten-Meter Temperature Summary
Copper Flat Met 1
Second Quarter 2011
40
30
20
10
0
Degrees Celsius
4/1/11
4/8/11
4/15/11
4/22/11
4/29/11
5/6/11
5/13/11
5/20/11
5/27/11
6/3/11
6/10/11
6/17/11
6/24/11
Date
Mean T10
Max T10
Min T10



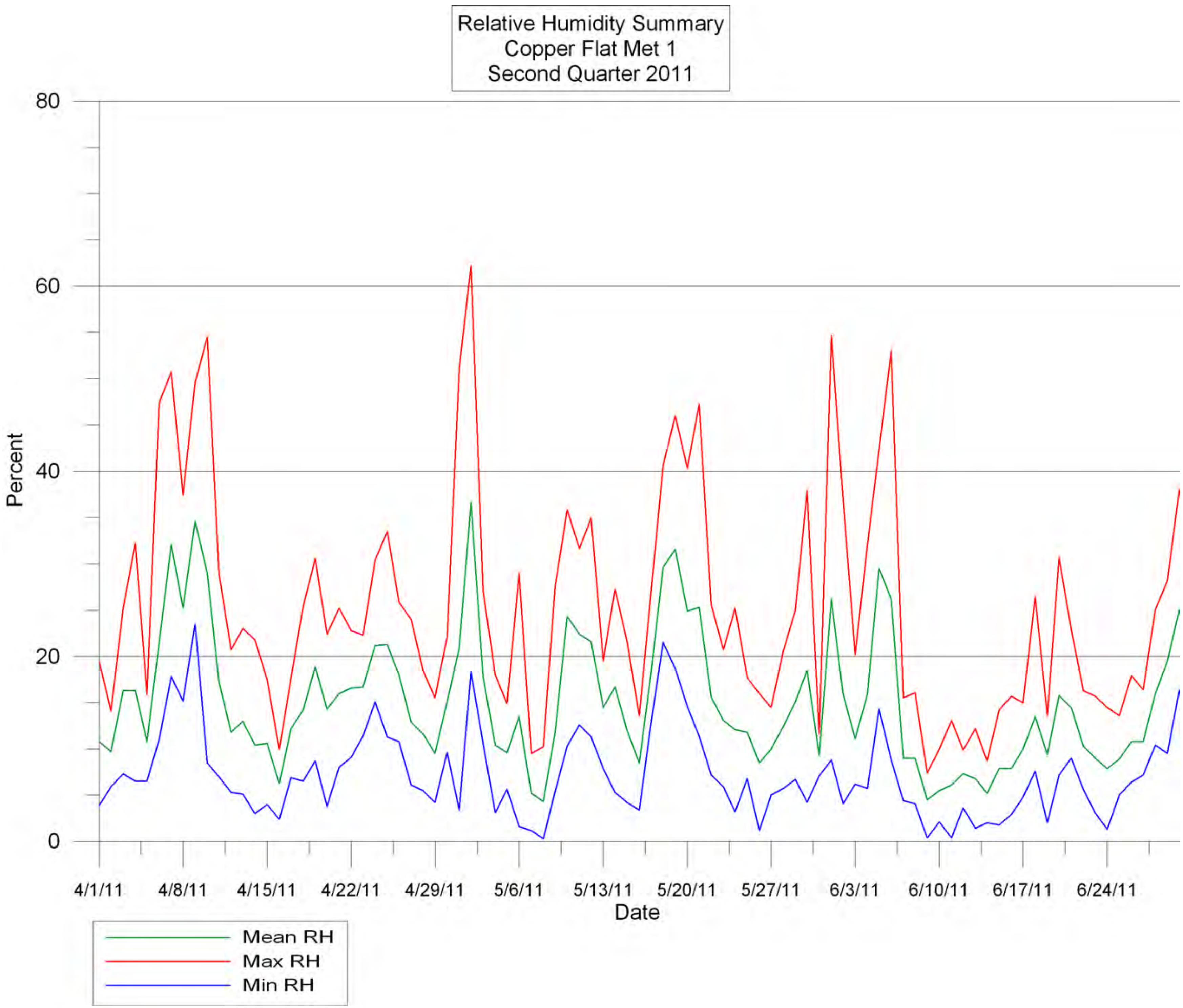
Two-Meter Temperature Summary
Copper Flat Met 1
Second Quarter 2011
40
30
20
10
0
Degrees Celsius
4/1/11
4/8/11
4/15/11
4/22/11
4/29/11
5/6/11
5/13/11
5/20/11
5/27/11
6/3/11
6/10/11
6/17/11
6/24/11
Date
Max T2
Min T2
Mean T2


Delta Temperature Summary
Copper Flat Met 1
Second Quarter 2011
4
2
0
-2
-4
Degrees Celsius
4/1/11
4/8/11
4/15/11
4/22/11
4/29/11
5/6/11
5/13/11
5/20/11
5/27/11
6/3/11
6/10/11
6/17/11
6/24/11
Date
Mean DT
Max DT
Min DT

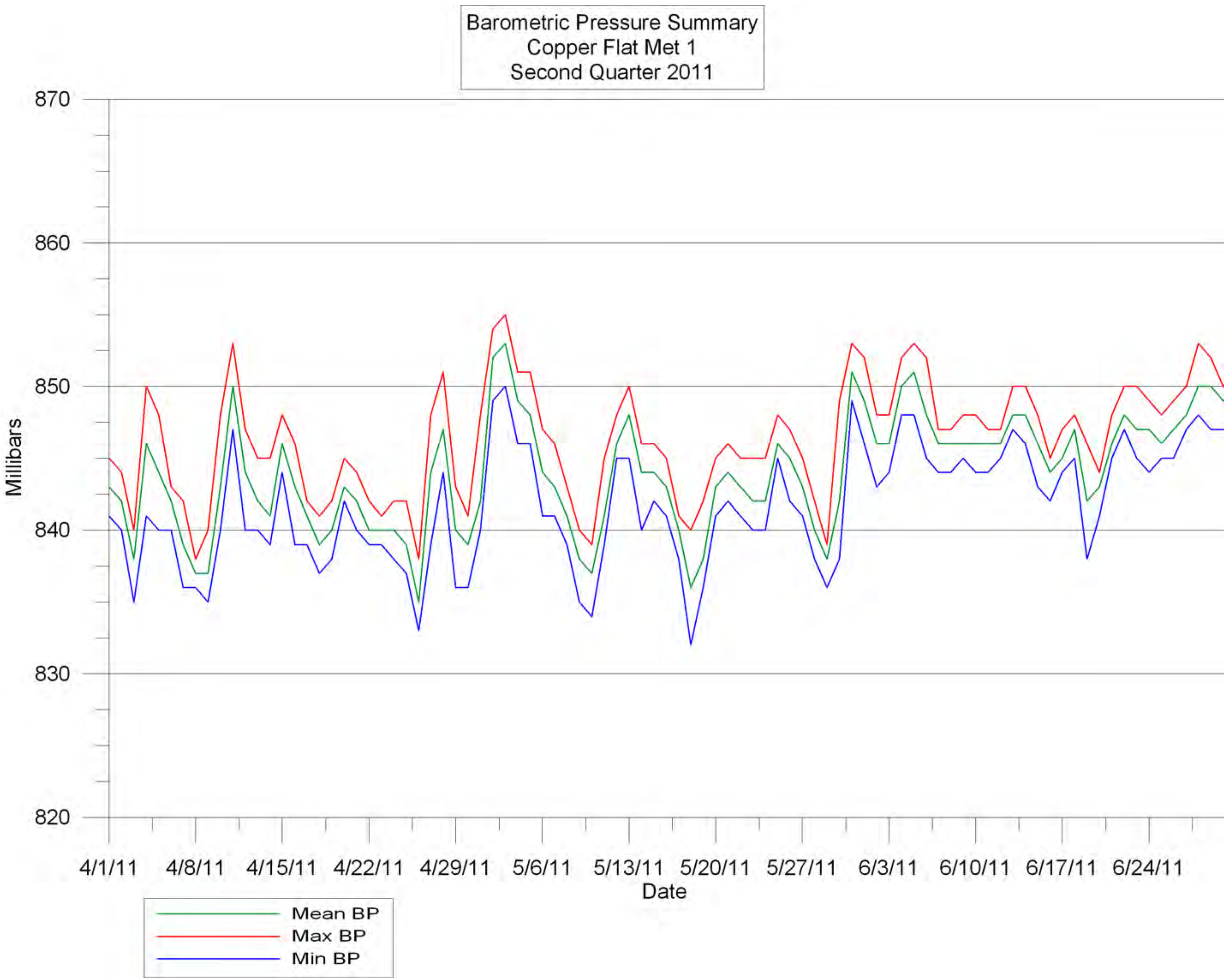
Net Radiation Summary
Copper Flat Met 1
Second Quarter 2011
Watts Per Square Meter
800
600
400
200
0
-200
4/1/11
4/8/11
4/15/11
4/22/11
4/29/11
5/6/11
5/13/11
5/20/11
5/27/11
6/3/11
6/10/11
6/17/11
6/24/11
Date
Mean NR
Max NR
Min NR



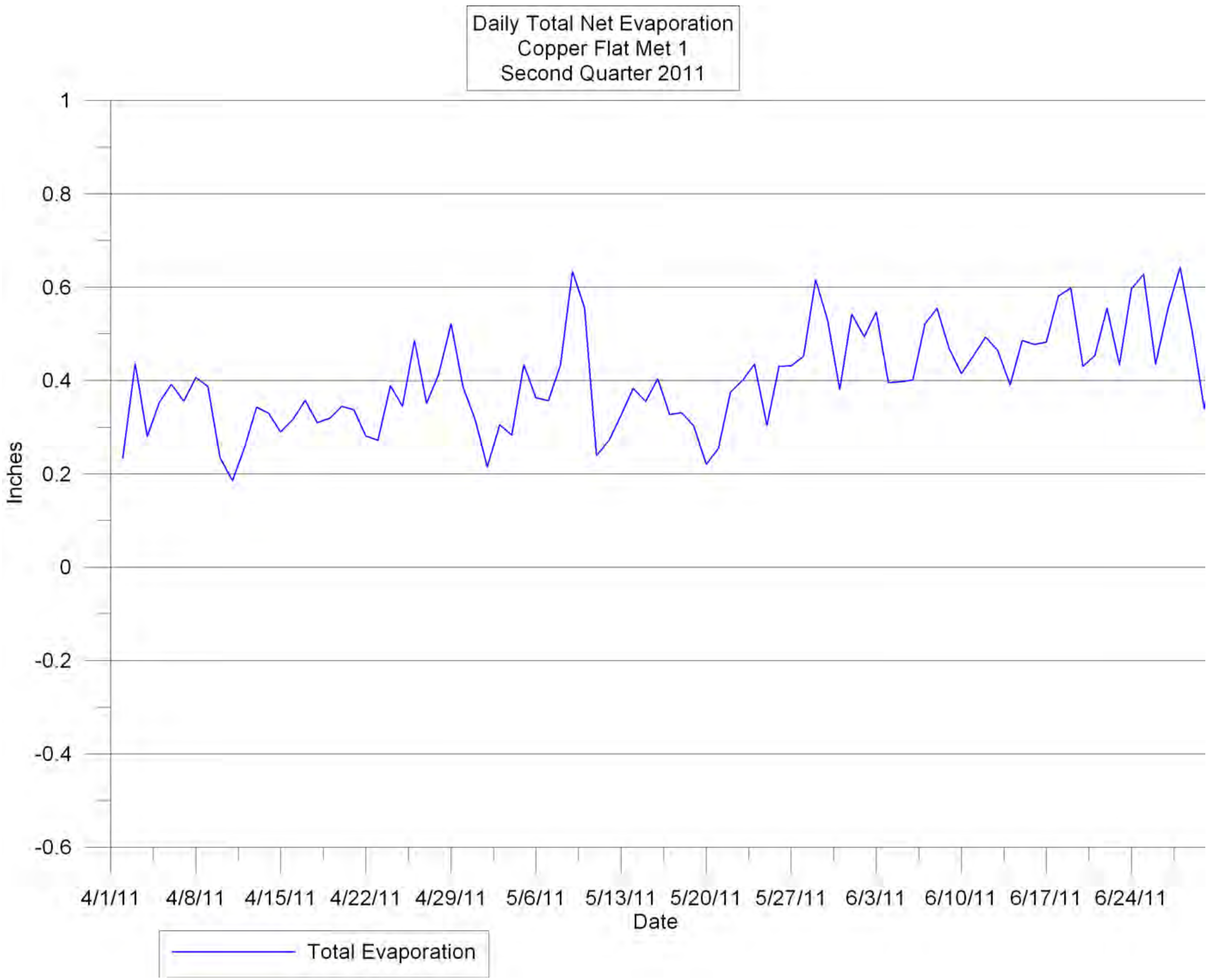
Precipitation Summary
Copper Flat Met 1
Second Quarter 2011
0.02
0.016
0.012
0.008
0.004
0
Precipitation Event (Inches)
Cumulative Precip (Inches)
4/1/11
4/8/11
4/15/11
4/22/11
4/29/11
5/6/11
5/13/11
5/20/11
5/27/11
6/3/11
6/10/11
6/17/11
6/24/11
Date
Event
Cumulative



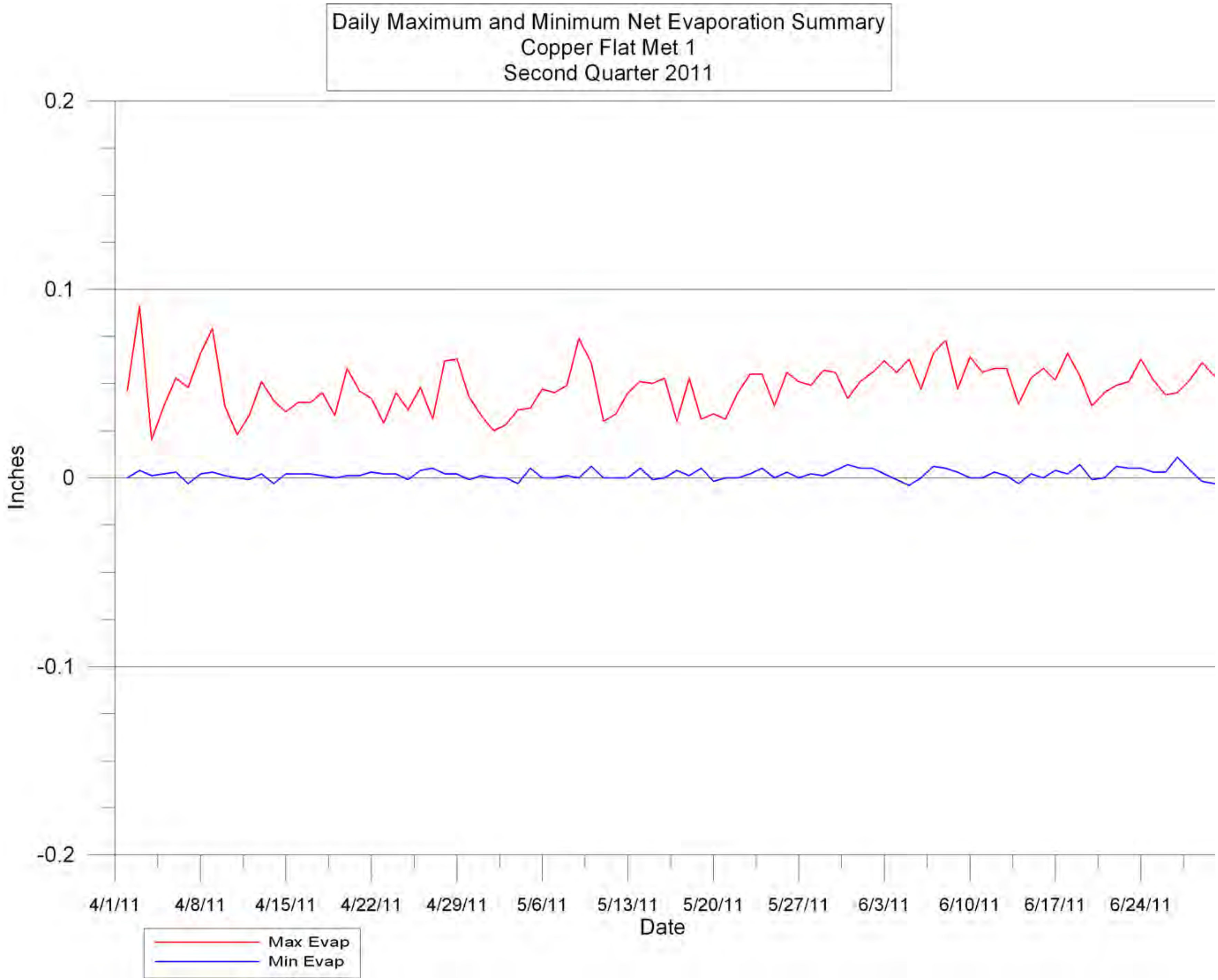
Relative Humidity Summary
Copper Flat Met 1
Second Quarter 2011
80
60
40
20
0
Percent
4/1/11
4/8/11
4/15/11
4/22/11
4/29/11
5/6/11
5/13/11
5/20/11
5/27/11
6/3/11
6/10/11
6/17/11
6/24/11
Date
Mean RH
Max RH
Min RH



Barometric Pressure Summary
Copper Flat Met 1
Second Quarter 2011
870
860
850
840
830
820
Millibars
4/1/11
4/8/11
4/15/11
4/22/11
4/29/11
5/6/11
5/13/11
5/20/11
5/27/11
6/3/11
6/10/11
6/17/11
6/24/11
Date
Mean BP
Max BP
Min BP



Daily Total Net Evaporation
Copper Flat Met 1
Second Quarter 2011
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
Inches
4/1/11
4/8/11
4/15/11
4/22/11
4/29/11
5/6/11
5/13/11
5/20/11
5/27/11
6/3/11
6/10/11
6/17/11
6/24/11
Date
Total Evaporation



Daily Maximum and Minimum Net Evaporation Summary
Copper Flat Met 1
Second Quarter 2011
0.2
0.1
0
-0.1
-0.2
Inches
4/1/11
4/8/11
4/15/11
4/22/11
4/29/11
5/6/11
5/13/11
5/20/11
5/27/11
6/3/11
6/10/11
6/17/11
6/24/11
Date
Max Evap
Min Evap

New Mexico Copper Corporation

Copper Flat Mine

Meteorological Quarterly Summary Report
Copper Flat Met 1

Third Quarter 2011
(July through September 2011)

Prepared By:

Class One Technical Services, Inc.
3500 Comanche N.E. Suite G
Albuquerque, New Mexico
87107

November 29, 2011

Table of Contents

1.0 INTRODUCTION

This report is a summary of the basic meteorological data collected at Copper Flat Mine 10-meter meteorological tower for the Third quarter of 2011. Data reduction and performance audits during this quarter were performed by Class One Technical Services. The most recent field performance audit was conducted on January 13, 2011.

The Copper Flat meteorological tower is located on the Copper Flat Mine. The site coordinates in the UTM Coordinate System are:

Site - Met 1

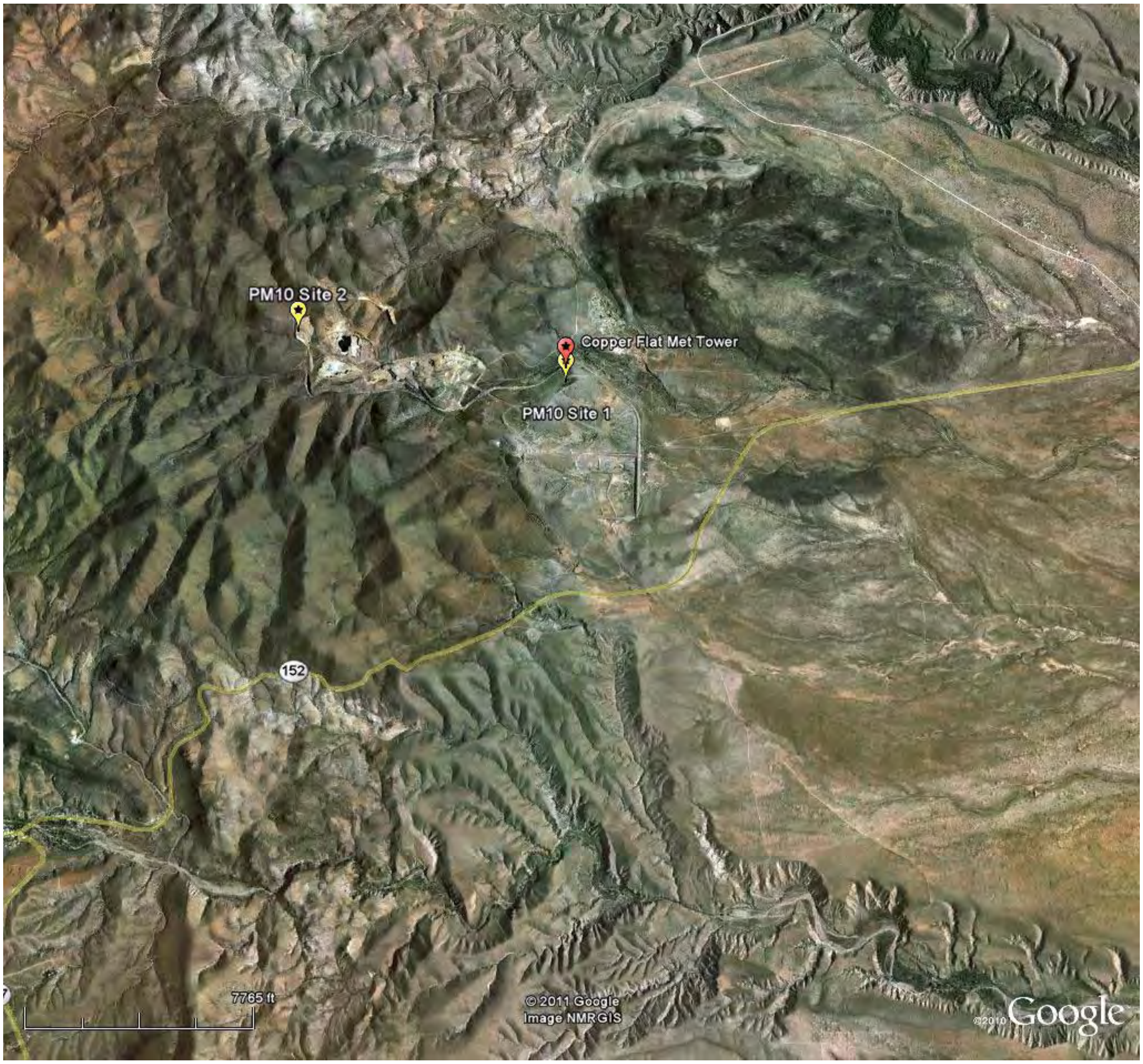
North: 3,650,579
East: 265,718

The tower location and general environs of the tower are shown in Figure 1. The tower site includes the following instrumentation:

Instrument	Manufacture	Model	Range
Wind Speed (10m)	Climatronics	F460	0-50 m/s
Wind Direction (10m)	Climatronics	F460	0-360 deg
Temperature (10m)	Climatronics	100093	-30 ^{o}C to +50 ^{o}C
Temperature (2m)	Climatronics	100093	-30 ^{o}C to +50 ^{o}C
Relative Humidity	Rotronic	MP801A	0-100%
Precipitation	Climatronics	100508-G0	0.01 in (per tip)
Net Radiation	Kipp & Zonen (Wavelength)	NR LITE	0.20 - 100 micron
Barometric Pressure	Climatronics	102663-G1	17.72 to 32.49 in. Hg
Evaporation Pan	NovaLynx	255-100	0 to 9 inches water
Data Logger	Campbell CR1000		

The wind speed, wind direction, temperature, and relative humidity sensors are mounted at ten (10) meters above ground level. The wind speed and wind direction sensors are mounted at three (3) meters. The temperature, solar radiation, and barometric pressure sensors are mounted at two (2) meters above ground level. The precipitation gauge is located at ground level.

Figure 1: Map of Copper Flat PM_{10} Sampler Locations



2.0 REPORTING CRITERIA

The following criteria have been used in preparing the quarterly summaries for the El Segundo meteorological data for this report:

a. Temperature Summaries (10-m temperature, 2-m temperature, delta temperature, and temperature lapse rate)

For each day of each month in the quarter the mean, maximum and minimum temperature, in degrees, Celsius are reported. The maxima and the minima are based on one-hour averages. For a 24-hour mean value to be *valid*, at least 18 hourly values must have been present during the 24-hour period. If less than 18 hours of valid data are available, the mean *is calculated, but data may not be representative and should be used with care*. Similarly, maxima and minima are *included* for these periods. Even though some data may have been available on these days, the maxima and minima may be misleading if the missing data happened to occur during the hottest or coldest part of the day.

For each month in the quarter the mean temperature for the month is calculated from all the hourly data, including data on those days which did not have enough data to calculate a 24-hour mean. Monthly averages *are calculated for months with less than* 4 valid 24-hour means in the month. *The* monthly maximum *and* minimum are reported as well. While 4 valid days are *considered valid* to report a mean, means for months with less than 18 days of valid data may not be representative and should be used with care.

Means, maxima and minima are reported for the entire quarter if there is at least one valid month of data in the quarter. As such, these values may not be truly representative of the entire quarter if significant amounts of data are missing. The validity of the quarterly values depends on their intended use and care should be taken with quarters with low data capture.

b. Wind Speed Summary

For each day of each month the 24-hour mean wind speed and the maximum hourly wind speed has been reported in units of meters per second. The criterion for valid 24-hour means is the same as that described above for mean temperatures.

For each month, the mean wind speed and the maximum wind speed are reported. The criteria for determining the monthly values are the same as those described above for monthly temperature values. For each quarter, the mean for the entire quarter and the maximum hourly value in the quarter is reported. The criteria for reporting quarterly values are the same as those described above for quarterly temperature values.

c. Wind Data Summary

The Wind Data Summary report gives a JFD (Joint Frequency Distribution) of wind direction and wind speed. Wind directions are divided into 16 sectors, each 22.5 degrees wide. The north sector covers 348.75 degrees to 11.25 degrees (i.e. it is symmetrical about zero degrees). Wind speeds are divided into 8 categories. The data in each wind speed/wind direction category are given as a fraction of the total month to the nearest 1 percent. The total fraction for each wind direction sector and each wind speed category is also given.

A quarterly JFD is printed if at least one valid month of data existed in the quarter. As such, it is possible that the quarterly JFD may not be truly representative of the full quarter if only one month of data is available.

d. Precipitation Summary

For each day in the quarter, the total precipitation in inches is reported along with a running precipitation total beginning at the first day of the quarter. Precipitation for a day is reported if at least one hour of data is available during the day.

For each quarter, the total precipitation for the quarter is reported along with the total number of hours during which precipitation occurred. A quarterly precipitation value is reported if there is any valid precipitation during the quarter. Care must be taken in use of the quarterly precipitation values if there were significant missing data during the quarter.

e. Relative Humidity Summaries

For each day in the quarter the mean, maximum and minimum relative humidity, in percent, is reported. The maxima and the minima are based on one-hour averages. For a 24-hour mean value to be *valid*, at least 18 hourly values must have been present during the 24-hour period. If less than 18 hours of valid data are available, the mean is *calculated*, *but data may not be representative and should be used with care*. Similarly, maxima and minima are *included* for these periods. Even though some data may have been available on these days, the maxima and minima may be misleading if the missing data happened to occur during the hottest or coldest part of the day.

For each month in the quarter the mean temperature for the month is calculated from all the hourly data, including data on those days which did not have enough data to calculate a 24-hour mean. Monthly averages *are calculated for months with less than* 4 valid 24-hour means in the month. *The* monthly maximum *and* minimum are reported as well. While 4 valid days are *considered valid* to report a mean, means for months with less than 18 days of valid data may not be representative and should be used with care.

Means, maxima and minima are reported for the entire quarter if there is at least one valid month of data in the quarter. As such, these values may not be truly representative of the entire quarter if significant amounts of data are missing.

f. Data Capture Summary

For each month and each parameter the percent of valid data, based on hourly values, is reported as well as the average data capture for the entire month. Also, the percent of valid data for the quarter for each parameter and the average data capture for the quarter are given.

g. Barometric Pressure Summary

Barometric pressure is summarized in inches of Mercury (in. Hg). The pressure data are the actual site pressures; they have not been "corrected" to sea level as is typically done with National Weather Service data. The reporting requirements for valid averages, maxima, and minima are the same as those for temperature and relative humidity summaries.

h. Net Radiation Summary

For each day in the quarter the daily maximum net radiation in watts per square meter is reported. The maxima are based on one-hour averages.

i. Evaporation Summary

For each day of the quarter, the total, minimum, and maximum evaporation values are reported in inches. Minima and maxima are based on one-hour averages. Positive values indicate evaporation, or loss of water from the evaporation pan, whereas negative values indicate precipitation or addition of water to the evaporation pan by other means.

For a 24-hour total value to be *valid*, at least 18 hourly values must have been present during the 24-hour period. If less than 18 hours of valid data are available, the total is *calculated, but data may not be representative and should be used with care*. Similarly, maxima and minima are *included* for these periods. Even though some data may have been available on these days, the maxima and minima may be misleading if the missing data happened to occur during the hottest or coldest part of the day, or during a precipitation event.

For each month in the quarter, the total evaporation is calculated from all the hourly data, including data on those days which did not have enough data to calculate a 24-hour total. The monthly maximum and minimum are reported as well.

3.0 Meteorological Data Summary

The Copper Flat Met 1 meteorological data for Third quarter 2011 is presented in section 5.0 Numerical Summaries, on pages 14-24. The following text and tables represent the summarized data in section 5.0 Numerical Summaries.

Wind Speed

The average ten-meter wind speed for the Third quarter was 4.5 m/s. The maximum hourly ten-meter wind speed for the meteorological tower was 13.3 m/s and was recorded July 20, 2011 at 1300 MST. Forty-two percent of the hourly wind speeds at the ten-meter level were observed in the >3.0 to 5.0 m/s wind speed class, while thirty-three percent were in the >5.0 to 9.0 m/s wind speed class.

Table 1 below summarizes the monthly hourly average and maximum wind speeds in meters per second (m/s).

Table 1: Monthly Wind Speed Summary

Month	Mean Hourly Wind Speed (meters/second)	Maximum Hourly Wind Speed (meters/second)	Date of Maximum Hourly Wind Speed
July	4.6	13.3	Jul. 20 @ 1300
August	4.5	12.9	Aug. 12 @ 2100
September	4.4	11.6	Sep. 14 @ 0100

Wind Direction

The prevailing wind directions for the quarter were from the Southeast (SE), West, Northwest (NW) and North-northwest (NNW) sectors. Winds from these sector each occurred approximately ten percent of the time. Winds from the SE occurred five percent of the time in the >3.0 to 5.0 m/s wind speed class. Winds from the west occurred five percent of the time in the >3.0 to 5.0 m/s wind speed class. Winds from the NW occurred five percent of the time in the >5.0 to 9.0 m/s wind speed class. Winds from the NNW occurred five percent of the time in the >5.0 to 9.0 m/s wind speed class.

Temperature

The mean quarterly 10-meter temperature was 25.1 degrees Celsius (^oC). The maximum hourly temperature of 34.7^{o}C was recorded on August 8, 2011 at 1700 MST. The minimum temperature of 12.8^{o}C was recorded on September 16, 2011 at 0600 MST.

The mean quarterly 2-meter temperature was 25.3^{o}C. The maximum hourly temperature of 35.8^{o}C was recorded on August 8, 2011 at 1600 MST. The minimum hourly temperature of 12.5^{o}C was recorded on September 16, 2011 at 0600 MST.

Table 2 below represents the monthly mean, minimum, and maximum temperatures for the 10 and 2-meter levels of the meteorological tower.

Table 2: Monthly Temperature Summary

10-Meter Temperature

Month	Max Hrly Temp ^{o}C	Date of Max Temp	Min Hrly Temp ^{o}C	Date of Min Temp	Mean Hrly Temp ^{o}C
July	33.8	Jul. 9 @ 16-1700	18.7	Jul. 29 @ 0500	26.6
August	34.7	Aug. 8 @ 1700	17.9	Aug. 12 @ 2100	26.3
September	31.7	Sep. 3 @ 1700	12.8	Sep. 16 @ 0600	22.5

2-Meter Temperature

Month	Max Hrly Temp °C	Date of Max Temp	Min Hrly Temp °C	Date of Min Temp	Mean Hrly Temp °C
July	35.3	Jul. 21 @ 1600	18.7	Jul. 29 @ 0500	26.9
August	35.8	Aug. 8 @ 1600	17.8	Aug. 12 @ 2100	26.4
September	33.0	Sep. 1 @ 1500	12.5	Sep. 16 @ 0600	22.5

Net Radiation

The maximum hourly net radiation for the Third Quarter 2011 was 664 w/m^2 and occurred on August 17, 2011 at 1200 MST. Table 4 below summarizes the monthly maximum net radiation in watts per square meter (w/m^2).

Table 4: Monthly Net Radiation Summary

Month	Maximum Hrly Net Radiation (w/m^2)	Date of Maximum Hourly Net Radiation
July	656	Jul. 12 @ 1200
August	664	Aug. 17 @ 1200
September	610	Sep. 7 @ 1200

Precipitation

The total precipitation for Third Quarter 2011 was 4.23 inches, with a duration of 48 hours. Seventy-four percent of the observed precipitation, 3.12 inches, fell in the month of August. The largest single day precipitation amount was 1.77 inches was recorded on August 18, 2011. Table 5 summarizes the total monthly precipitation for July, August, and September 2011.

Table 5: Monthly Precipitation Summary

Month	Total Precipitation (inches)	Percent Of Total (%)	Max. Daily Precipitation Event (inches)	Date of Max Daily Precip Event
July	0.43	10	0.25	Jul. 11
August	3.12	74	1.77	Aug. 18
September	0.68	16	0.31	Sep. 15

Relative Humidity

The mean relative humidity for the quarter was 38 percent. The maximum hourly relative humidity of 94 percent was recorded on September 4, 2011. The minimum hourly relative humidity value of 8 percent was recorded on August 8, 2011. Table 6 below represents the monthly mean, minimum and maximum relative humidity values for the meteorological tower.

Table 6: Monthly Relative Humidity Summary

Month	Mean Hrly Relative Humidity (%)	Minimum Hrly Relative Humidity (%)	Maximum Hrly Relative Humidity (%)
July	36	12	86
August	41	8	91
September	37	11	94

Barometric Pressure

The mean barometric pressure for the Third Quarter 2011 was 845 milibars. The maximum hourly barometric pressure value of 858 mbars occurred on July 31, 2011. Table 7 below represents the monthly mean, minimum and maximum barometric pressure values for the meteorological tower.

Table 7: Monthly Barometric Pressure Summary

Month	**Mean Hrly Barometric Pressure (mbars)**	**Minimum Hrly Barometric Pressure (mbars)**	**Maximum Hrly Barometric Pressure (mbars)**
July	851	846	858
August	842	832	857
September	842	836	850

Evaporation

Table 8 represents the monthly net sum, minimum and maximum evaporation values for the meteorological tower.

The net sum evaporation for the quarter was 22.475 inches. The minimum hour evaporation for the quarter was -0.997 and occurred on August 18, 2011. The maximum evaporation for the quarter was 0.416 inches and occurred on July 20, 2011.

Table 8: Monthly Evaporation Summary

Month	**Total Monthly Net Evaporation (inches)**	**Minimum Hourly Evaporation (inches)**	**Maximum Hourly Evaporation (inches)**
July	10.356	-0.305	0.416
August	5.941	-0.997	0.191
September	6.178	-0.153	0.053

4.0 DATA CAPTURE DESCRIPTION

Overall data capture for the Third quarter of 2011 was approximately ninety-nine (99) percent (excluding Evaporation data and edits).

July 2011

Overall data capture for the month was approximately ninety-nine (99) percent for all parameters. All data loss is attributed one to three hours of invalid data per day for evaporation at the time the evaporation pan is filled.

August 2011

Overall data capture for the month was approximately ninety-eight (98) percent for all parameters. All data loss is attributed one to three hours of invalid data per day for evaporation at the time the evaporation pan is filled. Additional data loss occurred during a program modification.

September 2011

Overall data capture for the month was approximately ninety-nine (99) percent for all parameters. All data loss is attributed one to three hours of invalid data per day for evaporation at the time the evaporation pan is filled.

5.0 Numerical Summaries

Copper Flat Met 1

Third Quarter 2011

Copper Flat - Met 1

Q3 - 2011 Quarterly Data Capture Report
(percentages)
07/01/2011 to 09/30/2011

Parameter	July Values Count	July Capture Pct	August Values Count	August Capture Pct	September Values Count	September Capture Pct	Qtr Total Count	Qtr Total Capture Pct
Wind Speed 10m	741	99.60	737	99.06	719	99.86	2197	99.50
Wind Direction 10m	741	99.60	737	99.06	719	99.86	2197	99.50
Sigma Theta 10m	741	99.60	737	99.06	719	99.86	2197	99.50
Temp 10m	740	99.46	737	99.06	719	99.86	2196	99.46
Temp 2m	740	99.46	737	99.06	719	99.86	2196	99.46
Delta Temp	740	99.46	737	99.06	719	99.86	2196	99.46
Relative Humidity	742	99.73	737	99.06	719	99.86	2198	99.55
Net Radiation	742	99.73	737	99.06	719	99.86	2198	99.55
Precipitation	742	99.73	737	99.06	719	99.86	2198	99.55
Evaporation	742	99.73	737	99.06	719	99.86	2198	99.55
Barometric Pressure	742	99.73	737	99.06	719	99.86	2198	99.55
Station AVERAGE	741	99.60	737	99.06	719	99.86	2197	99.50

Report Date
11/29/2011

Copper Flat - Met 1

Q3 - 2011 Quarterly Summary Report For Wind Speed 10m (m/s)

07/01/2011 to 09/30/2011

DAY	July Mean	July Min	July Max	August Mean	August Min	August Max	September Mean	September Min	September Max
1	4.8	1.8	10.2	4.5	1.6	7.7	4.5	2.3	7.2
2	4.6	2.9	6.5	4.3	1.8	9.0	4.1	1.6	8.9
3	4.8	1.0	11.3	5.1	3.3	6.8	4.6	2.4	8.2
4	4.9	2.4	10.8	4.8	2.2	11.3	4.8	1.6	7.5
5	3.6	1.8	6.0	4.4	1.4	10.2	3.5	0.8	5.2
6	4.2	1.3	6.6	4.9	1.1	9.9	4.8	1.8	8.1
7	4.1	3.1	5.4	5.1	2.5	8.5	5.1	1.1	10.8
8	4.4	2.4	6.7	5.1	1.3	8.3	4.2	1.4	7.0
9	4.4	1.5	8.4	5.5	2.6	11.4	4.9	2.2	9.5
10	4.0	1.3	6.1	3.8	1.2	8.0	3.6	1.0	6.8
11	6.0	1.6	13.1	3.9	1.4	8.0	4.5	1.7	9.6
12	4.0	1.1	7.6	5.0	1.1	12.9	4.9	1.1	10.7
13	4.5	1.4	9.4	4.6	1.8	12.2	4.4	2.1	6.8
14	4.9	1.1	9.2	4.2	1.6	9.5	5.0	1.3	11.6
15	4.6	2.2	7.8	4.4	0.9	9.9	4.7	1.6	9.5
16	4.4	1.2	7.7	3.6	1.0	8.3	4.4	1.3	8.3
17	5.9	1.5	10.2	3.8	2.1	9.5	4.5	1.4	7.9
18	3.8	1.4	6.4	4.1	1.5	8.6	3.6	2.3	5.3
19	3.6	1.7	6.3	4.2	1.3	8.2	4.7	2.5	6.8
20	5.7	1.4	13.3	5.7	2.8	9.6	3.1	1.7	4.2
21	4.0	1.1	9.3	5.6	2.8	9.1	4.4	1.5	10.7
22	3.7	1.5	6.2	4.2	1.3	7.1	4.2	1.4	7.0
23	4.4	1.8	12.7	4.0	1.9	6.8	3.6	1.8	5.9
24	3.6	0.9	7.6	5.8	2.8	12.0	3.5	1.3	8.1
25	4.1	0.9	5.8	5.8	3.8	7.8	5.4	1.3	9.6
26	5.4	1.5	8.8	3.8	3.0	5.1	4.9	2.8	6.5
27	6.0	2.5	11.0	3.2	1.2	4.8	4.7	2.7	6.4
28	5.3	1.5	13.2	3.0	1.5	5.5	4.1	1.4	6.7
29	4.3	1.3	9.0	5.2	2.2	11.3	4.1	2.0	7.7
30	4.8	2.8	7.8	4.3	1.6	7.4	5.2	3.0	7.2
31	4.6	2.5	8.5	4.9	1.4	8.7			
Monthly Mean	4.6			4.5			4.4		
Monthly Min		0.9			0.9			0.8	
Monthly Max			13.3			12.9			11.6
Quarterly Mean	4.5								
Quarterly Min	0.8								
Quarterly Max	13.3								

Copper Flat - Met 1

Q3 - 2011 Quarterly Wind Summary Report
(Wind Direction 10m vs Wind Speed 10m)
07/01/2011 to 09/30/2011

WS CLASS	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTALS
CALM	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
0.5 TO 1.0	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.0032
>1.0 TO 3.0	0.019	0.013	0.007	0.014	0.014	0.015	0.015	0.011	0.010	0.009	0.007	0.014	0.025	0.023	0.020	0.014	0.2289
>3.0 TO 5.0	0.027	0.019	0.017	0.011	0.014	0.024	0.048	0.042	0.019	0.016	0.018	0.013	0.052	0.028	0.029	0.041	0.4178
>5.0 TO 9.0	0.032	0.011	0.003	0.002	0.001	0.005	0.037	0.030	0.018	0.017	0.013	0.013	0.026	0.025	0.047	0.045	0.3250
>9.0 TO 15.0	0.001	0.000	0.000	0.000	0.000	0.001	0.003	0.002	0.000	0.001	0.001	0.000	0.000	0.005	0.006	0.004	0.0250
>15.0 TO 20.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
>20.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0000
TOTAL	0.080	0.043	0.027	0.027	0.029	0.046	0.104	0.085	0.046	0.043	0.040	0.040	0.104	0.080	0.102	0.103	

Report Date
11/29/2011

Copper Flat - Met 1

Q3 - 2011 Quarterly Summary Report For Temp 10m
(deg C)
07/01/2011 to 09/30/2011

DAY	July Mean	July Min	July Max	August Mean	August Min	August Max	September Mean	September Min	September Max
1	27.1	22.7	32.9	25.4	20.3	30.8	26.4	22.0	31.6
2	27.0	23.0	31.2	26.8	22.5	32.7	25.9	20.9	30.9
3	24.9	19.2	30.4	26.7	23.4	31.4	26.5	23.0	31.7
4	25.6	19.2	30.6	25.7	21.1	30.8	21.6	17.4	26.6
5	27.3	22.4	31.7	26.4	22.9	30.6	20.7	17.1	24.2
6	28.3	24.6	31.7	26.2	20.5	31.1	23.7	19.0	29.1
7	28.7	23.5	32.6	29.4	25.6	34.1	23.9	19.2	30.5
8	29.3	23.8	33.2	30.5	25.7	34.7	21.6	16.4	26.2
9	29.1	23.2	33.8	28.6	25.1	34.0	20.8	18.5	25.5
10	28.7	23.5	32.9	28.2	22.8	32.2	19.3	17.0	24.2
11	24.9	20.4	30.9	25.4	19.6	29.8	20.7	15.3	25.6
12	24.5	19.0	30.2	24.0	17.9	29.7	21.9	18.8	24.5
13	25.1	21.5	29.6	23.2	19.8	29.6	22.6	17.1	28.4
14	25.3	19.2	31.3	22.6	19.2	26.7	20.1	16.6	24.6
15	28.1	22.7	32.6	23.4	20.0	28.6	17.0	14.5	21.3
16	28.7	24.2	32.8	24.8	20.2	30.1	18.8	12.8	24.0
17	27.9	24.7	31.0	25.6	22.9	30.8	21.2	16.9	25.5
18	27.8	23.0	32.1	23.0	19.6	29.1	21.9	17.5	26.4
19	28.4	23.8	32.3	23.8	19.4	28.6	23.4	19.7	27.4
20	27.1	24.5	31.8	25.1	21.7	28.6	23.9	19.4	28.5
21	27.1	22.3	32.1	24.6	21.0	28.2	23.5	19.8	27.2
22	26.4	22.4	30.2	26.1	21.4	31.0	22.4	18.5	26.7
23	25.5	20.0	31.4	28.2	23.3	32.6	23.2	17.8	28.0
24	24.2	19.3	28.8	28.2	23.2	33.2	24.4	19.5	29.2
25	25.7	20.5	30.8	26.1	20.9	31.5	23.8	20.1	27.4
26	26.7	22.6	31.9	27.2	22.9	31.9	23.5	19.4	26.4
27	25.8	21.9	30.2	28.4	24.2	32.2	23.9	19.7	28.0
28	25.9	22.8	32.0	28.6	24.3	33.1	23.6	19.8	27.6
29	23.4	18.7	28.4	27.3	24.4	32.2	23.6	20.0	28.0
30	24.9	20.7	29.9	28.7	24.0	33.4	19.8	15.4	24.2
31	24.3	21.7	27.8	27.5	23.5	33.4			
Monthly Mean	26.6			26.3			22.5		
Monthly Min		18.7			17.9			12.8	
Monthly Max			33.8			34.7			31.7
Quarterly Mean	25.1								
Quarterly Min	12.8								
Quarterly Max	34.7								

Report Date
11/29/2011

Copper Flat - Met 1

Q3 - 2011 Quarterly Summary Report For Temp 2m
(deg C)
07/01/2011 to 09/30/2011

DAY	July Mean	July Min	July Max	August Mean	August Min	August Max	September Mean	September Min	September Max
1	27.4	21.9	34.1	25.8	19.9	32.5	26.5	21.0	33.0
2	27.5	22.6	32.3	27.1	21.9	34.4	25.8	19.9	31.9
3	25.5	18.9	31.6	26.9	23.2	32.7	26.6	22.7	32.5
4	26.0	18.9	32.4	26.0	20.3	32.1	21.8	17.6	27.7
5	27.5	21.6	33.1	26.6	22.0	31.6	21.0	17.0	25.1
6	28.7	24.1	33.2	26.5	19.8	32.4	24.0	18.2	30.1
7	29.1	22.8	33.7	29.5	24.9	35.2	24.2	19.4	31.6
8	29.5	22.7	34.4	30.6	24.7	35.8	21.8	16.2	27.1
9	29.5	22.4	35.3	28.2	23.9	34.9	21.1	18.2	26.7
10	29.0	22.8	34.3	28.5	22.9	32.9	19.6	16.2	25.2
11	25.2	20.1	32.5	25.8	19.6	30.8	20.8	15.0	26.6
12	24.8	18.8	31.3	24.4	17.8	31.3	22.0	18.3	25.6
13	25.4	20.7	30.5	23.1	19.4	30.8	22.8	16.4	29.6
14	25.8	19.2	32.1	22.7	18.4	27.9	20.3	16.2	25.5
15	28.3	22.0	34.0	23.6	20.0	29.9	17.2	14.3	22.6
16	29.0	22.9	34.2	24.8	19.9	31.3	18.7	12.5	24.7
17	28.4	24.4	32.5	25.6	22.0	31.6	21.1	15.3	26.6
18	28.1	21.9	33.4	22.8	19.1	29.6	21.8	16.2	27.0
19	28.7	22.8	33.5	23.9	18.6	29.8	23.3	18.4	28.7
20	27.3	23.9	33.1	25.3	21.0	29.1	23.6	17.8	29.4
21	27.5	21.4	33.5	24.9	20.9	29.6	23.4	19.3	28.1
22	26.7	22.1	30.7	26.3	20.6	32.2	22.3	17.7	27.4
23	25.9	19.6	32.9	28.3	22.2	34.0	23.2	16.6	29.0
24	24.6	19.7	30.3	28.4	23.0	34.5	24.0	17.7	30.0
25	26.2	20.1	32.1	26.5	20.5	32.4	23.7	19.6	28.4
26	27.2	22.0	33.4	27.4	22.2	33.0	23.1	18.6	27.5
27	26.2	21.6	31.2	28.5	22.8	33.4	23.7	18.9	29.1
28	26.2	22.6	33.6	28.7	23.0	34.2	23.3	18.6	28.7
29	23.8	18.7	29.8	27.2	23.4	33.0	23.5	18.6	29.0
30	25.3	20.2	31.3	28.6	22.5	34.1	20.0	15.2	25.0
31	24.6	21.6	29.5	27.3	22.1	34.7			
Monthly Mean	26.9			26.4			22.5		
Monthly Min		18.7			17.8			12.5	
Monthly Max			35.3			35.8			33.0
Quarterly Mean	25.3								
Quarterly Min	12.5								
Quarterly Max	35.8								

Report Date
11/29/2011

Copper Flat - Met 1

Q3 - 2011 Quarterly Summary Report For Delta Temp (deg C)

07/01/2011 to 09/30/2011

DAY	July Mean	July Min	July Max	August Mean	August Min	August Max	September Mean	September Min	September Max
1	-0.33	-1.71	1.03	-0.40	-1.79	0.57	-0.08	-1.50	1.18
2	-0.43	-1.73	0.97	-0.29	-1.85	0.80	0.09	-1.38	1.46
3	-0.59	-1.84	0.39	-0.23	-1.60	0.67	-0.10	-1.42	0.92
4	-0.37	-1.84	0.94	-0.23	-1.48	0.76	-0.23	-1.20	0.60
5	-0.19	-1.83	1.18	-0.22	-1.45	0.85	-0.32	-1.39	0.46
6	-0.38	-1.78	0.74	-0.24	-1.71	1.15	-0.28	-1.58	0.81
7	-0.34	-1.70	1.03	-0.13	-1.48	1.22	-0.33	-1.68	0.71
8	-0.27	-1.80	1.48	-0.01	-1.39	1.46	-0.23	-1.51	1.07
9	-0.39	-1.77	0.82	0.39	-0.91	1.45	-0.29	-1.50	0.63
10	-0.39	-1.78	0.99	-0.30	-1.54	0.56	-0.25	-1.62	0.76
11	-0.35	-1.79	0.44	-0.38	-1.71	0.72	-0.13	-1.18	1.15
12	-0.34	-1.56	0.80	-0.43	-1.75	0.60	-0.11	-1.18	0.95
13	-0.30	-1.53	0.91	0.06	-1.23	0.89	-0.24	-1.54	0.69
14	-0.48	-1.92	0.67	-0.14	-1.49	1.00	-0.16	-1.05	0.45
15	-0.21	-1.87	1.59	-0.22	-1.34	1.08	-0.15	-1.71	0.77
16	-0.31	-1.70	1.34	-0.03	-1.53	1.01	0.13	-1.10	1.14
17	-0.51	-1.81	0.47	-0.04	-1.37	1.00	0.09	-1.55	1.79
18	-0.31	-1.80	1.14	0.19	-0.81	0.94	0.18	-1.28	1.57
19	-0.23	-1.53	1.12	-0.14	-1.39	0.86	0.10	-1.52	1.46
20	-0.20	-1.37	0.82	-0.21	-1.17	0.80	0.31	-1.33	1.79
21	-0.34	-1.72	0.98	-0.22	-1.44	0.97	0.10	-1.45	1.55
22	-0.28	-1.31	0.47	-0.17	-1.56	0.85	0.12	-1.59	1.68
23	-0.43	-1.57	0.40	-0.07	-1.35	1.04	0.06	-1.35	1.45
24	-0.41	-1.69	0.29	-0.20	-1.52	0.86	0.41	-1.36	1.94
25	-0.49	-1.75	0.62	-0.36	-1.59	0.64	0.10	-1.35	1.31
26	-0.54	-1.97	0.72	-0.18	-1.40	0.85	0.37	-1.23	1.70
27	-0.43	-1.50	0.43	-0.06	-1.50	1.44	0.17	-1.18	1.40
28	-0.25	-1.53	0.52	-0.06	-1.32	1.40	0.23	-1.46	1.76
29	-0.33	-1.60	0.81	0.05	-1.32	1.49	0.12	-1.32	1.65
30	-0.35	-1.87	0.93	0.14	-1.18	1.65	-0.23	-1.40	0.41
31	-0.29	-1.74	0.75	0.20	-1.42	1.70			
Monthly Mean	-0.36			-0.13			-0.02		
Monthly Min		-1.97			-1.85			-1.71	
Monthly Max			1.59			1.70			1.94
Quarterly Mean	-0.17								
Quarterly Min	-1.97								
Quarterly Max	1.94								

Report Date
11/29/2011

Copper Flat - Met 1

Q3 - 2011 Quarterly Summary Report For Net Radiation (W/m2)

07/01/2011 to 09/30/2011

DAY	July Mean	July Min	July Max	August Mean	August Min	August Max	September Mean	September Min	September Max
1	142	-147	589	126	-83	553	121	-117	563
2	140	-93	601	132	-86	597	125	-87	575
3	139	-121	583	81	-108	569	122	-112	590
4	165	-117	605	106	-69	596	115	-98	608
5	118	-96	611	87	-157	642	118	-77	548
6	138	-103	605	113	-67	597	124	-79	557
7	139	-110	577	126	-118	581	113	-73	610
8	133	-108	590	134	-109	618	105	-100	539
9	146	-88	588	-34	-92	179	90	-79	536
10	136	-102	572	97	-64	598	89	-133	559
11	97	-170	609	92	-94	572	90	-104	477
12	151	-62	656	122	-148	618	82	-79	481
13	99	-76	549	107	-106	646	103	-90	563
14	151	-98	623	119	-61	588	65	-125	457
15	148	-98	594	106	-77	446	65	-149	550
16	144	-92	590	91	-60	581	85	-71	472
17	145	-86	575	140	-60	664	102	-95	553
18	131	-94	604	40	-61	418	108	-97	553
19	101	-91	575	161	-71	654	102	-95	539
20	102	-89	570	125	-64	659	98	-101	546
21	132	-75	583	118	-71	628	84	-86	525
22	56	-71	483	131	-82	604	99	-108	540
23	150	-114	650	125	-79	600	94	-101	520
24	109	-124	575	124	-110	592	87	-109	520
25	153	-80	569	150	-67	599	52	-98	508
26	143	-85	582	127	-90	575	38	-96	418
27	115	-69	581	124	-95	569	82	-98	509
28	68	-178	545	120	-85	574	86	-106	511
29	110	-181	601	94	-176	583	80	-134	497
30	122	-86	505	96	-174	573	82	-95	478
31	85	-69	544	114	-136	574			
Monthly Mean	126			111			94		
Monthly Min		-181			-176			-149	
Monthly Max			656			664			610
Quarterly Mean	110								
Quarterly Min	-181								
Quarterly Max	664								

Report Date
11/29/2011

Copper Flat - Met 1

Q3 - 2011 Quarterly Precipitation Summary
(inches)
07/01/2011 to 09/30/2011

Day of Month	Jul Precip (inches)	Jul Sum	Jul Duration (hours)	Aug Precip (inches)	Aug Sum	Aug Duration (hours)	Sep Precip (inches)	Sep Sum	Sep Duration (hours)
1	0.00	0.00		0.00	0.00		0.05	0.05	1:00
2	0.00	0.00		0.00	0.00		0.00	0.05	
3	0.02	0.02	1:00	0.01	0.01	1:00	0.15	0.20	2:00
4	0.01	0.03	1:00	0.00	0.01		0.06	0.26	1:00
5	0.00	0.03		0.01	0.02	1:00	0.00	0.26	
6	0.00	0.03		0.00	0.02		0.00	0.26	
7	0.00	0.03		0.19	0.21	2:00	0.00	0.26	
8	0.00	0.03		0.00	0.21		0.00	0.26	
9	0.00	0.03		0.00	0.21		0.00	0.26	
10	0.00	0.03		0.00	0.21		0.04	0.30	2:00
11	0.25	0.28	4:00	0.00	0.21		0.02	0.32	2:00
12	0.00	0.28		0.41	0.62	4:00	0.00	0.32	
13	0.00	0.28		0.15	0.77	2:00	0.00	0.32	
14	0.00	0.28		0.00	0.77		0.03	0.35	2:00
15	0.00	0.28		0.01	0.78	1:00	0.31	0.66	2:00
16	0.00	0.28		0.38	1.16	2:00	0.02	0.68	2:00
17	0.00	0.28		0.01	1.17	1:00	0.00	0.68	
18	0.00	0.28		1.77	2.94	3:00	0.00	0.68	
19	0.00	0.28		0.00	2.94		0.00	0.68	
20	0.00	0.28		0.00	2.94		0.00	0.68	
21	0.00	0.28		0.00	2.94		0.00	0.68	
22	0.00	0.28		0.00	2.94		0.00	0.68	
23	0.11	0.39	2:00	0.00	2.94		0.00	0.68	
24	0.00	0.39		0.05	2.99	2:00	0.00	0.68	
25	0.00	0.39		0.00	2.99		0.00	0.68	
26	0.00	0.39		0.00	2.99		0.00	0.68	
27	0.00	0.39		0.00	2.99		0.00	0.68	
28	0.01	0.40	1:00	0.00	2.99		0.00	0.68	
29	0.02	0.42	1:00	0.02	3.01	1:00	0.00	0.68	
30	0.00	0.42		0.03	3.04	1:00	0.00	0.68	
31	0.01	0.43	1:00	0.08	3.12	2:00			
Monthly Total:	0.43		11:00	3.12		23:00	0.68		14:00
Qtrly Total:	4.23		48:00						

Report Date
11/29/2011

Copper Flat - Met 1

Q3 - 2011 Quarterly Summary Report For Relative Humidity (%)

07/01/2011 to 09/30/2011

DAY	July Mean	July Min	July Max	August Mean	August Min	August Max	September Mean	September Min	September Max
1	28.8	14.4	39.9	47.0	27.5	67.1	36.8	18.1	59.4
2	32.2	15.9	46.1	39.8	22.4	56.8	39.4	20.9	59.9
3	40.3	24.5	74.7	39.7	24.3	54.5	34.6	20.0	57.6
4	38.0	19.8	68.8	39.6	25.1	56.7	62.1	38.2	94.0
5	25.4	16.3	37.4	39.7	23.3	63.1	58.1	43.6	81.0
6	21.2	15.9	28.4	38.4	22.6	61.8	37.1	19.5	51.0
7	20.3	12.7	29.5	26.5	16.0	40.2	41.0	14.1	67.1
8	19.6	12.5	31.2	19.6	8.2	37.3	34.7	12.8	66.5
9	22.2	12.0	35.3	20.9	13.8	31.0	34.2	19.9	44.5
10	23.5	14.7	34.3	28.9	17.1	45.0	52.0	33.0	71.0
11	42.7	22.5	75.1	43.7	28.9	83.2	48.4	28.1	78.2
12	47.1	24.9	71.0	54.7	30.6	84.5	39.7	31.6	49.4
13	44.9	29.9	60.0	55.8	30.1	77.1	37.6	18.9	59.0
14	40.2	14.5	76.2	59.8	40.8	75.0	50.0	26.2	70.8
15	20.0	13.1	28.6	58.0	34.5	76.5	65.9	45.9	86.6
16	26.8	15.6	37.4	51.5	31.0	74.6	58.8	34.3	86.8
17	30.8	23.6	38.8	47.9	26.9	60.0	43.1	20.9	67.7
18	25.3	13.0	36.5	58.5	32.3	90.9	33.8	21.9	54.1
19	28.5	19.4	39.6	52.9	32.6	79.4	28.5	18.6	39.7
20	33.2	20.9	43.9	45.8	34.5	60.4	26.0	15.9	37.5
21	32.2	19.7	44.5	51.1	36.4	69.7	25.0	17.1	31.0
22	36.3	24.5	45.9	43.6	27.2	63.4	27.8	15.3	38.6
23	48.5	23.1	81.9	34.6	21.5	50.2	30.4	16.5	52.2
24	56.5	34.0	82.4	33.3	19.8	55.0	18.4	10.7	29.9
25	49.6	26.4	84.4	40.4	23.2	58.8	18.7	12.2	27.0
26	40.0	21.7	54.0	36.5	20.4	53.7	24.2	17.9	30.9
27	39.3	26.4	53.4	29.6	18.6	44.3	22.8	13.8	29.7
28	40.4	22.3	61.9	29.1	17.0	42.1	24.8	15.7	33.2
29	56.3	33.0	85.7	34.6	22.4	48.2	24.4	14.7	36.5
30	44.6	26.3	65.2	26.6	13.1	47.6	33.4	24.4	40.5
31	50.6	37.8	65.7	32.7	17.2	45.1			
Monthly Mean	35.7			40.9			37.1		
Monthly Min		12.0			8.2			10.7	
Monthly Max			85.7			90.9			94.0
Quarterly Mean	37.9								
Quarterly Min	8.2								
Quarterly Max	94.0								

Report Date
11/29/2011

Copper Flat - Met 1

Q3 - 2011 Quarterly Summary Report For Barometric Pressure
(mbars)
07/01/2011 to 09/30/2011

DAY	July Mean	July Min	July Max	August Mean	August Min	August Max	September Mean	September Min	September Max
1	849	847	850	856	853	857	839	836	841
2	851	849	853	854	851	855	838	836	840
3	852	848	854	853	851	854	838	836	840
4	851	849	853	853	852	855	842	840	844
5	851	849	853	854	852	855	843	841	845
6	852	849	854	854	852	856	842	840	843
7	851	848	853	852	850	854	843	841	845
8	849	847	851	851	850	853	845	842	847
9	848	846	850	843	833	853	842	839	844
10	849	846	850	834	832	836	842	841	844
11	850	848	852	836	834	838	845	842	846
12	851	848	853	836	835	839	846	844	847
13	850	847	851	838	836	841	843	841	845
14	849	846	851	839	837	841	841	838	842
15	848	847	850	838	836	839	841	839	842
16	849	848	851	838	837	839	841	839	843
17	852	851	854	841	839	843	841	840	843
18	854	852	856	840	837	842	844	842	846
19	853	850	855	837	835	839	844	841	846
20	851	849	852	837	836	838	841	839	843
21	850	847	851	840	838	841	842	840	844
22	850	848	851	840	838	842	844	842	846
23	852	850	853	838	837	840	845	843	847
24	854	853	856	839	837	840	842	839	844
25	854	851	856	841	839	843	840	838	841
26	850	848	852	842	840	844	840	839	842
27	851	849	852	841	839	843	842	841	844
28	852	850	853	839	837	841	843	841	844
29	855	853	856	838	836	840	843	842	847
30	856	853	857	837	835	839	847	844	850
31	856	854	858	838	836	839			
Monthly Mean	851			842			842		
Monthly Min		846			832			836	
Monthly Max			858			857			850
Quarterly Mean	845								
Quarterly Min	832								
Quarterly Max	858								

Copper Flat Met I

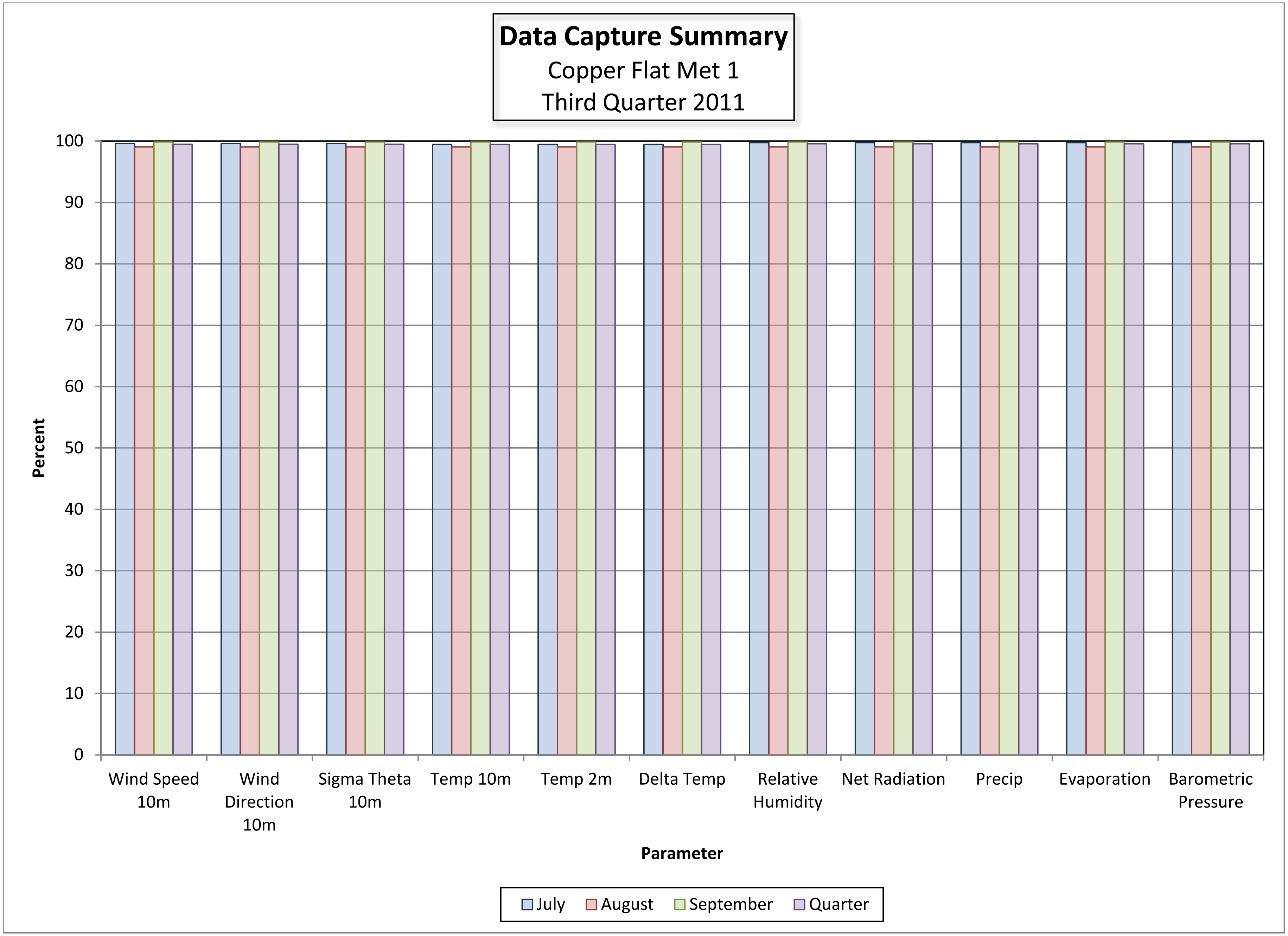
Q3 - 2011 Quarterly Summary Report for Daily Total Net Evaporation
Positive Values Indicate Evaporation
(Inches)
07/01/2011 to 09/30/2011

Day	July Daily Total	July Hourly Min	July Hourly Max	August Daily Total	August Hourly Min	August Hourly Max	September Daily Total	September Hourly Min	September Hourly Max
1	0.365	-0.003	0.087	0.26	-0.003	0.036	0.264	-0.002	0.044
2	0.387	-0.002	0.043	0.302	-0.003	0.046	0.339	0.001	0.038
3	0.331	-0.03	0.036	0.314	-0.002	0.045	0.151	-0.039	0.032
4	0.045	-0.305	0.066	0.287	-0.003	0.071	0.108	-0.002	0.027
5	0.384	-0.003	0.095	0.277	-0.001	0.044	0.15	-0.002	0.022
6	0.422	0	0.045	0.299	-0.002	0.04	0.35	0	0.053
7	0.41	-0.001	0.044	0.273	-0.088	0.042	0.299	-0.003	0.051
8	0.451	0	0.049	0.423	-0.001	0.048	0.25	-0.002	0.043
9	0.451	0	0.057	0.429	-0.002	0.191	0.213	-0.002	0.038
10	0.398	-0.004	0.045	0.277	-0.001	0.03	0.099	-0.003	0.02
11	0.155	-0.023	0.036	0.233	-0.003	0.032	0.223	-0.003	0.03
12	0.249	-0.001	0.036	-0.035	-0.185	0.036	0.25	0.001	0.03
13	0.259	-0.001	0.041	0.048	-0.082	0.051	0.277	-0.001	0.036
14	0.358	-0.003	0.041	0.182	-0.002	0.036	0.214	-0.001	0.037
15	0.43	-0.001	0.06	0.174	-0.001	0.033	-0.087	-0.153	0.023
16	0.502	0	0.055	-0.157	-0.273	0.033	0.11	-0.013	0.026
17	0.464	-0.002	0.051	0.259	-0.003	0.062	0.232	-0.002	0.032
18	0.357	-0.002	0.048	-1.373	-0.997	0.003	0.188	-0.003	0.031
19	0.292	-0.001	0.039	0.32	0	0.03	0.257	-0.008	0.039
20	0.75	-0.002	0.416	0.315	0	0.033	0.17	-0.025	0.027
21	0.317	-0.001	0.043	0.287	0.002	0.029	0.228	-0.001	0.048
22	0.203	-0.002	0.024	0.345	-0.003	0.036	0.189	-0.002	0.028
23	0.238	-0.051	0.058	0.3	-0.002	0.06	0.238	-0.001	0.032
24	0.182	-0.001	0.035	0.286	-0.012	0.037	0.201	-0.002	0.039
25	0.287	-0.002	0.039	0.32	-0.002	0.04	0.243	-0.002	0.033
26	0.391	-0.002	0.051	0.255	-0.002	0.039	0.16	-0.003	0.024
27	0.314	0	0.055	0.275	-0.002	0.034	0.222	-0.002	0.043
28	0.264	-0.003	0.04	0.265	-0.002	0.036	0.204	-0.001	0.025
29	0.254	-0.005	0.049	0.246	-0.018	0.043	0.219	-0.002	0.03
30	0.256	-0.001	0.039	-0.031	-0.266	0.034	0.217	0.005	0.028
31	0.190	-0.002	0.052	0.286	-0.002	0.051			
Monthly Total	10.356			5.941			6.178		
Monthly Min		-0.305			-0.997			-0.153	
Monthly Max			0.416			0.191			0.053
Quarterly Total	22.475								
Quarterly Min	-0.997								
Quarterly Max	0.416								

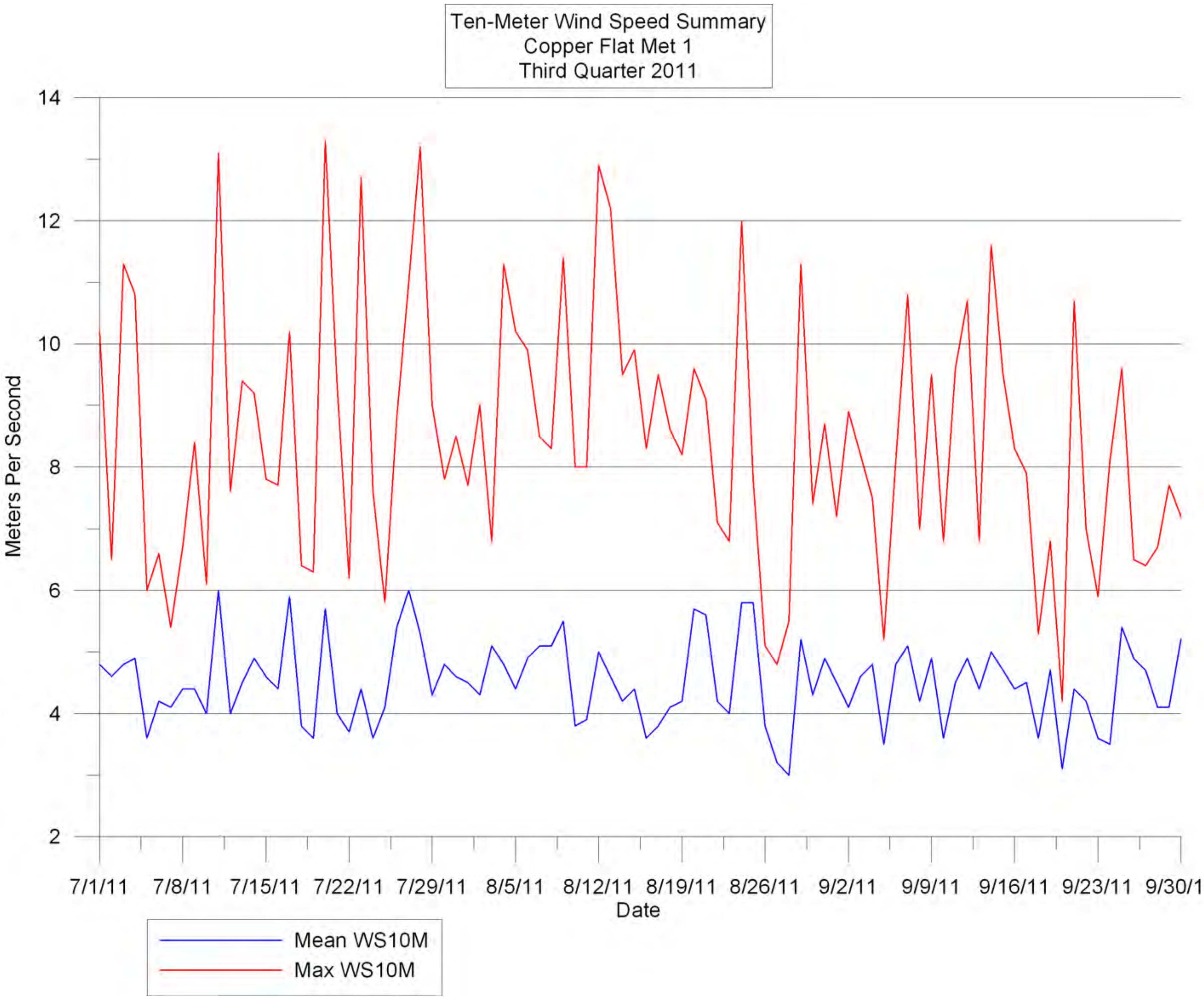
6.0 Graphical Summaries

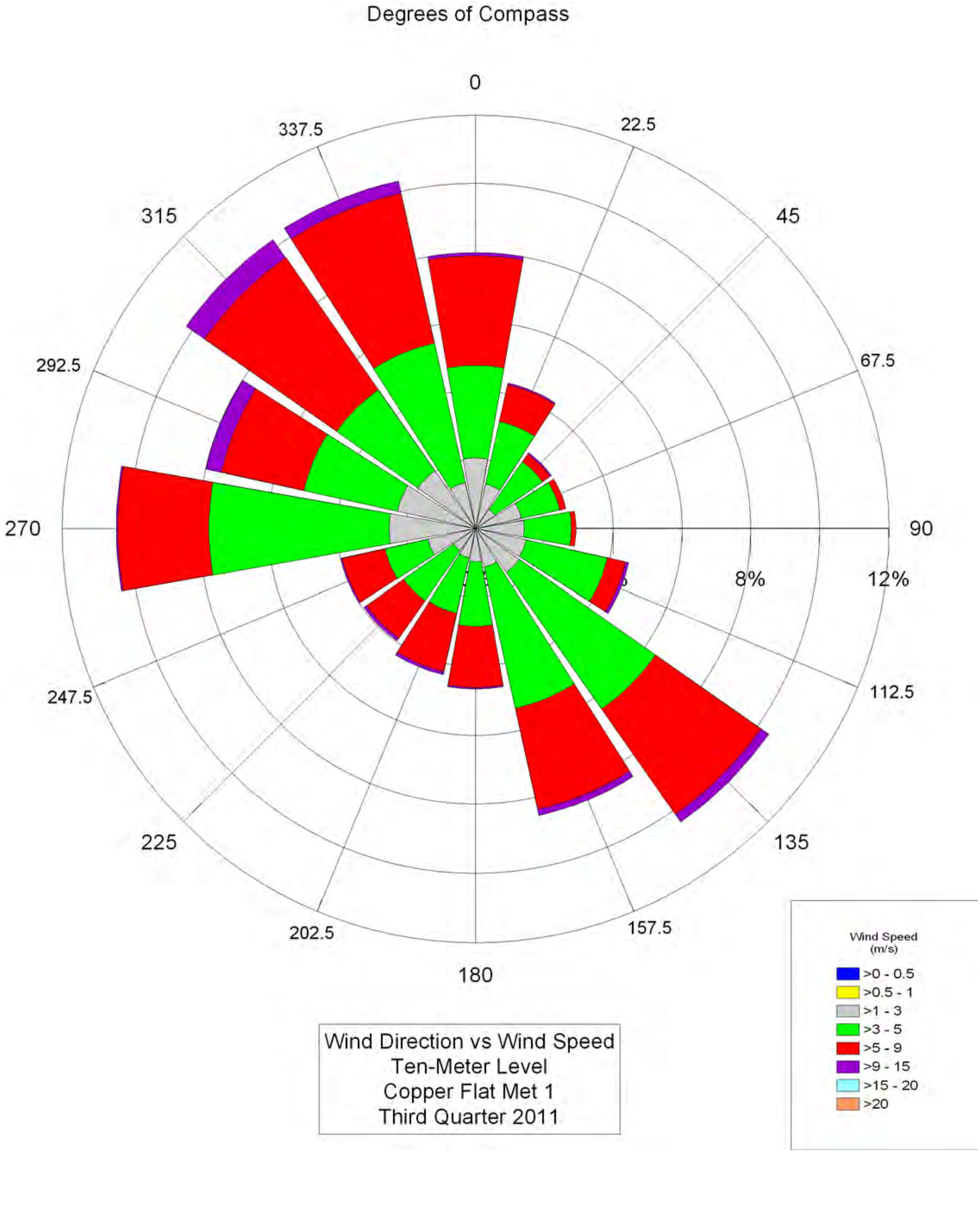
Copper Flat Met 1

Third Quarter 2011

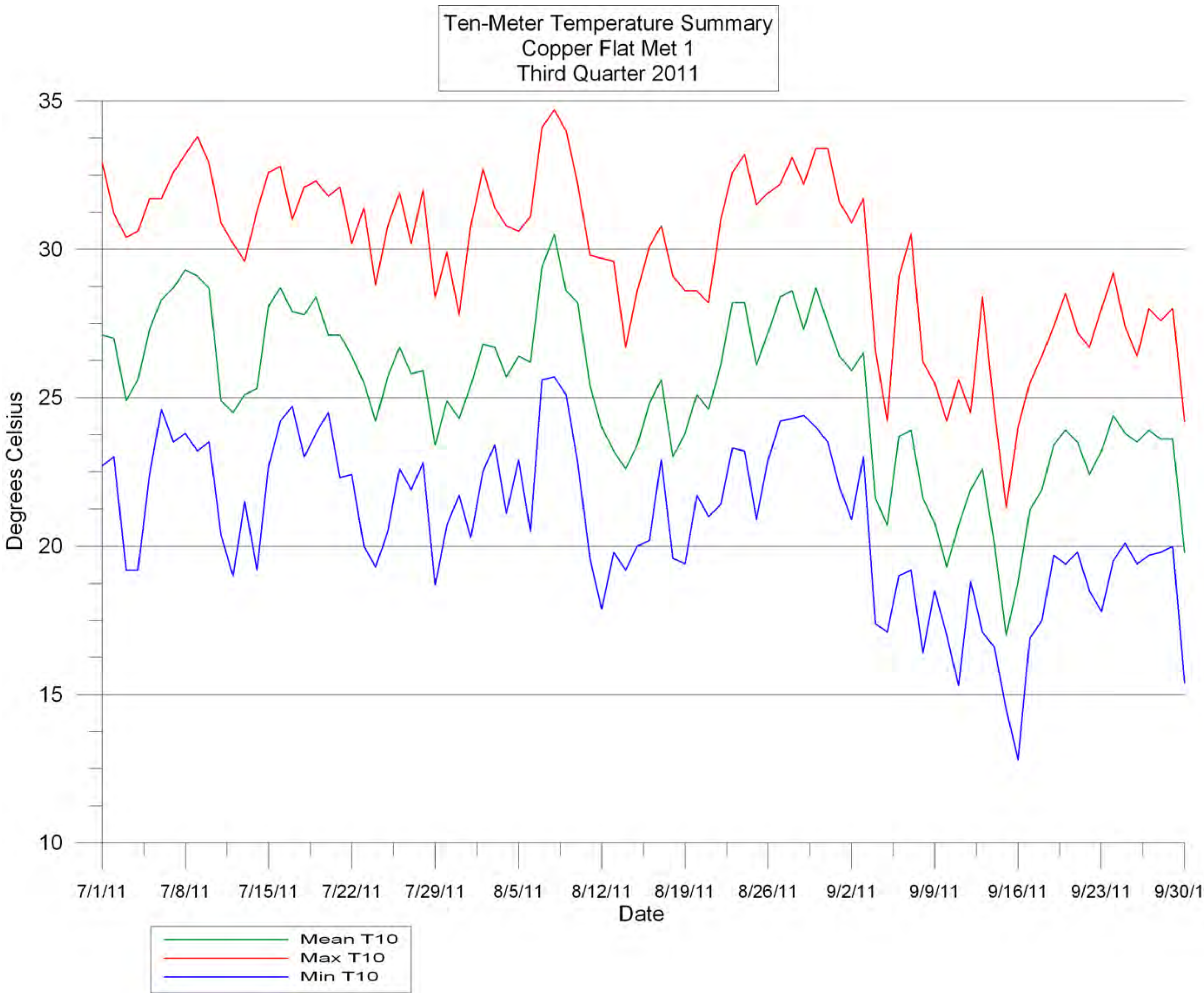


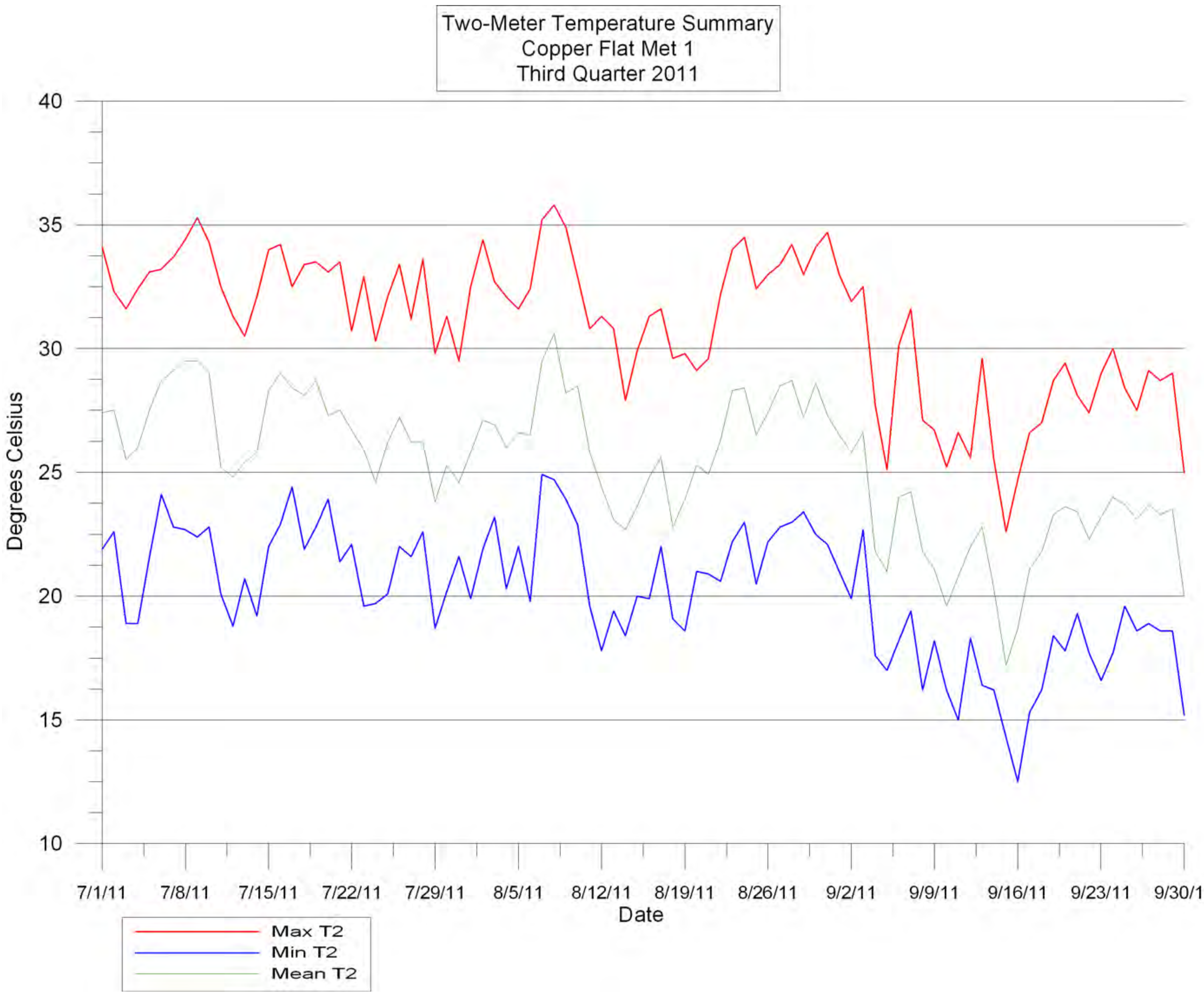
Data Capture Summary
Copper Flat Met 1
Third Quarter 2011
Percent
100
90
80
70
60
50
40
30
20
10
0
Wind Speed 10m
Wind Direction 10m
Sigma Theta 10m
Temp 10m
Temp 2m
Delta Temp
Relative Humidity
Net Radiation
Precip
Evaporation
Barometric Pressure
Parameter
July
August
September
Quarter


Ten-Meter Wind Speed Summary
Copper Flat Met 1
Third Quarter 2011
Meters Per Second
14
12
10
8
6
4
2
7/1/11
7/8/11
7/15/11
7/22/11
7/29/11
8/5/11
8/12/11
8/19/11
8/26/11
9/2/11
9/9/11
9/16/11
9/23/11
9/30/11
Date
Mean WS10M
Max WS10M



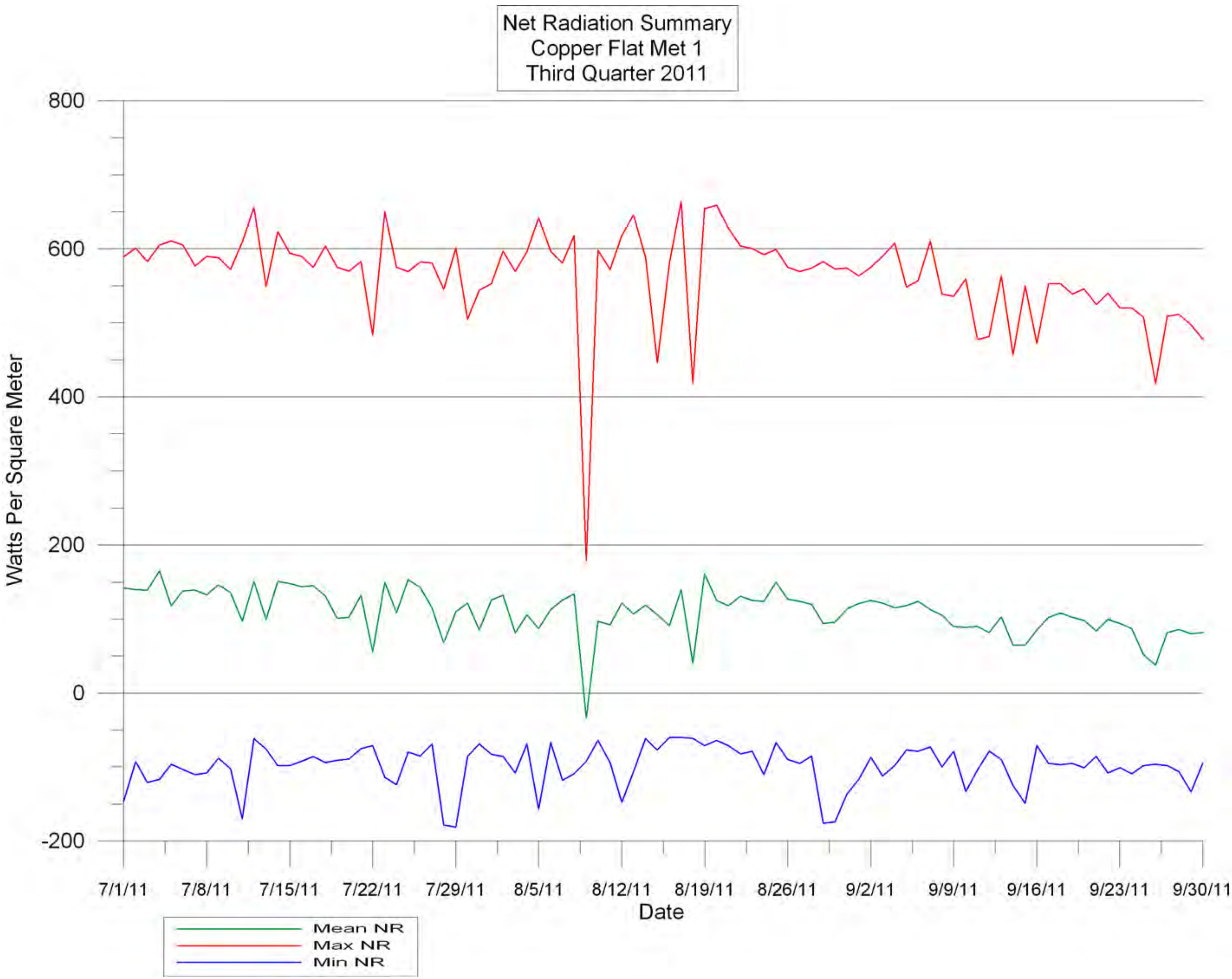
Wind Direction vs Wind Speed
Ten-Meter Level
Copper Flat Met 1
Third Quarter 2011


Ten-Meter Temperature Summary
Copper Flat Met 1
Third Quarter 2011
Degrees Celsius
35
30
25
20
15
10
7/1/11
7/8/11
7/15/11
7/22/11
7/29/11
8/5/11
8/12/11
8/19/11
8/26/11
9/2/11
9/9/11
9/16/11
9/23/11
9/30/11
Date
Mean T10
Max T10
Min T10

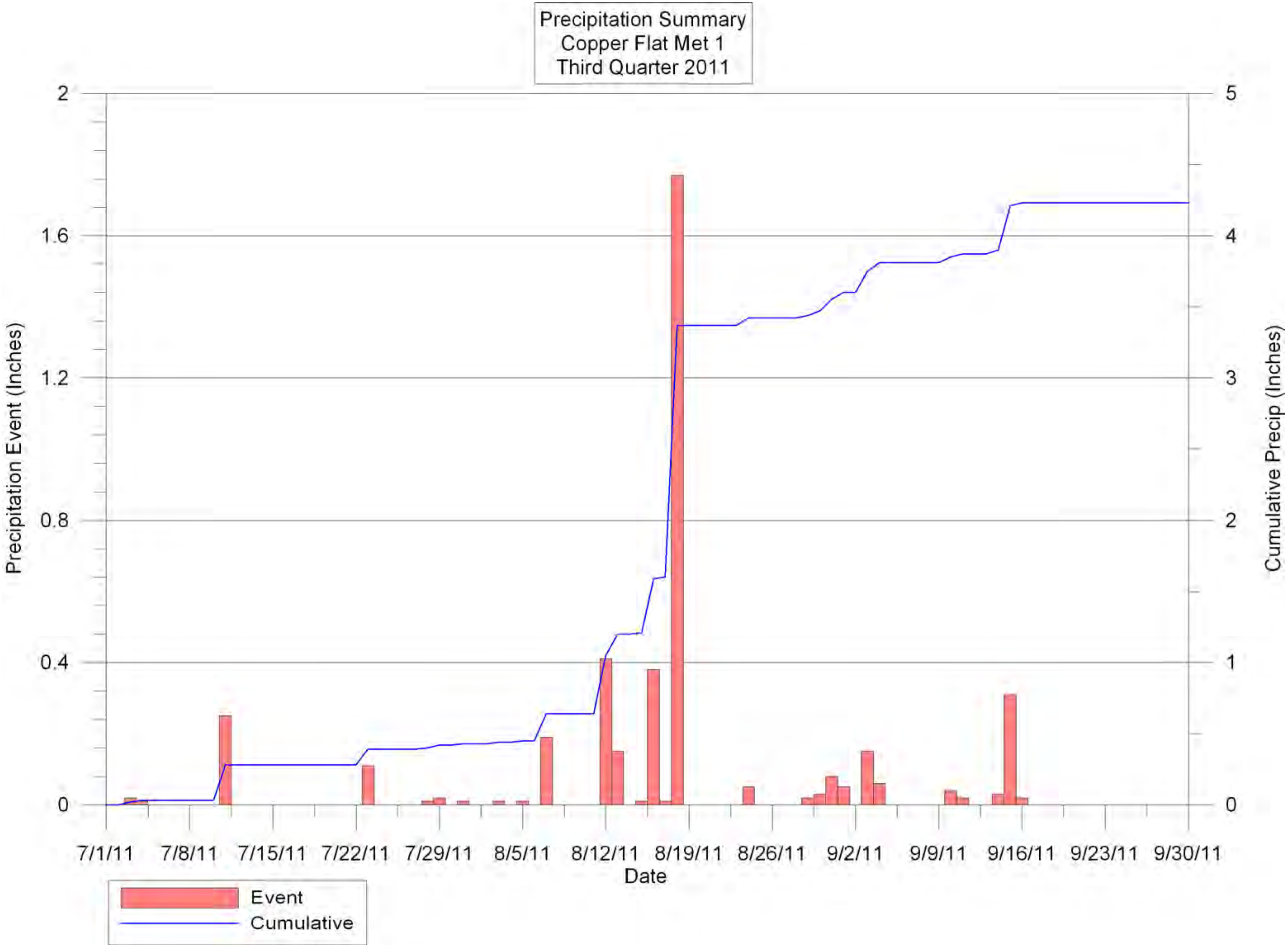


Two-Meter Temperature Summary
Copper Flat Met 1
Third Quarter 2011
40
35
30
25
20
15
10
Degrees Celsius
7/1/11
7/8/11
7/15/11
7/22/11
7/29/11
8/5/11
8/12/11
8/19/11
8/26/11
9/2/11
9/9/11
9/16/11
9/23/11
9/30/11
Date
Max T2
Min T2
Mean T2

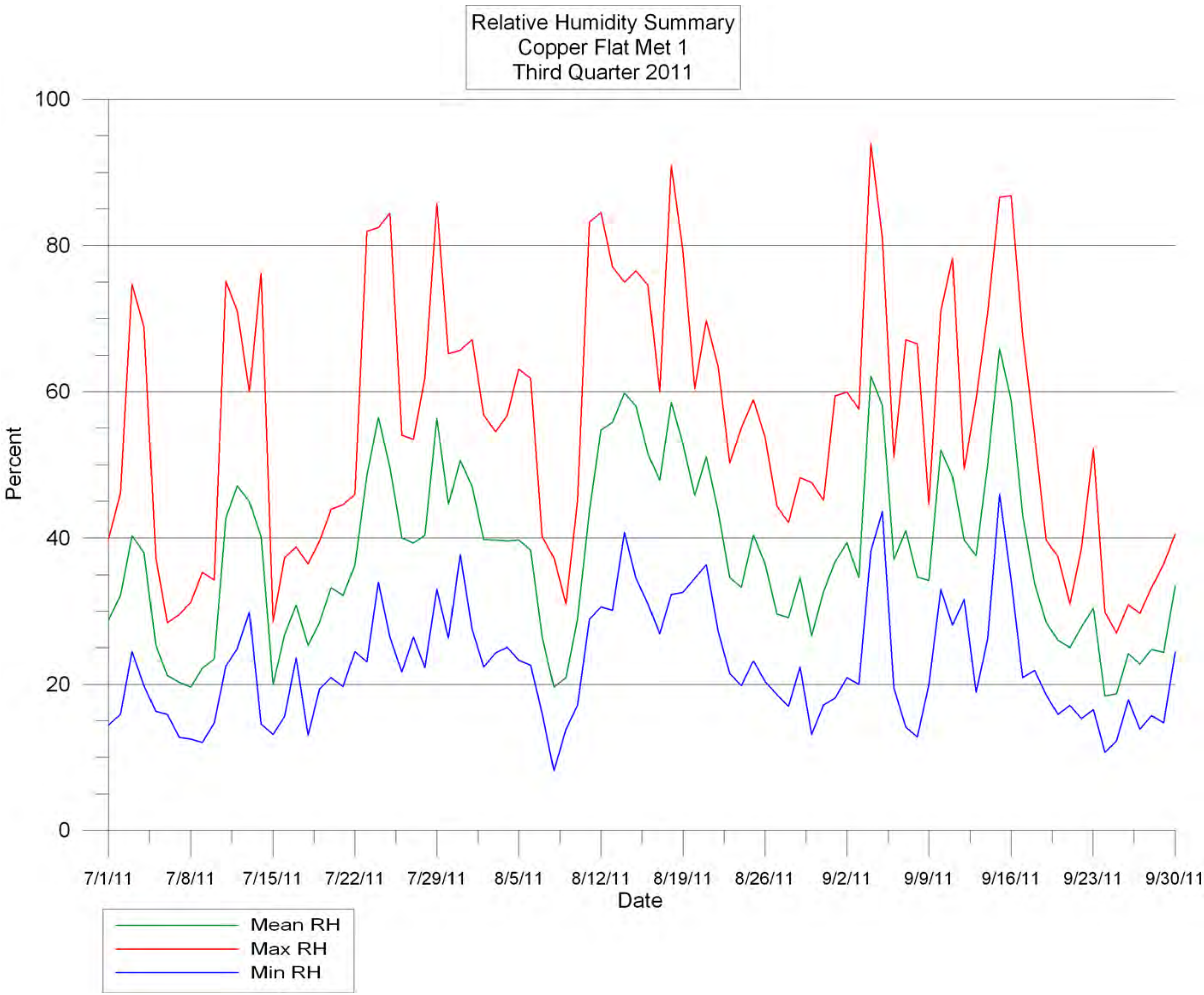

Delta Temperature Summary
Copper Flat Met 1
Third Quarter 2011
Degrees Celsius
2
1
0
-1
-2
7/1/11
7/8/11
7/15/11
7/22/11
7/29/11
8/5/11
8/12/11
8/19/11
8/26/11
9/2/11
9/9/11
9/16/11
9/23/11
9/30/11
Date
Mean DT
Max DT
Min DT

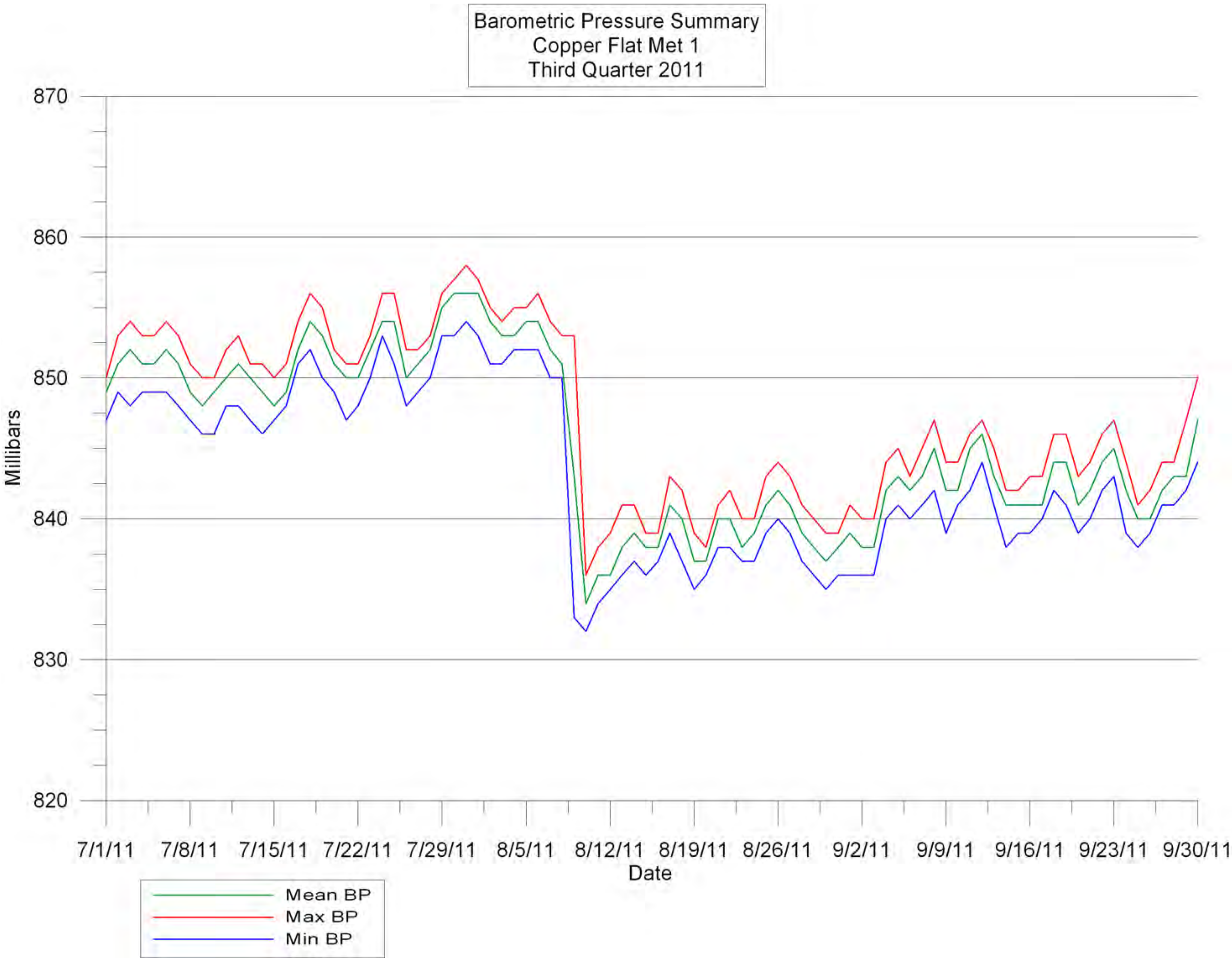


Net Radiation Summary
Copper Flat Met 1
Third Quarter 2011
800
600
400
200
0
-200
Watts Per Square Meter
7/1/11
7/8/11
7/15/11
7/22/11
7/29/11
8/5/11
8/12/11
8/19/11
8/26/11
9/2/11
9/9/11
9/16/11
9/23/11
9/30/11
Date
Mean NR
Max NR
Min NR

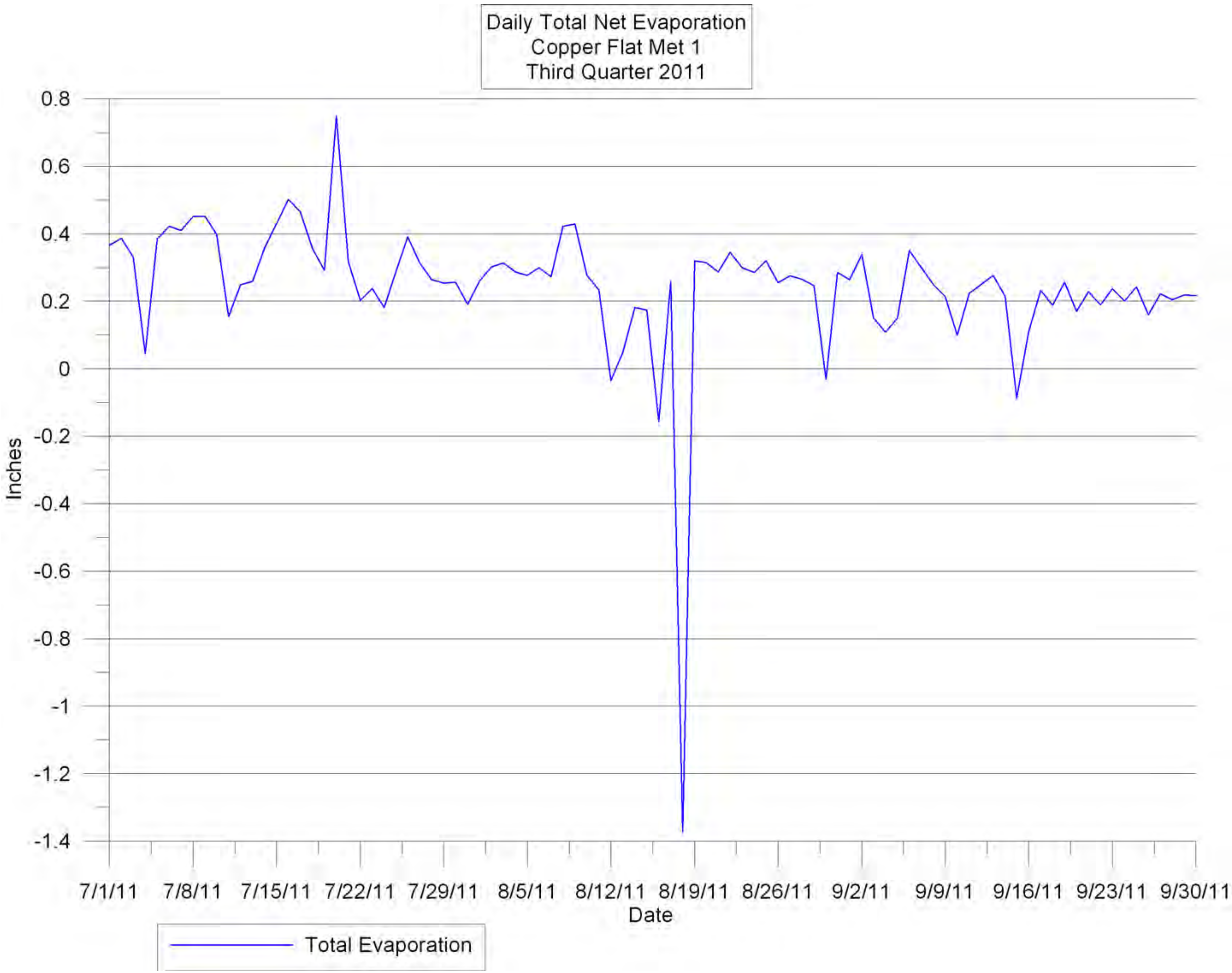


Precipitation Summary
Copper Flat Met 1
Third Quarter 2011
Precipitation Event (Inches)
Cumulative Precip (Inches)
2
1.6
1.2
0.8
0.4
0
5
4
3
2
1
0
7/1/11
7/8/11
7/15/11
7/22/11
7/29/11
8/5/11
8/12/11
8/19/11
8/26/11
9/2/11
9/9/11
9/16/11
9/23/11
9/30/11
Date
Event
Cumulative

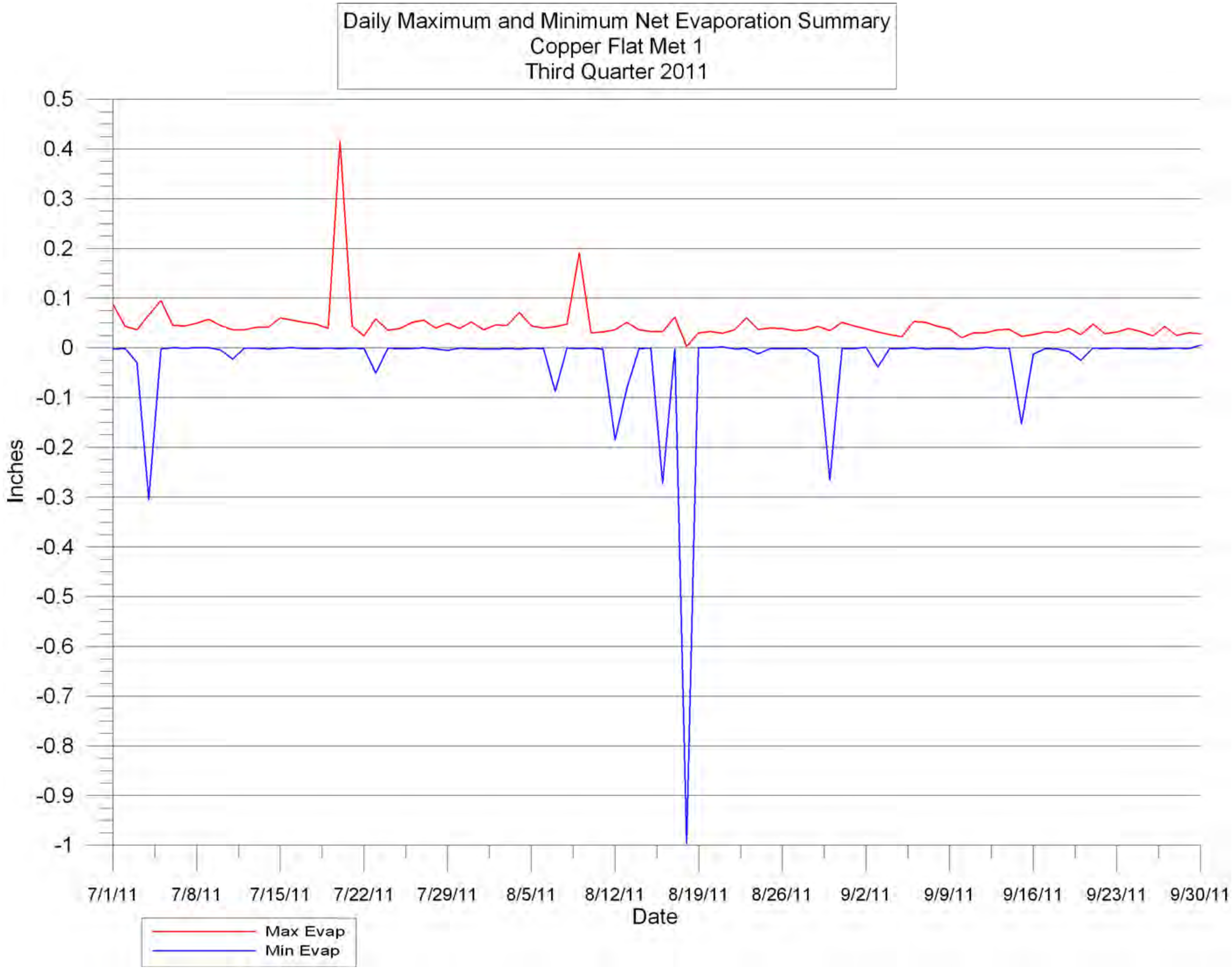

Relative Humidity Summary
Copper Flat Met 1
Third Quarter 2011
100
80
60
40
20
0
Percent
7/1/11
7/8/11
7/15/11
7/22/11
7/29/11
8/5/11
8/12/11
8/19/11
8/26/11
9/2/11
9/9/11
9/16/11
9/23/11
9/30/11
Date
Mean RH
Max RH
Min RH



Barometric Pressure Summary
Copper Flat Met 1
Third Quarter 2011
870
860
850
840
830
820
Millibars
7/1/11
7/8/11
7/15/11
7/22/11
7/29/11
8/5/11
8/12/11
8/19/11
8/26/11
9/2/11
9/9/11
9/16/11
9/23/11
9/30/11
Date
Mean BP
Max BP
Min BP



Daily Total Net Evaporation
Copper Flat Met 1
Third Quarter 2011
Inches
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
7/1/11
7/8/11
7/15/11
7/22/11
7/29/11
8/5/11
8/12/11
8/19/11
8/26/11
9/2/11
9/9/11
9/16/11
9/23/11
9/30/11
Date
Total Evaporation



Daily Maximum and Minimum Net Evaporation Summary
Copper Flat Met 1
Third Quarter 2011
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1
Inches
7/1/11
7/8/11
7/15/11
7/22/11
7/29/11
8/5/11
8/12/11
8/19/11
8/26/11
9/2/11
9/9/11
9/16/11
9/23/11
9/30/11
Date
Max Evap
Min Evap

Appendix 2-B

Air Quality PM_{10} Monitoring Quarterly Reports

New Mexico Copper Corporation

Copper Flat Mine

Air Monitoring Program Quarterly Report
for
Particulate Samplers

Third Quarter 2010
(July through September)

Prepared By:

Class One Technical Services, Inc.
3500 Comanche Rd NE, Suite G
Albuquerque, New Mexico 87107

November 21, 2010

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New Mexico Copper Corporation – Copper Flat Mine
Third Quarter 2010 Particulate Report

Executive Summary

Data capture for Third Quarter 2010 ranged from fifty (50) percent at Site 2 to ninety (90) percent at Site 1. Sampler Site 2 had five invalid runs on 08/10/10, 08/18/10, 08/24/10, 08/30/10 and 09/05/10 due to a dead batter at the sampler. Site 1 had one invalid run on 08/12/10 due to the sampler not running as scheduled.

The Federal 24-hour PM_{10} standard of 150 $\mu g/m^3$ was not exceeded during Third Quarter 2010. The highest PM_{10} concentration of 49$\mu g/m^3$ was recorded on 09/17/10, by sampler Site 2. The second highest concentration of 15 $\mu g/m^3$ was recorded on 09/05/10 by Site 1.

The table below summarizes the percent data capture and maximum particulate concentrations recorded during Third Quarter 2010 for each sampler.

Sampler	Parameter	24-Hour Max Conc. ($\mu g/m^3$)	Date of Maximum Concentration	Quarterly Percent Data Capture
Site 1	PM_{10}	15	09/05/10	90
SH02	PM_{10}	49	09/17/10	50

Note: Federal 24-Hour PM_{10} Standard: 150 $\mu g/m^3$

New Mexico Copper Corporation – Copper Flat Mine
Third Quarter 2010 Particulate Report

Introduction

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. During Third Quarter 2010, Class One Technical Services (CTS) conducted quality assurance, instrument repair (as requested), data reduction, and data reporting for each particulate sampler. The daily operations such as filter changes, mass flow readings, flow checks, and general instrument checks were handled entirely by New Mexico Copper Corporation, Copper Flat environmental quality staff. The samplers initiated operations on August 6, 2010.

Each sampler runs once every six days for a full twenty-four hour period from midnight to midnight. All samplers run simultaneously.

During quarterly sampler flow checks, flow rate is adjusted to be within five (5) percent of 16.67 litres 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 (Q_{ACT}).

Actual flow rates are converted into standard flow rates (Q_{STD}) at standard temperature (298 °K) 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 Q_{ACT} and Q_{STD} together with net weight gain are used to determine the 24-hour particulate concentration in micrograms per cubic meter ($\mu g/m^3$).

PM_{10} concentrations based on standard flow rates are reported to comply with the National Ambient Air Quality Standards (NAAQS) promulgated in December 2006. The Environmental Protection Agency implemented the new standard January 1, 2007.

PM_{10}

USEPA Quality Assurance Handbook for Air Pollution Measurement Systems: Volume II, Ambient Air Specific Methods (Section 2.11.0, April 1989) and 40 CFR Part 50, Appendix K (Revised July 1997).

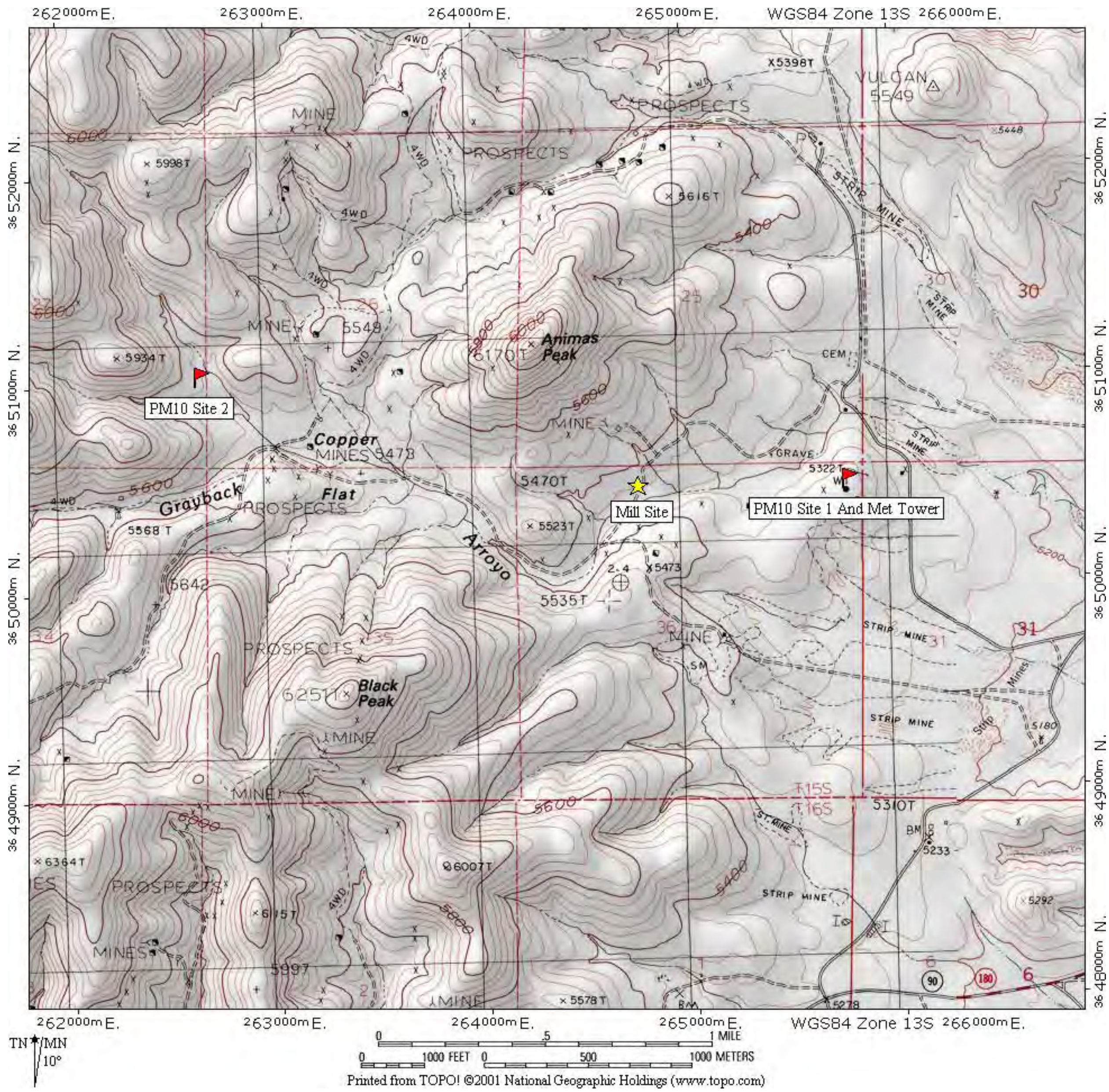
New Mexico Copper Corporation – Copper Flat Mine
Third Quarter 2010 Particulate Report

Copper Flat Mine Particulate Samplers
Coordinates and Elevations

Sampler	Coordinates	Elevation (ft.)
Site 1 (PM_{10})	UTM Coordinates: Easting 265,721 meters Northing 3,650,419 meters	5402
SH02 (PM_{10})	UTM Coordinates: Easting 262,618 meters Northing 3,651,000 meters	5596

Note: Coordinates taken with portable GPS unit set in the NAD 83 mode.

Figure 1: Map of Particulate Sampler Locations



Site 1 PM_{10} Particulate Data Summary

Run Date	Q_{ACT} (cmm)[1]	Filter Pre Weight (g)	Filter Post Weight (g)	24 Hour Q_{ACT} Concentration (ug/m^3)	24 Hour Q_{STD} Concentration (ug/m^3)
8/6/10	16.73	0.145366	0.145624	11	13
8/12/10	16.96	0.146491	0.146565	I(1)	I(1)
8/18/10	16.79	0.146169	0.146357	8	10
8/24/10	16.56	0.148676	0.148910	10	12
8/30/10	16.62	0.147224	0.147423	8	10
9/5/10	16.79	0.146243	0.146540	12	15
9/11/10	16.68	0.148182	0.148426	10	13
9/17/10	16.62	0.144214	0.124536	6	7
9/23/10	16.56	0.145360	0.145557	8	10
9/29/10	16.84	0.144612	0.144810	8	10

[1]Acceptable Actual Flow Rates (Q_{ACT}) for PM_{10}: 15.0 to 18.4 liters per minute (lpm)

I(1) represents invalid or missing data. The number in parentheses refers to the listing under the "Data Capture Summary" heading for Site 1.

	Actual Arithmetic Mean (µg/m^3)	Standard Arithmetic Mean (µg/m^3)	Data Capture (percent)
August	9.3	11.3	80
September	8.8	11.0	100
Quarter	***9.0***	***11.1***	***90***

New Mexico Copper Corporation – Copper Flat Mine
Third Quarter 2010 Particulate Report

Quarterly PM_{10} Calculations
Sampler Site 1

Number of Days in the Quarter (N): 92

Number of Strata with Samples (M): 9

Number of Observed Exceedances by Stratum

Stratum #	Observed Exceedances (V)
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0

New Mexico Copper Corporation – Copper Flat Mine
Third Quarter 2010 Particulate Report

Quarterly PM_{10} Calculations
Sampler Site 1

Number of Actual Samples by Stratum

Stratum#	Number of samples (K)
1	1
2	1
3	1
4	1
5	1
6	1
7	1
8	1
9	1

Expected Number of Exceedances for the Quarter: 0

$e_q = V_q [N_q / n_q]$

e_q= Expected number of exceedances for the quarter

$V_{q=}$ Observed number of exceedances

$N_{q=}$ Number of days in quarter

n_q= Number of days in quarter with PM_{10} data

Percent Data Capture for the Quarter: 90

References: 40 CFR Part 50, Appendix K (Revised June 18, 1997)
40 CFR Part 58, Appendix B

New Mexico Copper Corporation – Copper Flat Mine
Third Quarter 2010 Particulate Report

High Volume Sampler Operations and Data Capture Summary

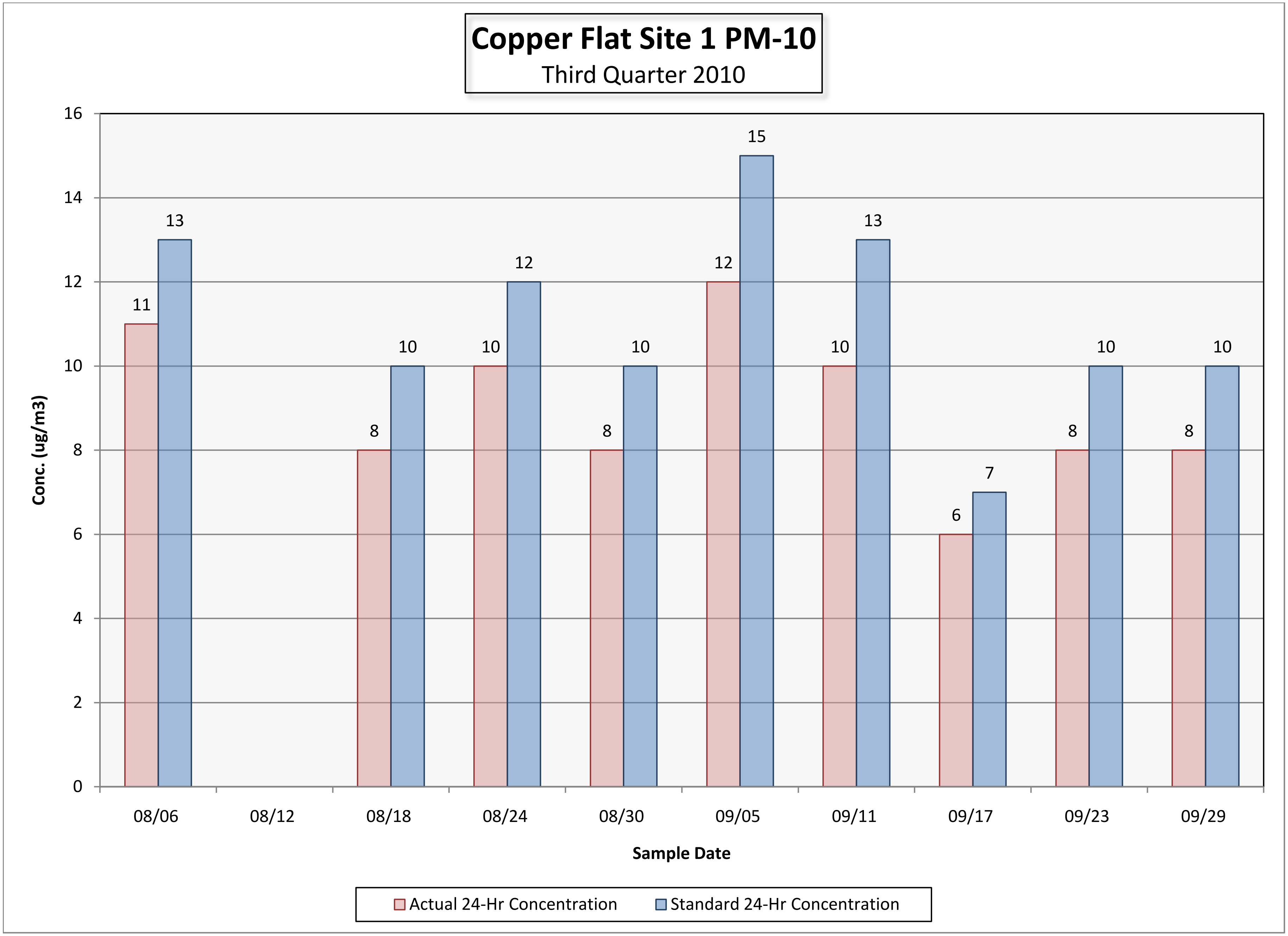
Sampler Site 1

Operations Summary

1) A site visit was performed on 08/03/10 to set-up sampler for initial run and perform a flow check.

Data Capture Summary

1) Sampler Site 1 had one invalid run on 08/12/10 due to the sampler not running as scheduled.


Copper Flat Site 1 PM-10
Third Quarter 2010
Conc. (ug/m3)
0
2
4
6
8
10
12
14
16
11
13
8
10
10
12
8
10
12
15
10
13
6
7
8
10
8
10
08/06
08/12
08/18
08/24
08/30
09/05
09/11
09/17
09/23
09/29
Sample Date
Actual 24-Hr Concentration
Standard 24-Hr Concentration

New Mexico Copper Corporation – Copper Flat Mine
Third Quarter 2010 Particulate Report

Site 2 PM_{10} Particulate Data Summary

Run Date	Q_{ACT} (cmm)[1]	Filter Pre Weight (g)	Filter Post Weight (g)	24 Hour Q_{ACT} Concentration (ug/m^3)	24 Hour Q_{STD} Concentration (ug/m^3)
8/6/10	16.71	0.147144	0.147348	8	11
8/12/10	16.93	0.145643	0.145726	I(1)	I(1)
8/18/10	16.73	0.100000	0.100000	I(1)	I(1)
8/24/10	16.54	0.100000	0.100000	I(1)	I(1)
8/30/10	16.59	0.100000	0.100000	I(1)	I(1)
9/5/10	16.76	0.100000	0.100000	I(1)	I(1)
9/11/10	16.65	0.144864	0.145107	10	13
9/17/10	16.59	0.144422	0.145374	40	49
9/23/10	16.54	0.145806	0.146000	8	10
9/29/10	16.82	0.144046	0.144227	7	9

[1] Acceptable Actual Flow Rates (Q_{ACT}) for PM_{10}: 15.0 to 18.4 liters per minute (lpm)

I(1) represents invalid or missing data. The number in parentheses refers to the listing under the "Data Capture Summary" heading for Site 2.

	Actual Arithmetic Mean ($\mu g/m^3$)	Standard Arithmetic Mean ($\mu g/m^3$)	Data Capture (percent)
August	8.0	11.0	20
September	16.3	20.3	80
Quarter	***14.6***	***18.4***	***50***

New Mexico Copper Corporation – Copper Flat Mine
Third Quarter 2010 Particulate Report

Quarterly PM_{10} Calculations
Sampler Site 2

Number of Days in the Quarter (N): 92

Number of Strata with Samples (M): 5

Number of Observed Exceedances by Stratum

Stratum #	Observed Exceedances (V)
1	0
2	0
3	0
4	0
5	0

New Mexico Copper Corporation – Copper Flat Mine
Third Quarter 2010 Particulate Report

Quarterly PM_{10} Calculations
Sampler Site 2

Number of Actual Samples by Stratum

Stratum#	Number of samples (K)
1	1
2	1
3	1
4	1
5	1

Expected Number of Exceedances for the Quarter: 0.0

$e_q = V_q [N_q / n_q]$

e_q= Expected number of exceedances for the quarter

$V_{q=}$ Observed number of exceedances

$N_{q=}$ Number of days in quarter

n_q= Number of days in quarter with PM_{10} data

Percent Data Capture for the Quarter: 50

References: 40 CFR Part 50, Appendix K (Revised June 18, 1997)
40 CFR Part 58, Appendix B

New Mexico Copper Corporation – Copper Flat Mine
Third Quarter 2010 Particulate Report

High Volume Sampler Operations and Data Capture Summary

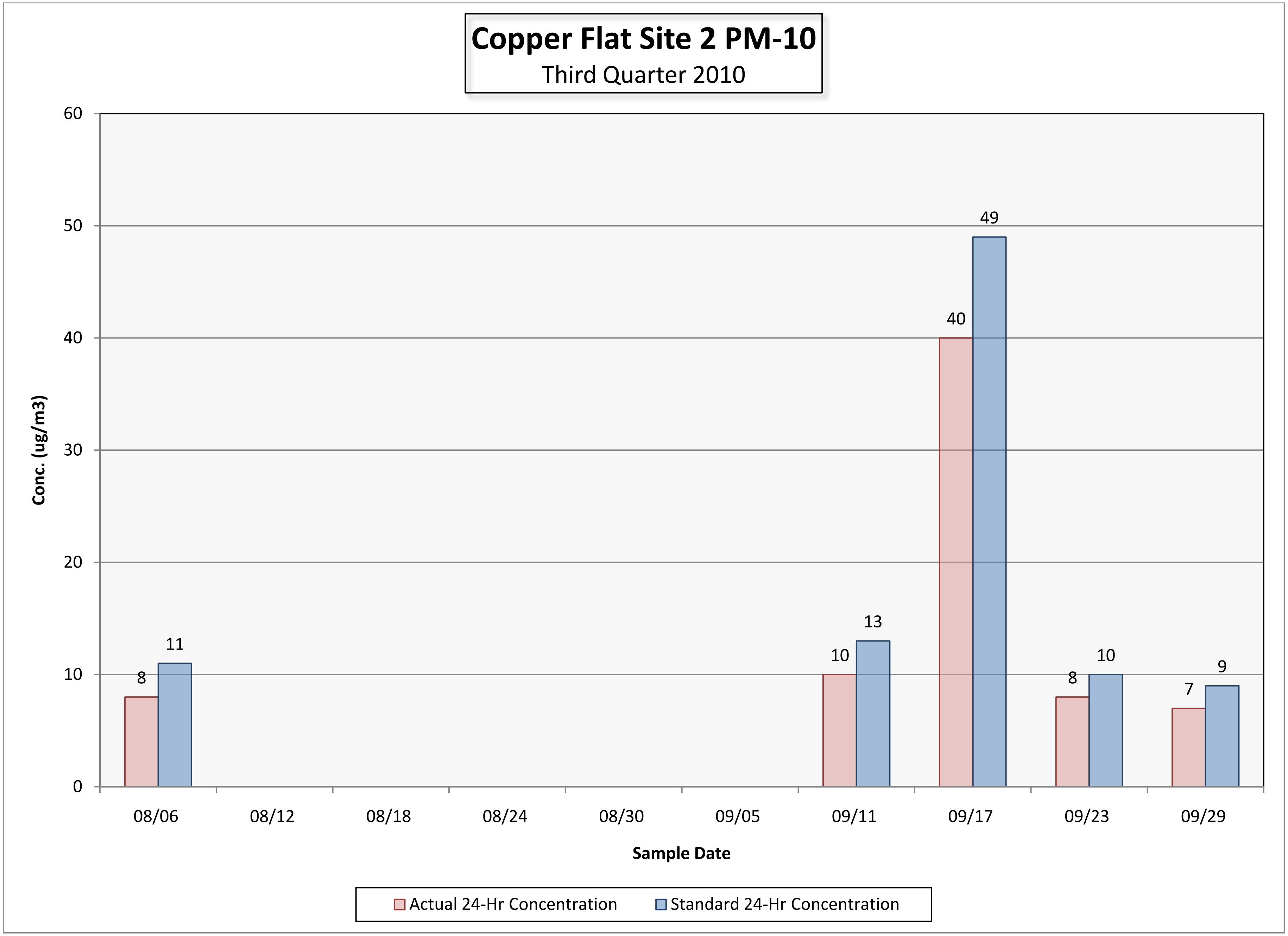
Sampler Site 2

Operations Summary

1) A site visit was performed on 08/03/10 to set-up sampler for initial run and perform a flow check.

Data Capture Summary

1) Sampler run dates 08/12/10, 08/18/10, 08/24/10, 08/30/10 and 09/05/10 were invalidated due to a dead battery at the sampler, causing the sampler to be inoperable.


Copper Flat Site 2 PM-10
Third Quarter 2010
Conc. (ug/m3)
0
10
20
30
40
50
60
8
11
10
13
40
49
8
10
7
9
08/06
08/12
08/18
08/24
08/30
09/05
09/11
09/17
09/23
09/29
Sample Date
Actual 24-Hr Concentration
Standard 24-Hr Concentration

Appendix A

Monthly Particulate Data Reports

New Mexico Copper Corporation - Copper Flat Mine
Particulate Matter 10 Micron (PM10) Report
Micrograms per Cubic Meter

Report Period: Third Quarter 2010

Sampler Site 1

Sample Day	Filter #	Start Weight (grams)	End Weight (grams)	Sample Time (min)	Ambient Temperature (C)	Actual Flow (lpm)	Standard Flow (slpm)	PM10 Actual (ug/m3)	PM10 Standard (ug/m3)	Valid Sample	Comments
8/6/2010	1	.145366	.145624	1440	24	16.73	13.45	11	13	☐	First Successfully Completed Run
8/12/2010	4	.146491	.146565	1	28	16.96	13.45	4364	5501	☑	Sampler Did Not Run
8/18/2010	5	.146169	.146357	1440	25	16.79	13.45	8	10	☐	
8/24/2010	6	.148676	.148910	1440	21	16.56	13.45	10	12	☐	
8/30/2010	7	.147224	.147423	1440	22	16.62	13.45	8	10	☐	
9/5/2010	8	.146243	.146540	1440	25	16.79	13.45	12	15	☐	
9/11/2010	9	.148182	.148426	1440	23	16.68	13.45	10	13	☐	
9/17/2010	11	.144214	.144358	1440	22	16.62	13.45	6	7	☐	
9/23/2010	14	.145360	.145557	1440	21	16.56	13.45	8	10	☐	
9/29/2010	15	.144612	.144810	1440	26	16.84	13.45	8	10	☐	

New Mexico Copper Corporation - Copper Flat Mine
Particulate Matter 10 Micron (PM10) Report
Micrograms per Cubic Meter

Report Period: Third Quarter 2010

Sampler Site 2

Sample Day	Filter #	Start Weight (grams)	End Weight (grams)	Sample Time (min)	Ambient Temperature (C)	Actual Flow (lpm)	Standard Flow (slpm)	PM10 Actual (ug/m3)	PM10 Standard (ug/m3)	Valid Sample	Comments
8/6/2010	2	.147144	.147348	1440	24	16.71	13.43	8	11	☐	First Successfully Completed Run at Sampler
8/12/2010	3	.145643	.145725	1	28	16.93	13.43	4843	6105	☑	No Run, Sampler Battery Dead
8/18/2010	0	.100000	.100000	1	25	16.76	13.43			☑	No Run, Sampler Battery Dead
8/24/2010	0	.100000	.100000	1	21	16.54	13.43			☑	No Run, Sampler Battery Dead
8/30/2010	0	.100000	.100000	1	22	16.59	13.43			☑	No Run, Sampler Battery Dead
9/5/2010	0	.100000	.100000	1	25	16.76	13.43			☑	No Run, Sampler Battery Dead
9/11/2010	10	.144864	.145107	1440	23	16.65	13.43	10	13	☐	
9/17/2010	12	.144422	.145374	1440	22	16.59	13.43	40	49	☐	
9/23/2010	13	.145806	.146000	1440	21	16.54	13.43	8	10	☐	
9/29/2010	16	.144046	.144227	1440	26	16.82	13.43	7	9	☐	

New Mexico Copper Corporation

Copper Flat Mine

Air Monitoring Program Quarterly Report
for
Particulate Samplers

Fourth Quarter 2010
(October through December)

Prepared By:

Class One Technical Services, Inc.
3500 Comanche Rd NE, Suite G
Albuquerque, New Mexico 87107

March 21, 2011

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New Mexico Copper Corporation – Copper Flat Mine
Fourth Quarter 2010 Particulate Report

Executive Summary

Data capture for Fourth Quarter 2010 was ninety-three (93) percent at both Site 1 and Site 2. Site 1 had one invalid run on 10/23/10 due to a run time that was too long, 4875 minutes. Site 2 had one invalid run on 12/28/10 due to a run time that was too short, 808 minutes. Optimum run time at both sites is between 1380 and 1500 minutes.

The Federal 24-hour PM_{10} standard of 150 $\mu g/m^3$ was not exceeded during Fourth Quarter 2010. The highest PM_{10} concentration of 52$\mu g/m^3$ was recorded on 10/29/10, by sampler Site 2. The second highest concentration of 31$\mu g/m^3$ was recorded on 11/28/10 by Site 1.

The table below summarizes the percent data capture and maximum particulate concentrations recorded during Fourth Quarter 2010 for each sampler.

Sampler	Parameter	24-Hour Max Conc. ($\mu g/m^3$)	Date of Maximum Concentration	Quarterly Percent Data Capture
Site 1	PM_{10}	31	11/28/10	93
Site 2	PM_{10}	52	10/29/10	93

Note: Federal 24-Hour PM_{10} Standard: 150 $\mu g/m^3$

New Mexico Copper Corporation – Copper Flat Mine
Fourth Quarter 2010 Particulate Report

Introduction

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. During Fourth Quarter 2010, Class One Technical Services (CTS) conducted quality assurance, instrument repair (as requested), data reduction, and data reporting for each particulate sampler. The daily operations such as filter changes, mass flow readings, flow checks, and general instrument checks were handled entirely by New Mexico Copper Corporation, Copper Flat environmental quality staff. The samplers initiated operations on August 6, 2010.

Each sampler runs once every six days for a full twenty-four hour period from midnight to midnight. All samplers run simultaneously.

During quarterly sampler flow checks, flow rate is adjusted to be within five (5) percent of 16.67 litres 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 (Q_{ACT}).

Actual flow rates are converted into standard flow rates (Q_{STD}) at standard temperature (298 °K) 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 Q_{ACT} and Q_{STD} together with net weight gain are used to determine the 24-hour particulate concentration in micrograms per cubic meter ($\mu g/m^3$).

PM_{10} concentrations based on standard flow rates are reported to comply with the National Ambient Air Quality Standards (NAAQS) promulgated in December 2006. The Environmental Protection Agency implemented the new standard January 1, 2007.

PM_{10}

USEPA Quality Assurance Handbook for Air Pollution Measurement Systems: Volume II, Ambient Air Specific Methods (Section 2.11.0, April 1989) and 40 CFR Part 50, Appendix K (Revised July 1997).

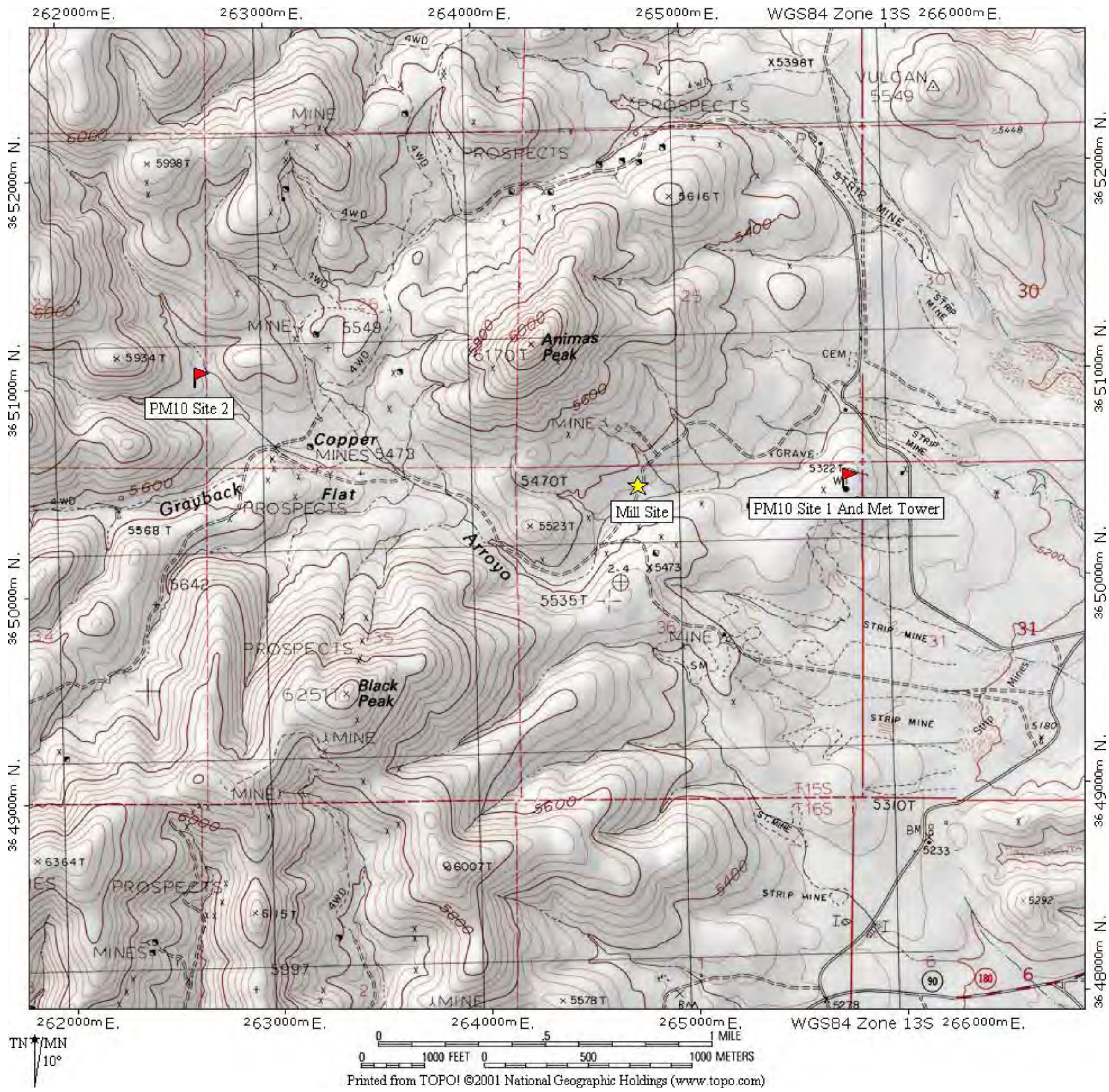
New Mexico Copper Corporation – Copper Flat Mine
Fourth Quarter 2010 Particulate Report

Copper Flat Mine Particulate Samplers
Coordinates and Elevations

Sampler	Coordinates	Elevation (ft.)
Site 1 (PM_{10})	UTM Coordinates: Easting 265,721 meters Northing 3,650,419 meters	5402
SH02 (PM_{10})	UTM Coordinates: Easting 262,618 meters Northing 3,651,000 meters	5596

Note: Coordinates taken with portable GPS unit set in the NAD 83 mode.

Figure 1: Map of Particulate Sampler Locations



New Mexico Copper Corporation – Copper Flat Mine
Fourth Quarter 2010 Particulate Report

Site 1 PM_{10} Particulate Data Summary

Run Date	Q_{ACT} (cmm)[1]	Filter Pre Weight (g)	Filter Post Weight (g)	24 Hour Q_{ACT} Concentration (ug/m³)	24 Hour Q_{STD} Concentration (ug/m³)
10/5/10	16.28	0.144126	0.144318	8	10
10/11/10	16.39	0.146096	0.146312	9	11
10/17/10	16.45	0.146305	0.146503	8	10
10/23/10	16.99	0.143459	0.143909	I(1)5	I(1)7
10/29/10	17.11	0.141296	0.141654	15	18
11/4/10	16.93	0.142715	0.143059	14	17
11/11/10	16.76	0.146777	0.147153	16	18
11/17/10	16.76	0.144790	0.144995	8	10
11/22/10	16.76	0.148271	0.148476	8	10
11/28/10	16.52	0.146104	0.146732	26	31
12/4/10	16.93	0.142164	0.142407	10	12
12/11/10	16.93	0.144603	0.144749	6	7
12/16/10	16.87	0.143598	0.143771	7	8
12/22/10	16.87	0.146151	0.146341	8	9
12/28/10	16.58	0.145754	0.145916	7	8

[1] Acceptable Actual Flow Rates (Q_{ACT}) for PM_{10}: 15.0 to 18.4 liters per minute (lpm)

I(1) represents invalid or missing data. The number in parentheses refers to the listing under the "Data Capture Summary" heading for Site 1.

	Actual Arithmetic Mean (µg/m³)	Standard Arithmetic Mean (µg/m³)	Data Capture (percent)
October	10.0	12.3	80
November	14.4	17.2	100
December	7.6	8.8	100
Quarter	***10.7***	***12.8***	***93***

New Mexico Copper Corporation – Copper Flat Mine
Fourth Quarter 2010 Particulate Report

Quarterly PM_{10} Calculations
Sampler Site 1

Number of Days in the Quarter (N): 92

Number of Strata with Samples (M): 14

Number of Observed Exceedances by Stratum

Stratum #	**Observed Exceedances (V)**
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	0
11	0
12	0
13	0
14	0

New Mexico Copper Corporation – Copper Flat Mine
Fourth Quarter 2010 Particulate Report

Quarterly PM_{10} Calculations
Sampler Site 1

Number of Actual Samples by Stratum

Stratum#	Number of samples (K)
1	1
2	1
3	1
4	1
5	1
6	1
7	1
8	1
9	1
10	1
11	1
12	1
13	1
14	1

Expected Number of Exceedances for the Quarter: 0

$e_q = V_q [N_q / n_q]$

e_q= Expected number of exceedances for the quarter

$V_{q=}$ Observed number of exceedances

$N_{q=}$ Number of days in quarter

n_q= Number of days in quarter with PM_{10} data

Percent Data Capture for the Quarter: 93

References: 40 CFR Part 50, Appendix K (Revised June 18, 1997)
40 CFR Part 58, Appendix B

New Mexico Copper Corporation – Copper Flat Mine
Fourth Quarter 2010 Particulate Report

Low Volume Sampler Operations and Data Capture Summary

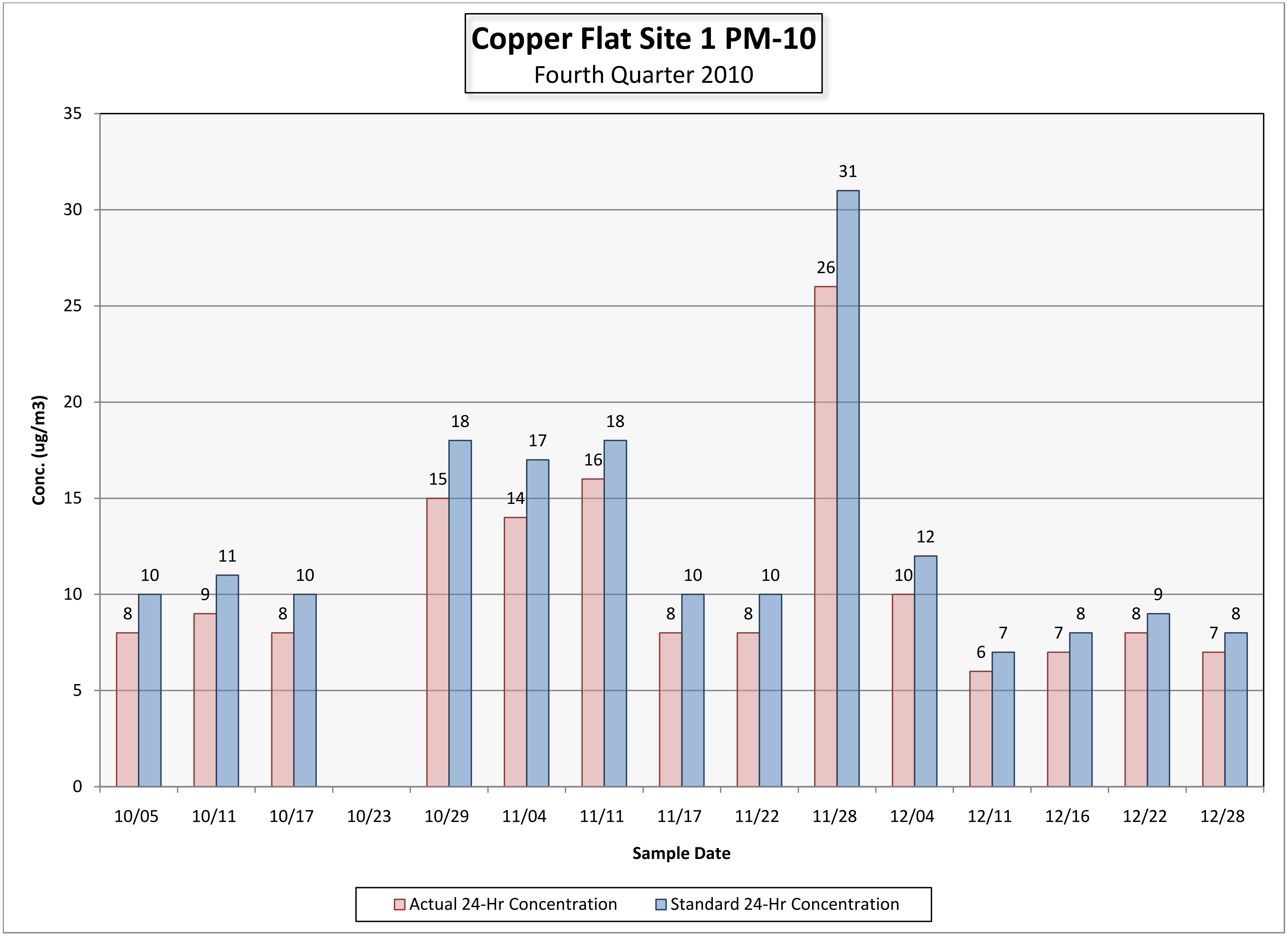
Sampler Site 1

Operations Summary

1) A site visit was performed on 10/18/10 to check flows.

Data Capture Summary

1) Sampler Site 1 had one invalid run on 10/23/10 due to a run time that was too long, 4875 minutes. Optimum run times are between 1380 and 1500 minutes.



Copper Flat Site 1 PM-10
Fourth Quarter 2010
Conc. (ug/m3)
0
5
10
15
20
25
30
35
8
10
9
11
8
10
15
18
14
17
16
18
8
10
8
10
26
31
10
12
6
7
7
8
8
9
7
8
10/05
10/11
10/17
10/23
10/29
11/04
11/11
11/17
11/22
11/28
12/04
12/11
12/16
12/22
12/28
Sample Date
Actual 24-Hr Concentration
Standard 24-Hr Concentration

New Mexico Copper Corporation – Copper Flat Mine
Fourth Quarter 2010 Particulate Report

Site 2 PM_{10} Particulate Data Summary

Run Date	Q_{ACT} (cmm)[1]	Filter Pre Weight (g)	Filter Post Weight (g)	24 Hour Q_{ACT} Concentration (ug/m^3)	24 Hour Q_{STD} Concentration (ug/m^3)
10/5/10	16.26	0.145176	0.145346	7	9
10/11/10	16.37	0.145323	0.145473	6	8
10/17/10	16.43	0.144643	0.144808	7	9
10/23/10	16.90	0.144921	0.145066	6	7
10/29/10	17.02	0.141541	0.142596	43	52
11/4/10	16.84	0.142496	0.142798	12	15
11/11/10	16.66	0.141066	0.141129	3	3
11/17/10	16.66	0.144471	0.144693	9	11
11/22/10	16.66	0.142827	0.142959	6	7
11/28/10	16.43	0.142806	0.143182	16	19
12/4/10	16.84	0.144689	0.144927	10	12
12/11/10	16.84	0.146597	0.146691	4	5
12/16/10	16.78	0.145691	0.145896	8	10
12/22/10	16.78	0.148330	0.148921	24	29
12/28/10	16.49	0.145394	0.145559	I(1)12	I(1)15

[1]Acceptable Actual Flow Rates (Q_{ACT}) for PM_{10}: 15.0 to 18.4 liters per minute (lpm)

I(1) represents invalid or missing data. The number in parentheses refers to the listing under the "Data Capture Summary" heading for Site 2.

	Actual Arithmetic Mean (µg/m^3)	Standard Arithmetic Mean (µg/m^3)	Data Capture (percent)
October	13.8	17.0	100
November	9.2	11.0	100
December	9.2	14.0	80
Quarter	***10.7***	***14.0***	***93***

New Mexico Copper Corporation – Copper Flat Mine
Fourth Quarter 2010 Particulate Report

Quarterly PM_{10} Calculations
Sampler Site 2

Number of Days in the Quarter (N): 92

Number of Strata with Samples (M): 14

Number of Observed Exceedances by Stratum

Stratum #	Observed Exceedances (V)
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	0
11	0
12	0
13	0
14	0

New Mexico Copper Corporation – Copper Flat Mine
Fourth Quarter 2010 Particulate Report

Quarterly PM_{10} Calculations
Sampler Site 2

Number of Actual Samples by Stratum

Stratum#	Number of samples (K)
1	1
2	1
3	1
4	1
5	1
6	1
7	1
8	1
9	1
10	1
11	1
12	1
13	1
14	1

Expected Number of Exceedances for the Quarter: 0.0

$e_q = V_q [N_q / n_q]$

e_q= Expected number of exceedances for the quarter

$V_{q=}$ Observed number of exceedances

$N_{q=}$ Number of days in quarter

n_q= Number of days in quarter with PM_{10} data

Percent Data Capture for the Quarter: 93

References: 40 CFR Part 50, Appendix K (Revised June 18, 1997)
40 CFR Part 58, Appendix B

New Mexico Copper Corporation – Copper Flat Mine
Fourth Quarter 2010 Particulate Report

Low Volume Sampler Operations and Data Capture Summary

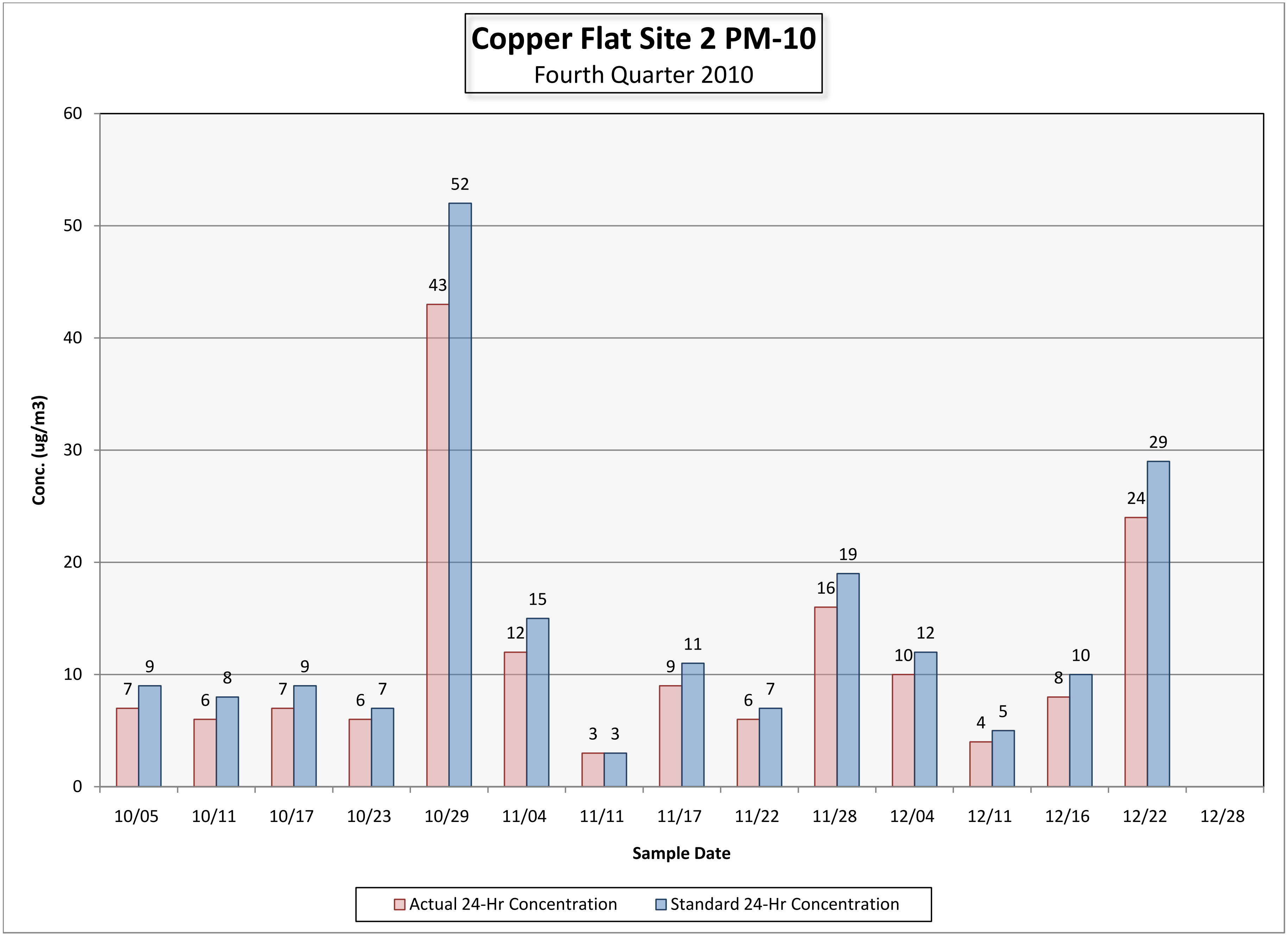
Sampler Site 2

Operations Summary

1) A site visit was performed on 10/18/10 to check flows.

Data Capture Summary

1) Sampler run date 12/28/10 was invalidated due to a run time that was too short, 808 minutes. Optimum run times are between 1380 and 1500 minutes.



Copper Flat Site 2 PM-10
Fourth Quarter 2010
Conc. (ug/m3)
0
10
20
30
40
50
60
7
9
6
8
7
9
6
7
43
52
12
15
3
3
9
11
6
7
16
19
10
12
4
5
8
10
24
29
10/05
10/11
10/17
10/23
10/29
11/04
11/11
11/17
11/22
11/28
12/04
12/11
12/16
12/22
12/28
Sample Date
Actual 24-Hr Concentration
Standard 24-Hr Concentration

Appendix A

Monthly Particulate Data Reports

New Mexico Copper Corporation - Copper Flat Mine
Particulate Matter 10 Micron (PM10) Report
Micrograms per Cubic Meter

Report Period: Fourth Quarter 2010

Sampler Site 1

Sample Day	Filter #	Start Weight (grams)	End Weight (grams)	Sample Time (min)	Ambient Temperature (C)	Actual Flow (lpm)	Standard Flow (slpm)	PM10 Actual (ug/m3)	PM10 Standard (ug/m3)	Valid Sample	Comments
10/5/2010	17	.144126	.144318	1440	16	16.28	13.45	8	10	☐	
10/11/2010	19	.146096	.146312	1440	18	16.39	13.45	9	11	☐	
10/17/2010	21	.146305	.146503	1440	19	16.45	13.45	8	10	☐	
10/23/2010	23	.143459	.143909	4875	14	16.99	14.14	5	7	☑	Run time too long
10/29/2010	25	.141296	.141654	1440	16	17.11	14.14	15	18	☐	
11/4/2010	27	.142715	.143059	1440	13	16.93	14.14	14	17	☐	
11/11/2010	29	.146777	.147153	1440	10	16.76	14.14	16	18	☐	
11/17/2010	31	.144790	.144995	1440	10	16.76	14.14	8	10	☐	
11/22/2010	33	.148271	.148476	1440	10	16.76	14.14	8	10	☐	
11/28/2010	35	.146104	.146732	1440	6	16.52	14.14	26	31	☐	
12/4/2010	37	.142164	.142407	1440	13	16.93	14.14	10	12	☐	
12/11/2010	39	.144603	.144749	1440	13	16.93	14.14	6	7	☐	

Sample Day	Filter #	Start Weight (grams)	End Weight (grams)	Sample Time (min)	Ambient Temperature (C)	Actual Flow (lpm)	Standard Flow (slpm)	PM10 Actual (ug/m3)	PM10 Standard (ug/m3)	Valid Sample	Comments
12/16/2010	42	.143598	.143771	1440	12	16.87	14.14	7	8	☐	
12/22/2010	44	.146151	.146341	1440	12	16.87	14.14	8	9	☐	
12/28/2010	45	.145754	.145916	1440	7	16.58	14.14	7	8	☐	

New Mexico Copper Corporation - Copper Flat Mine
Particulate Matter 10 Micron (PM10) Report
Micrograms per Cubic Meter

Report Period: Fourth Quarter 2010

Sampler Site 2

Sample Day	Filter #	Start Weight (grams)	End Weight (grams)	Sample Time (min)	Ambient Temperature (C)	Actual Flow (lpm)	Standard Flow (slpm)	PM10 Actual (ug/m3)	PM10 Standard (ug/m3)	Valid Sample	Comments
10/5/2010	18	.145176	.145346	1440	16	16.26	13.43	7	9	☐	
10/11/2010	20	.145323	.145473	1440	18	16.37	13.43	6	8	☐	
10/17/2010	22	.144643	.144808	1440	19	16.43	13.43	7	9	☐	
10/23/2010	24	.144921	.145066	1440	14	16.90	14.06	6	7	☐	
10/29/2010	26	.141541	.142596	1440	16	17.02	14.06	43	52	☐	
11/4/2010	28	.142496	.142798	1440	13	16.84	14.06	12	15	☐	
11/11/2010	30	.141066	.141129	1440	10	16.66	14.06	3	3	☐	
11/17/2010	32	.144471	.144693	1440	10	16.66	14.06	9	11	☐	
11/22/2010	34	.142827	.142959	1440	10	16.66	14.06	6	7	☐	
11/28/2010	36	.142806	.143182	1440	6	16.43	14.06	16	19	☐	
12/4/2010	38	.144689	.144927	1440	13	16.84	14.06	10	12	☐	
12/11/2010	40	.146597	.146691	1440	13	16.84	14.06	4	5	☐	

Sample Day	Filter #	Start Weight (grams)	End Weight (grams)	Sample Time (min)	Ambient Temperature (C)	Actual Flow (lpm)	Standard Flow (slpm)	PM10 Actual (ug/m3)	PM10 Standard (ug/m3)	Valid Sample	Comments
12/16/2010	41	.145691	.145896	1440	12	16.78	14.06	8	10	☐	
12/22/2010	43	.148330	.148921	1440	12	16.78	14.06	24	29	☐	
12/28/2010	46	.145394	.145559	808	7	16.49	14.06	12	15	☑	Run time too short

New Mexico Copper Corporation

Copper Flat Mine

Air Monitoring Program Quarterly Report
for
Particulate Samplers

First Quarter 2011
(January through March)

Prepared By:

Class One Technical Services, Inc.
3500 Comanche Rd NE, Suite G
Albuquerque, New Mexico 87107

June 9, 2011

Table Of Contents

New Mexico Copper Corporation – Copper Flat Mine
First Quarter 2011 Particulate Report

Executive Summary

Data capture for First Quarter 2011 ranged from ninety-three (93) percent at Site 2 to one hundred (100) percent at Site 1. Site 2 had one invalid run on 01/03/11 due to dead batteries at the sampler, resulting in no run being completed.

The Federal 24-hour PM_{10} standard of 150 $\mu g/m^3$ was not exceeded during First Quarter 2011. The highest PM_{10} concentration of 18 $\mu g/m^3$ was first recorded on 02/02/11, by sampler Site 1. The second highest concentration of 18 $\mu g/m^3$ was recorded on 02/20/11 by Site 1.

The table below summarizes the percent data capture and maximum particulate concentrations recorded during First Quarter 2011 for each sampler.

Sampler	Parameter	24-Hour Max Conc. ($\mu g/m^3$)	Date of Maximum Concentration	Quarterly Percent Data Capture
Site 1	PM_{10}	18	02/02/11	100
Site 2	PM_{10}	15	03/10/11	93

Note: Federal 24-Hour PM_{10} Standard: 150 $\mu g/m^3$

New Mexico Copper Corporation – Copper Flat Mine
First Quarter 2011 Particulate Report

Introduction

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. During First Quarter 2011, Class One Technical Services (CTS) conducted quality assurance, instrument repair (as requested), data reduction, and data reporting for each particulate sampler. The daily operations such as filter changes, mass flow readings, flow checks, and general instrument checks were handled entirely by New Mexico Copper Corporation, Copper Flat environmental quality staff. The samplers initiated operations on August 6, 2010.

Each sampler runs once every six days for a full twenty-four hour period from midnight to midnight. All samplers run simultaneously.

During quarterly sampler flow checks, flow rate is adjusted to be within five (5) percent of 16.67 litres 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 (Q_{ACT}).

Actual flow rates are converted into standard flow rates (Q_{STD}) at standard temperature (298 °K) 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 Q_{ACT} and Q_{STD} together with net weight gain are used to determine the 24-hour particulate concentration in micrograms per cubic meter ($\mu g/m^3$).

PM_{10} concentrations based on standard flow rates are reported to comply with the National Ambient Air Quality Standards (NAAQS) promulgated in December 2006. The Environmental Protection Agency implemented the new standard January 1, 2007.

PM_{10}

USEPA Quality Assurance Handbook for Air Pollution Measurement Systems: Volume II, Ambient Air Specific Methods (Section 2.11.0, April 1989) and 40 CFR Part 50, Appendix K (Revised July 1997).

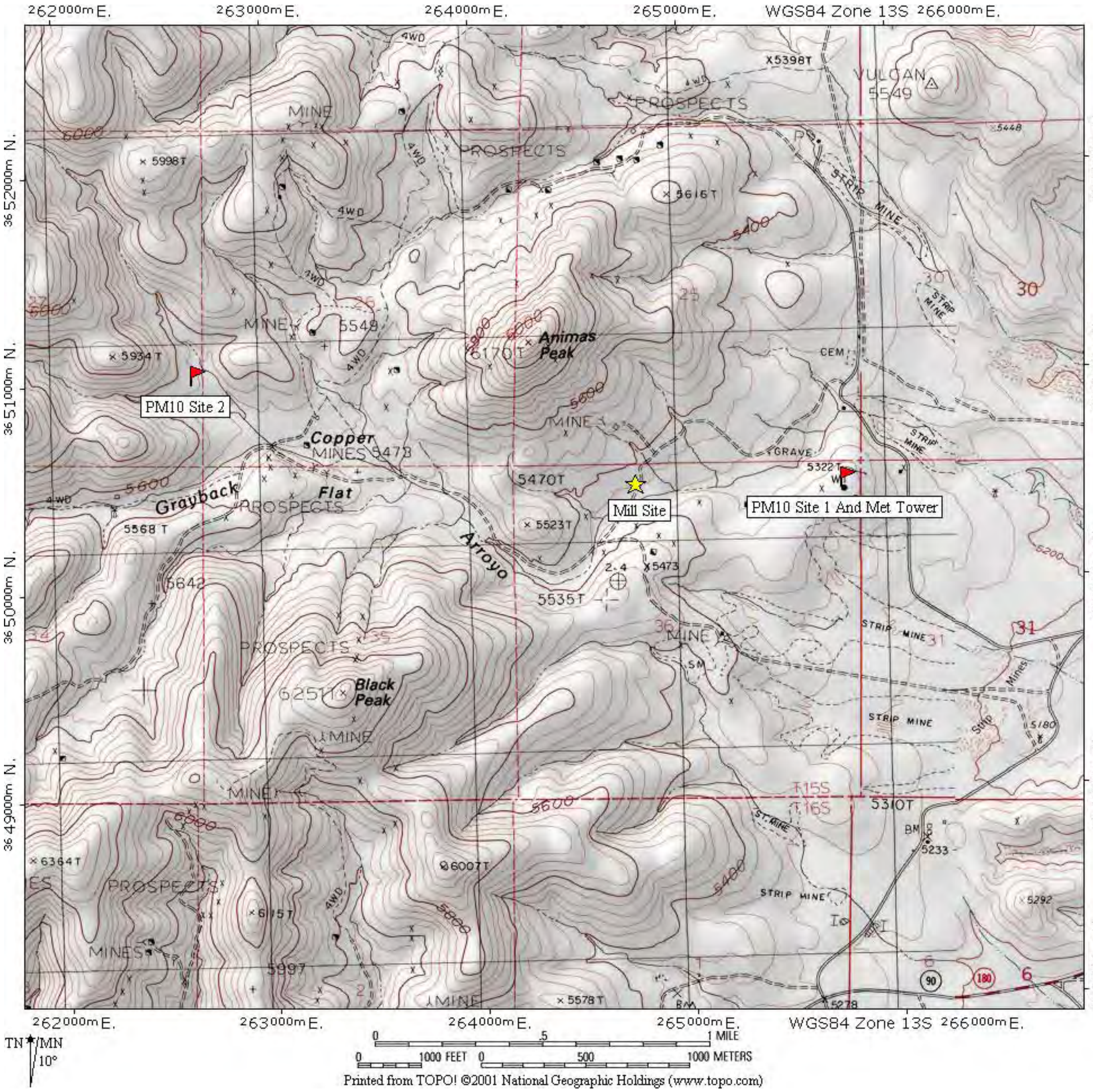
New Mexico Copper Corporation – Copper Flat Mine
First Quarter 2011 Particulate Report

Copper Flat Mine Particulate Samplers
Coordinates and Elevations

Sampler	Coordinates	Elevation (ft.)
Site 1 (PM_{10})	UTM Coordinates: Easting 265,721 meters Northing 3,650,419 meters	5402
SH02 (PM_{10})	UTM Coordinates: Easting 262,618 meters Northing 3,651,000 meters	5596

Note: Coordinates taken with portable GPS unit set in the NAD 83 mode.

Figure 1: Map of Particulate Sampler Locations



New Mexico Copper Corporation – Copper Flat Mine
First Quarter 2011 Particulate Report

Site 1 PM_{10} Particulate Data Summary

Run Date	Q_{ACT} (cmm)[1]	Filter Pre Weight (g)	Filter Post Weight (g)	24 Hour Q_{ACT} Concentration (ug/m^3)	24 Hour Q_{STD} Concentration (ug/m^3)
1/3/11	16.28	0.143922	0.144081	7	8
1/9/11	16.58	0.146498	0.146605	4	5
1/15/11	16.46	0.146682	0.146799	5	6
1/21/11	16.52	0.146200	0.146375	7	9
1/27/11	16.52	0.146288	0.146424	6	7
2/2/11	15.22	0.149074	0.149444	17	18
2/8/11	16.70	0.144233	0.144500	11	13
2/14/11	17.61	0.145312	0.145525	8	10
2/20/11	17.43	0.139608	0.139995	15	18
2/26/11	17.37	0.144972	0.145207	9	11
3/4/11	17.49	0.147906	0.148164	10	12
3/10/11	17.06	0.141371	0.141671	12	15
3/16/11	17.35	0.143436	0.143684	10	12
3/22/11	16.94	0.140722	0.140999	11	14
3/28/11	17.24	0.144990	0.145248	10	13

[1]Acceptable Actual Flow Rates (Q_{ACT}) for PM_{10}: 15.0 to 18.4 liters per minute (lpm)

I(1) represents invalid or missing data. The number in parentheses refers to the listing under the "Data Capture Summary" heading for Site 1.

	Actual Arithmetic Mean (μg/m^3)	Standard Arithmetic Mean (μg/m^3)	Data Capture (percent)
January	5.8	7.0	100
February	12.0	14.0	100
March	10.3	13.2	100
Quarter	***9.5***	***11.4***	***100***

New Mexico Copper Corporation – Copper Flat Mine
First Quarter 2011 Particulate Report

Quarterly PM_{10} Calculations
Sampler Site 1

Number of Days in the Quarter (N): 91

Number of Strata with Samples (M): 15

Number of Observed Exceedances by Stratum

Stratum #	Observed Exceedances (V)
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	0
11	0
12	0
13	0
14	0
15	0

New Mexico Copper Corporation – Copper Flat Mine
First Quarter 2011 Particulate Report

Quarterly PM_{10} Calculations
Sampler Site 1

Number of Actual Samples by Stratum

Stratum#	**Number of samples (K)**
1	1
2	1
3	1
4	1
5	1
6	1
7	1
8	1
9	1
10	1
11	1
12	1
13	1
14	1
15	1

Expected Number of Exceedances for the Quarter: 0

$e_q = V_q [N_q / n_q]$

e_q= Expected number of exceedances for the quarter

V_q= Observed number of exceedances

N_q= Number of days in quarter

n_q= Number of days in quarter with PM_{10} data

Percent Data Capture for the Quarter: 100

References: 40 CFR Part 50, Appendix K (Revised June 18, 1997)
40 CFR Part 58, Appendix B

New Mexico Copper Corporation – Copper Flat Mine
First Quarter 2011 Particulate Report

Low Volume Sampler Operations and Data Capture Summary

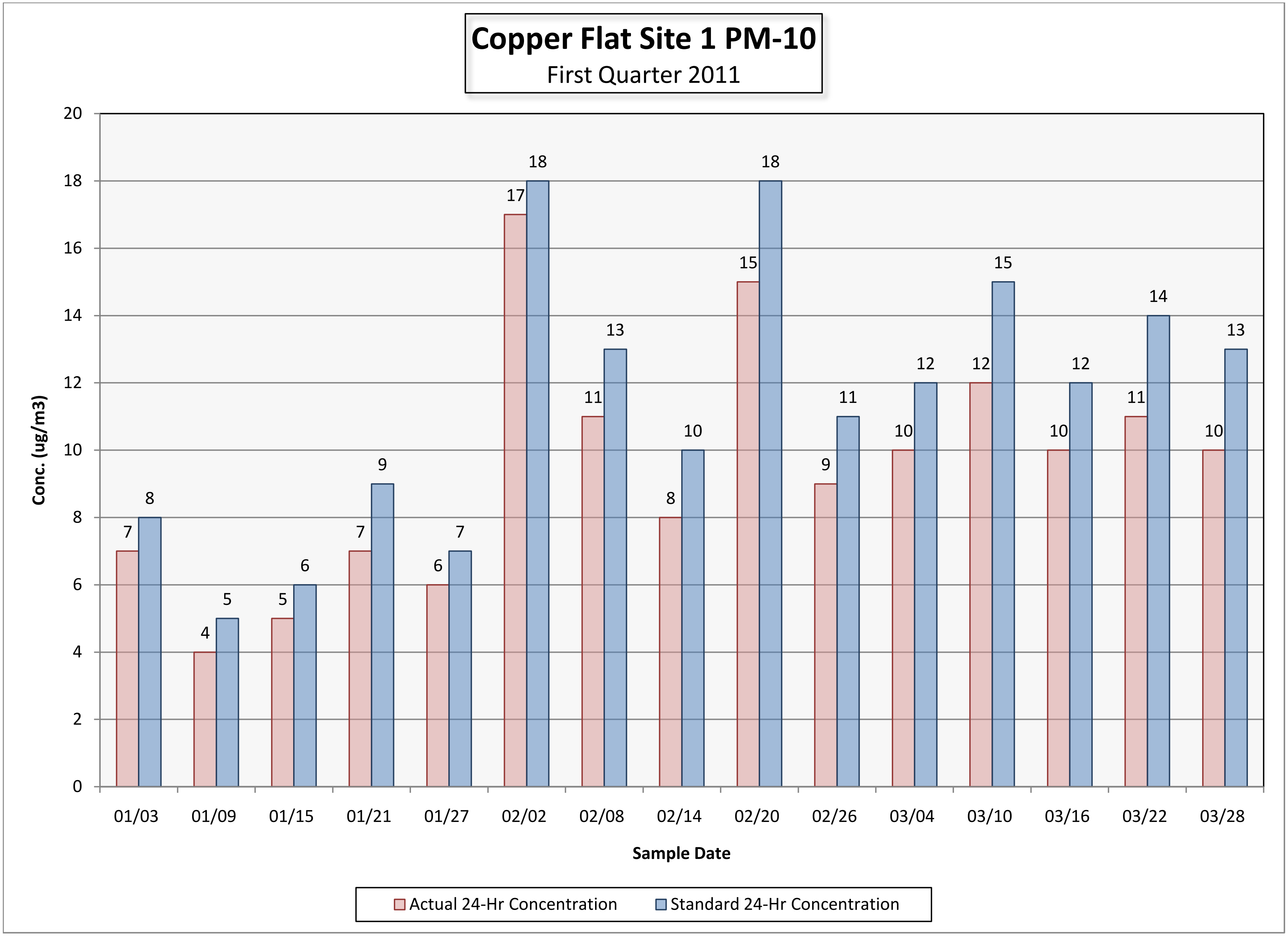
Sampler Site 1

Operations Summary

1) A site visit was performed on 02/11/11 to check flows.
2) A site visit was performed on 03/08/11 to check flows.

Data Capture Summary

Sampler Site 1 had one hundred percent data capture for the First Quarter 2011.


Copper Flat Site 1 PM-10
First Quarter 2011
Conc. (ug/m3)
0
2
4
6
8
10
12
14
16
18
20
7
8
4
5
5
6
7
9
6
7
17
18
11
13
8
10
15
18
9
11
10
12
12
15
10
12
11
14
10
13
01/03
01/09
01/15
01/21
01/27
02/02
02/08
02/14
02/20
02/26
03/04
03/10
03/16
03/22
03/28
Sample Date
Actual 24-Hr Concentration
Standard 24-Hr Concentration

New Mexico Copper Corporation – Copper Flat Mine
First Quarter 2011 Particulate Report

Site 2 PM_{10} Particulate Data Summary

Run Date	Q_{ACT} (cmm)[1]	Filter Pre Weight (g)	Filter Post Weight (g)	24 Hour Q_{ACT} Concentration (ug/m^3)	24 Hour Q_{STD} Concentration (ug/m^3)
1/3/11	16.19	0.144313	0.144367	I(1)	I(1)
1/9/11	16.49	0.142406	0.142535	5	6
1/15/11	16.37	0.143233	0.143360	5	6
1/21/11	16.43	0.144085	0.144287	9	10
1/27/11	16.43	0.148810	0.148973	7	8
2/2/11	15.13	0.145469	0.145683	10	11
2/8/11	16.61	0.145816	0.146080	11	13
2/14/11	17.40	0.146115	0.146349	9	11
2/20/11	17.22	0.141574	0.141876	12	14
2/26/11	17.16	0.145259	0.145464	8	10
3/4/11	17.03	0.144901	0.144918	1	1
3/10/11	16.78	0.142155	0.142449	12	15
3/16/11	17.07	0.144334	0.144571	10	12
3/22/11	16.66	0.142326	0.142586	11	13
3/28/11	16.95	0.143139	0.143366	9	11

[1] Acceptable Actual Flow Rates (Q_{ACT}) for PM_{10}: 15.0 to 18.4 liters per minute (lpm)

I(1) represents invalid or missing data. The number in parentheses refers to the listing under the "Data Capture Summary" heading for Site 2.

	Actual Arithmetic Mean (μg/m^3)	Standard Arithmetic Mean (μg/m^3)	Data Capture (percent)
January	6.5	7.5	80
February	10.0	11.8	100
March	8.6	10.4	100
Quarter	***8.5***	***10.1***	***93***

New Mexico Copper Corporation – Copper Flat Mine
First Quarter 2011 Particulate Report

Quarterly PM_{10} Calculations
Sampler Site 2

Number of Days in the Quarter (N): 91

Number of Strata with Samples (M): 14

Number of Observed Exceedances by Stratum

Stratum #	Observed Exceedances (V)
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	0
11	0
12	0
13	0
14	0

New Mexico Copper Corporation – Copper Flat Mine
First Quarter 2011 Particulate Report

Quarterly PM_{10} Calculations
Sampler Site 2

Number of Actual Samples by Stratum

Stratum#	Number of samples (K)
1	1
2	1
3	1
4	1
5	1
6	1
7	1
8	1
9	1
10	1
11	1
12	1
13	1
14	1

Expected Number of Exceedances for the Quarter: 0.0

$e_q = V_q [N_q / n_q]$

e_q= Expected number of exceedances for the quarter

$V_{q=}$ Observed number of exceedances

$N_{q=}$ Number of days in quarter

n_q= Number of days in quarter with PM_{10} data

Percent Data Capture for the Quarter: 93

References: 40 CFR Part 50, Appendix K (Revised June 18, 1997)
40 CFR Part 58, Appendix B

New Mexico Copper Corporation – Copper Flat Mine
First Quarter 2011 Particulate Report

Low Volume Sampler Operations and Data Capture Summary

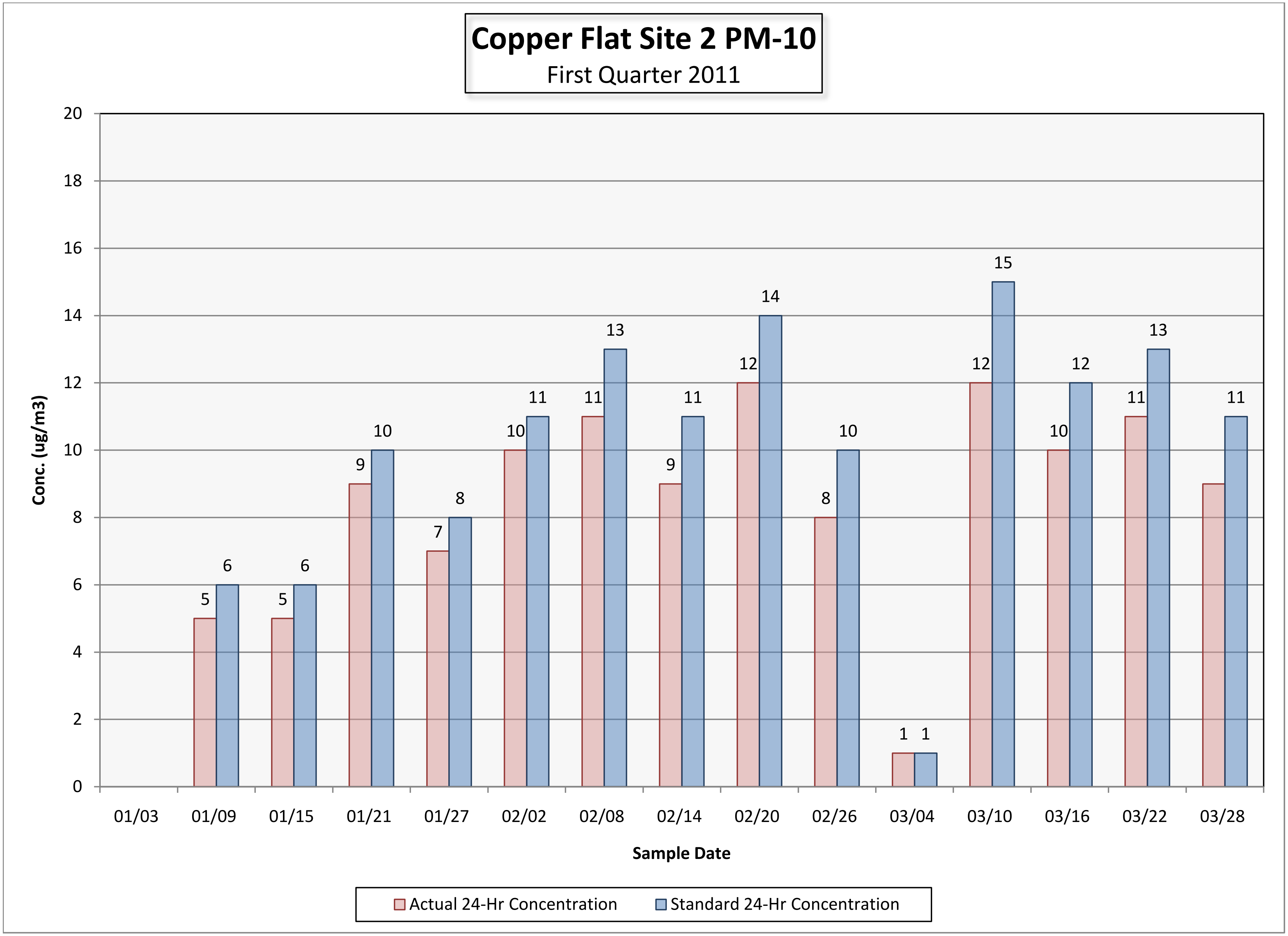
Sampler Site 2

Operations Summary

1) A site visit was performed on 02/11/11 to check flows.
2) A site visit was performed on 03/08/11 to check flows.

Data Capture Summary

1) Sampler Site 1 had one invalid run on 01/03/11 due to dead batteries at the sampler, resulting in no run being completed.



Copper Flat Site 2 PM-10
First Quarter 2011
Conc. (ug/m3)
20
18
16
14
12
10
8
6
4
2
0
5 6
5 6
9 10
7 8
10 11
11 13
9 11
12 14
8 10
1 1
12 15
10 12
11 13
9 11
01/03
01/09
01/15
01/21
01/27
02/02
02/08
02/14
02/20
02/26
03/04
03/10
03/16
03/22
03/28
Sample Date
Actual 24-Hr Concentration
Standard 24-Hr Concentration

Appendix A

Monthly Particulate Data Reports

New Mexico Copper Corporation - Copper Flat Mine
Particulate Matter 10 Micron (PM10) Report
Micrograms per Cubic Meter

Report Period: First Quarter 2011

Sampler Site 1

Sample Day	Filter #	Start Weight (grams)	End Weight (grams)	Sample Time (min)	Ambient Temperature (C)	Actual Flow (lpm)	Standard Flow (slpm)	PM10 Actual (ug/m3)	PM10 Standard (ug/m3)	Valid Sample	Comments
1/3/2011	47	.143922	.144081	1440	2	16.28	14.14	7	8	☐	
1/9/2011	49	.146498	.146605	1440	7	16.58	14.14	4	5	☐	
1/15/2011	51	.146682	.146799	1440	5	16.46	14.14	5	6	☐	
1/21/2011	53	.146200	.146375	1440	6	16.52	14.14	7	9	☐	
1/27/2011	55	.146288	.146424	1440	6	16.52	14.14	6	7	☐	
2/2/2011	57	.149074	.149444	1440	-16	15.22	14.14	17	18	☐	
2/8/2011	59	.144233	.144500	1440	9	16.70	14.14	11	13	☐	
2/14/2011	61	.145312	.145525	1440	14	17.61	14.65	8	10	☐	
2/20/2011	63	.139608	.139995	1440	11	17.43	14.65	15	18	☐	
2/26/2011	65	.144972	.145207	1440	10	17.37	14.65	9	11	☐	
3/4/2011	67	.147906	.148164	1440	12	17.49	14.65	10	12	☐	
3/10/2011	69	.141371	.141671	1440	14	17.06	14.19	12	15	☐	

Sample Day	Filter #	Start Weight (grams)	End Weight (grams)	Sample Time (min)	Ambient Temperature (C)	Actual Flow (lpm)	Standard Flow (slpm)	PM10 Actual (ug/m3)	PM10 Standard (ug/m3)	Valid Sample	Comments
3/16/2011	71	.143436	.143684	1440	19	17.35	14.19	10	12	☐	
3/22/2011	73	.140722	.140999	1440	12	16.94	14.19	11	14	☐	
3/28/2011	75	.144990	.145248	1440	17	17.24	14.19	10	13	☐	

New Mexico Copper Corporation - Copper Flat Mine
Particulate Matter 10 Micron (PM10) Report
Micrograms per Cubic Meter

Report Period: First Quarter 2011

Sampler Site 2

Sample Day	Filter #	Start Weight (grams)	End Weight (grams)	Sample Time (min)	Ambient Temperature (C)	Actual Flow (lpm)	Standard Flow (slpm)	PM10 Actual (ug/m3)	PM10 Standard (ug/m3)	Valid Sample	Comments
1/3/2011	48	.144313	.144367	1	2	16.19	14.06	3335	3840	☑	No Run due to dead batteries
1/9/2011	50	.142406	.142535	1440	7	16.49	14.06	5	6	☐	
1/15/2011	52	.143233	.143360	1440	5	16.37	14.06	5	6	☐	
1/21/2011	54	.144085	.144287	1440	6	16.43	14.06	9	10	☐	
1/27/2011	56	.148810	.148973	1440	6	16.43	14.06	7	8	☐	
2/2/2011	58	.145469	.145683	1440	-16	15.13	14.06	10	11	☐	
2/8/2011	60	.145816	.146080	1440	9	16.61	14.06	11	13	☐	
2/14/2011	62	.146115	.146349	1440	14	17.40	14.48	9	11	☐	
2/20/2011	64	.141574	.141876	1440	11	17.22	14.48	12	14	☐	
2/26/2011	66	.145259	.145464	1440	10	17.16	14.48	8	10	☐	
3/4/2011	68	.144901	.144918	1440	8	17.03	14.48	1	1	☐	
3/10/2011	70	.142155	.142449	1440	14	16.78	13.96	12	15	☐	

Sample Day	Filter #	Start Weight (grams)	End Weight (grams)	Sample Time (min)	Ambient Temperature (C)	Actual Flow (lpm)	Standard Flow (slpm)	PM10 Actual (ug/m3)	PM10 Standard (ug/m3)	Valid Sample	Comments
3/16/2011	72	.144334	.144571	1440	19	17.07	13.96	10	12	☐	
3/22/2011	74	.142326	.142586	1440	12	16.66	13.96	11	13	☐	
3/28/2011	76	.143139	.143366	1440	17	16.95	13.96	9	11	☐	

New Mexico Copper Corporation

Copper Flat Mine

Air Monitoring Program Quarterly Report
for
Particulate Samplers

Second Quarter 2011
(April through June)

Prepared By:

Class One Technical Services, Inc.
3500 Comanche Rd NE, Suite G
Albuquerque, New Mexico 87107

August 15, 2011

Table Of Contents

New Mexico Copper Corporation – Copper Flat Mine
Second Quarter 2011 Particulate Report

Executive Summary

Data capture for Second Quarter 2011 was one hundred (100) percent at Site 1 and Site 2.

The Federal 24-hour PM_{10} standard of 150 $\mu g/m^3$ was not exceeded during Second Quarter 2011. The highest PM_{10} concentration of 59 $\mu g/m^3$ was recorded on 04/09/11, by sampler Site 1. The second highest concentration of 44 $\mu g/m^3$ was recorded on 04/15/11 by Site 2.

The table below summarizes the percent data capture and maximum particulate concentrations recorded during Second Quarter 2011 for each sampler.

Sampler	Parameter	24-Hour Max Conc. ($\mu g/m^3$)	Date of Maximum Concentration	Quarterly Percent Data Capture
Site 1	PM_{10}	59	04/09/11	100
Site 2	PM_{10}	44	04/15/11	100

Note: Federal 24-Hour PM_{10} Standard: 150 $\mu g/m^3$

New Mexico Copper Corporation – Copper Flat Mine
Second Quarter 2011 Particulate Report

Introduction

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. During Second Quarter 2011, Class One Technical Services (CTS) conducted quality assurance, instrument repair (as requested), data reduction, and data reporting for each particulate sampler. The daily operations such as filter changes, mass flow readings, flow checks, and general instrument checks were handled entirely by New Mexico Copper Corporation, Copper Flat environmental quality staff. The samplers initiated operations on August 6, 2010.

Each sampler runs once every six days for a full twenty-four hour period from midnight to midnight. All samplers run simultaneously.

During quarterly sampler flow checks, flow rate is adjusted to be within four (4) percent of 16.67 litres 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 (Q_{ACT}).

Actual flow rates are converted into standard flow rates (Q_{STD}) at standard temperature (298 °K) 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 Q_{ACT} and Q_{STD} together with net weight gain are used to determine the 24-hour particulate concentration in micrograms per cubic meter ($\mu g/m^3$).

PM_{10} concentrations based on standard flow rates are reported to comply with the National Ambient Air Quality Standards (NAAQS) promulgated in December 2006. The Environmental Protection Agency implemented the new standard January 1, 2007.

PM_{10}

USEPA Quality Assurance Handbook for Air Pollution Measurement Systems: Volume II, Ambient Air Specific Methods (Section 2.11.0, December 2008) and 40 CFR Part 50, Appendix K (Revised October 2006).

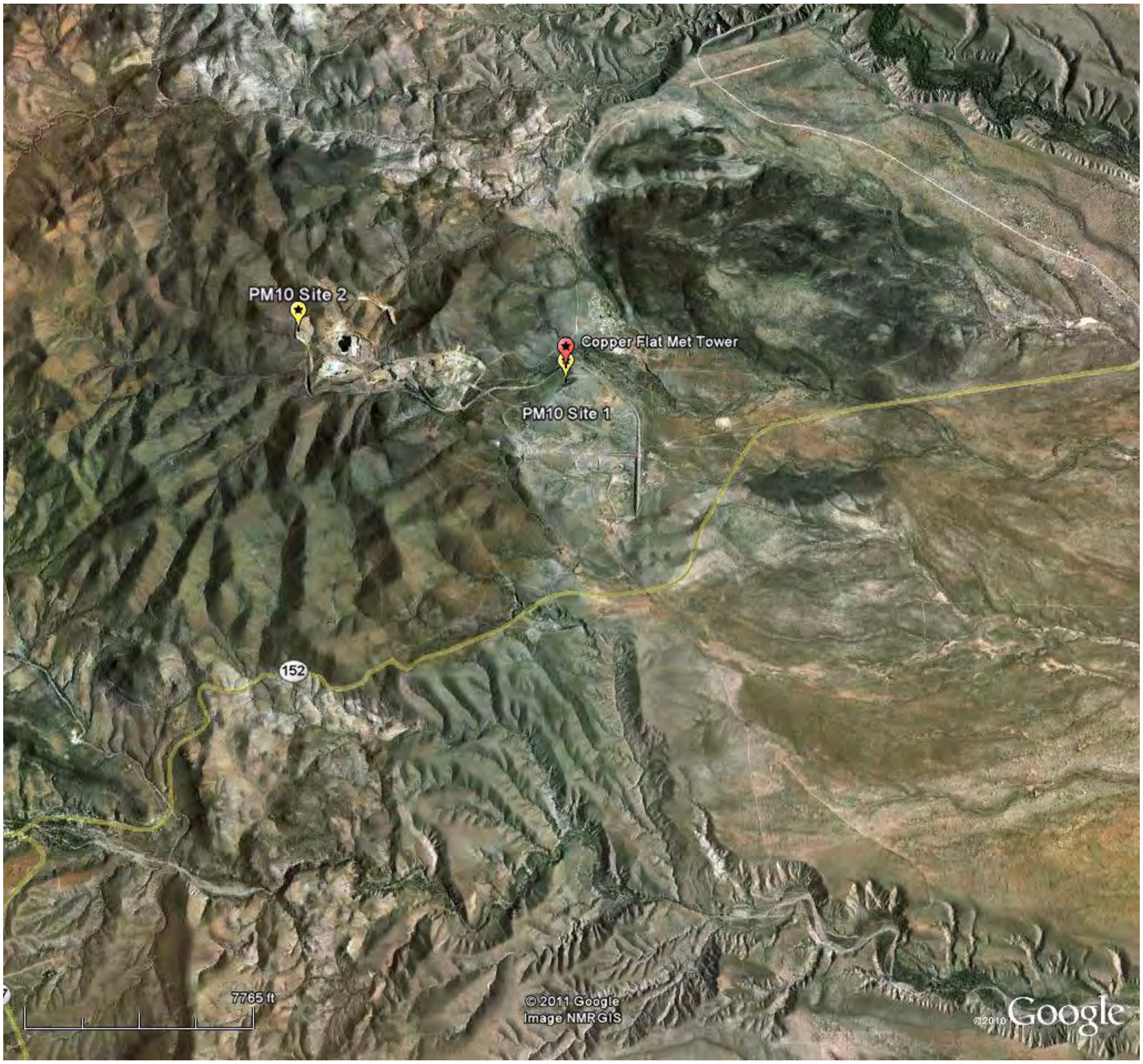
New Mexico Copper Corporation – Copper Flat Mine
Second Quarter 2011 Particulate Report

Copper Flat Mine Particulate Samplers
Coordinates and Elevations

Sampler	Coordinates	Elevation (ft.)
Site 1 (PM_{10})	UTM Coordinates: Easting 265,721 meters Northing 3,650,419 meters	5402
SH02 (PM_{10})	UTM Coordinates: Easting 262,618 meters Northing 3,651,000 meters	5596

Note: Coordinates taken with portable GPS unit set in the NAD 83 mode.

Figure 1: Map of Copper Flat PM_{10} Sampler Locations



New Mexico Copper Corporation – Copper Flat Mine
Second Quarter 2011 Particulate Report

Site 1 PM_{10} Particulate Data Summary

Run Date	Q_{ACT} (cmm)[1]	Filter Pre Weight (g)	Filter Post Weight (g)	24 Hour Q_{ACT} Concentration (ug/m^3)	24 Hour Q_{STD} Concentration (ug/m^3)
4/3/11	17.41	0.146926	0.147574	26	32
4/9/11	17.06	0.148009	0.149221	49	59
4/15/11	16.72	0.144533	0.145179	27	32
4/21/11	17.12	0.144011	0.144271	11	13
4/27/11	16.72	0.145450	0.145754	13	15
5/3/11	16.66	0.148011	0.148327	13	16
5/9/11	17.12	0.148568	0.149429	35	43
5/15/11	17.12	0.149001	0.149388	16	19
5/21/11	16.79	0.143858	0.144184	13	17
5/27/11	17.02	0.142398	0.142739	14	17
6/2/11	17.02	0.139567	0.140202	26	32
6/8/11	17.07	0.140869	0.141595	30	37
6/14/11	17.13	0.138674	0.139123	18	23
6/20/11	16.9	0.140849	0.141537	28	35
6/26/11	17.16	0.140730	0.141182	18	23

[1] Acceptable Actual Flow Rates (Q_{ACT}) for PM_{10}: 15.0 to 18.4 liters per minute (lpm)

I(1) represents invalid or missing data. The number in parentheses refers to the listing under the "Data Capture Summary" heading for Site 1.

	Actual Arithmetic Mean (µg/m^3)	Standard Arithmetic Mean (µg/m^3)	Data Capture (percent)
April	25.2	30.2	100
May	18.2	22.4	100
June	24.0	30.0	100
Quarter	***22.5***	***27.5***	***100***

New Mexico Copper Corporation – Copper Flat Mine
Second Quarter 2011 Particulate Report

Quarterly PM_{10} Calculations
Sampler Site 1

Number of Days in the Quarter (N): 91

Number of Strata with Samples (M): 15

Number of Observed Exceedances by Stratum

Stratum #	Observed Exceedances (V)
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	0
11	0
12	0
13	0
14	0
15	0

New Mexico Copper Corporation – Copper Flat Mine
Second Quarter 2011 Particulate Report

Quarterly PM_{10} Calculations
Sampler Site 1

Number of Actual Samples by Stratum

Stratum#	**Number of samples (K)**
1	1
2	1
3	1
4	1
5	1
6	1
7	1
8	1
9	1
10	1
11	1
12	1
13	1
14	1
15	1

Expected Number of Exceedances for the Quarter: 0

$e_q = V_q [N_q / n_q]$

e_q = Expected number of exceedances for the quarter

V_q = Observed number of exceedances

N_q = Number of days in quarter

n_q = Number of days in quarter with PM_{10} data

Percent Data Capture for the Quarter: 100

References: 40 CFR Part 50, Appendix K (Revised June 18, 1997)
40 CFR Part 58, Appendix B

Low Volume Sampler Operations and Data Capture Summary

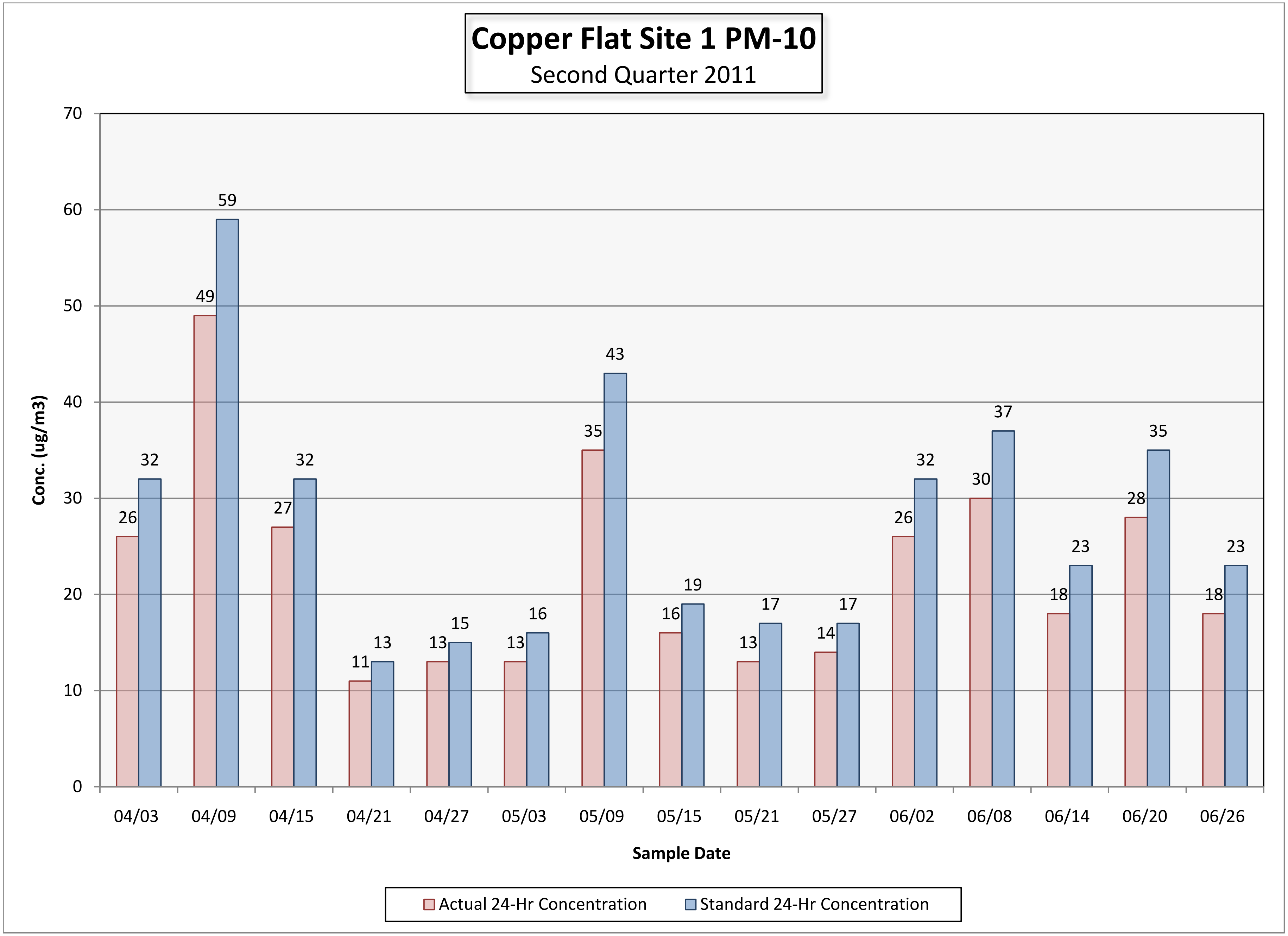
Sampler Site 1

Operations Summary

1) A site visit was performed on 04/13/11 to check flows.
2) A site visit was performed on 05/16/11 to check flows.
3) A site visit was performed on 06/24/11 to check flows.

Data Capture Summary

Sampler Site 1 had one hundred percent data capture for the Second Quarter 2011.



Copper Flat Site 1 PM-10
Second Quarter 2011
Conc. (ug/m3)
70
60
50
40
30
20
10
0
26
32
49
59
27
32
11
13
13
15
13
16
35
43
16
19
13
17
14
17
26
32
30
37
18
23
28
35
18
23
04/03
04/09
04/15
04/21
04/27
05/03
05/09
05/15
05/21
05/27
06/02
06/08
06/14
06/20
06/26
Sample Date
Actual 24-Hr Concentration
Standard 24-Hr Concentration

New Mexico Copper Corporation – Copper Flat Mine
Second Quarter 2011 Particulate Report

Site 2 PM_{10} Particulate Data Summary

Run Date	Q_{ACT} (cmm)[1]	Filter Pre Weight (g)	Filter Post Weight (g)	24 Hour Q_{ACT} Concentration (ug/m^3)	24 Hour Q_{STD} Concentration (ug/m^3)
4/3/11	17.13	0.143863	0.144332	19	23
4/9/11	16.78	0.147839	0.148617	32	39
4/15/11	16.41	0.142561	0.143425	37	44
4/21/11	16.81	0.142557	0.142817	11	13
4/27/11	16.41	0.145117	0.145384	11	14
5/3/11	16.36	0.143258	0.143595	14	17
5/9/11	16.81	0.144101	0.144932	34	42
5/15/11	16.81	0.144752	0.145102	14	18
5/21/11	16.68	0.143528	0.143790	11	13
5/27/11	16.91	0.139987	0.140266	11	14
6/2/11	16.91	0.139014	0.139722	29	36
6/8/11	16.96	0.143825	0.144540	29	37
6/14/11	17.02	0.140090	0.140490	16	21
6/20/11	16.79	0.138034	0.138157	5	6
6/26/11	16.97	0.139909	0.140353	18	23

[1]Acceptable Actual Flow Rates (Q_{ACT}) for PM_{10}: 15.0 to 18.4 liters per minute (lpm)

I(1) represents invalid or missing data. The number in parentheses refers to the listing under the "Data Capture Summary" heading for Site 2.

	Actual Arithmetic Mean (µg/m^3)	Standard Arithmetic Mean (µg/m^3)	Data Capture (percent)
April	22.0	26.6	100
May	16.8	20.8	100
June	19.4	24.6	100
Quarter	***19.4***	***24.0***	***100***

Quarterly PM_{10} Calculations
Sampler Site 2

Number of Days in the Quarter (N): 91

Number of Strata with Samples (M): 15

Number of Observed Exceedances by Stratum

Stratum #	Observed Exceedances (V)
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	0
11	0
12	0
13	0
14	0
15	0

New Mexico Copper Corporation – Copper Flat Mine
Second Quarter 2011 Particulate Report

Quarterly PM_{10} Calculations
Sampler Site 2

Number of Actual Samples by Stratum

Stratum#	Number of samples (K)
1	1
2	1
3	1
4	1
5	1
6	1
7	1
8	1
9	1
10	1
11	1
12	1
13	1
14	1
15	1

Expected Number of Exceedances for the Quarter: 0.0

$e_q = V_q [N_q / n_q]$

e_q= Expected number of exceedances for the quarter

V_q= Observed number of exceedances

N_q= Number of days in quarter

n_q= Number of days in quarter with PM_{10} data

Percent Data Capture for the Quarter: 100

References: 40 CFR Part 50, Appendix K (Revised June 18, 1997)
40 CFR Part 58, Appendix B

New Mexico Copper Corporation – Copper Flat Mine
Second Quarter 2011 Particulate Report

Low Volume Sampler Operations and Data Capture Summary

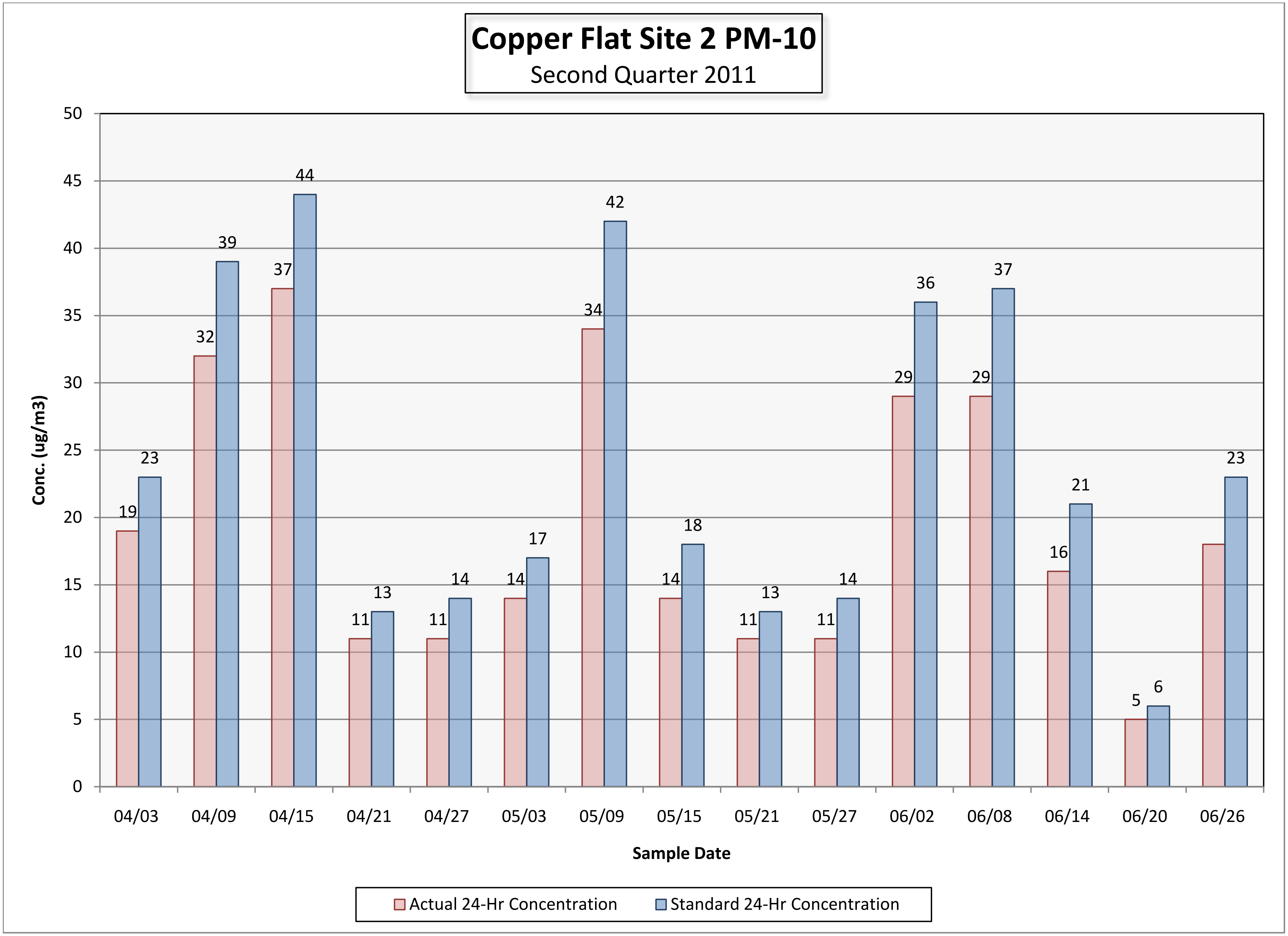
Sampler Site 2

Operations Summary

1) A site visit was performed on 04/13/11 to check flows.
2) A site visit was performed on 05/16/11 to check flows.
3) A site visit was performed on 06/24/11 to check flows.

Data Capture Summary

Sampler Site 2 had one hundred percent data capture for the Second Quarter 2011.


Copper Flat Site 2 PM-10
Second Quarter 2011
Conc. (ug/m3)
0
5
10
15
20
25
30
35
40
45
50
19
23
32
39
37
44
11
13
11
14
14
17
34
42
14
18
11
13
11
14
29
36
29
37
16
21
5
6
23
04/03
04/09
04/15
04/21
04/27
05/03
05/09
05/15
05/21
05/27
06/02
06/08
06/14
06/20
06/26
Sample Date
Actual 24-Hr Concentration
Standard 24-Hr Concentration

Appendix A

Monthly Particulate Data Reports

New Mexico Copper Corporation - Copper Flat Mine
Particulate Matter 10 Micron (PM10) Report
Micrograms per Cubic Meter

Report Period: Second Quarter 2011

Sampler Site 1

Sample Day	Filter #	Start Weight (grams)	End Weight (grams)	Sample Time (min)	Ambient Temperature (C)	Actual Flow (lpm)	Standard Flow (slpm)	PM10 Actual (ug/m3)	PM10 Standard (ug/m3)	Valid Sample	Comments
4/3/2011	77	.146926	.147574	1440	20	17.41	14.19	26	32	☐	
4/9/2011	79	.148009	.149221	1440	14	17.06	14.19	49	59	☐	
4/15/2011	81	.144533	.145179	1440	14	16.72	13.91	27	32	☐	
4/21/2011	83	.144011	.144271	1440	21	17.12	13.91	11	13	☐	
4/27/2011	85	.145450	.145754	1440	14	16.72	13.91	13	15	☐	
5/3/2011	87	.148011	.148327	1440	13	16.66	13.91	13	16	☐	
5/9/2011	89	.148568	.149429	1440	21	17.12	13.91	35	43	☐	
5/15/2011	91	.149001	.149388	1440	21	17.12	13.91	16	19	☐	
5/21/2011	93	.143858	.144184	1440	22	16.79	13.59	13	17	☐	
5/27/2011	95	.142398	.142739	1440	26	17.02	13.59	14	17	☐	
6/2/2011	97	.139567	.140202	1440	26	17.02	13.59	26	32	☐	
6/8/2011	99	.140869	.141595	1440	27	17.07	13.59	30	37	☐	

Sample Day	Filter #	Start Weight (grams)	End Weight (grams)	Sample Time (min)	Ambient Temperature (C)	Actual Flow (lpm)	Standard Flow (slpm)	PM10 Actual (ug/m3)	PM10 Standard (ug/m3)	Valid Sample	Comments
6/14/2011	101	.138674	.139123	1440	28	17.13	13.59	18	23	☐	
6/20/2011	103	.140849	.141537	1440	24	16.90	13.59	28	35	☐	
6/26/2011	105	.140730	.141182	1440	31	17.16	13.48	18	23	☐	

New Mexico Copper Corporation - Copper Flat Mine
Particulate Matter 10 Micron (PM10) Report
Micrograms per Cubic Meter

Report Period: Second Quarter 2011

Sampler Site 2

Sample Day	Filter #	Start Weight (grams)	End Weight (grams)	Sample Time (min)	Ambient Temperature (C)	Actual Flow (lpm)	Standard Flow (slpm)	PM10 Actual (ug/m3)	PM10 Standard (ug/m3)	Valid Sample	Comments
4/3/2011	78	.143863	.144332	1440	20	17.13	13.96	19	23	☐	
4/9/2011	80	.147839	.148617	1440	14	16.78	13.96	32	39	☐	
4/15/2011	82	.142561	.143425	1440	14	16.41	13.66	37	44	☐	
4/21/2011	84	.142557	.142817	1440	21	16.81	13.66	11	13	☐	
4/27/2011	86	.145117	.145384	1440	14	16.41	13.66	11	14	☐	
5/3/2011	88	.143258	.143595	1440	13	16.36	13.66	14	17	☐	
5/9/2011	90	.144101	.144932	1440	21	16.81	13.66	34	42	☐	
5/15/2011	92	.144752	.145102	1440	21	16.81	13.66	14	18	☐	
5/21/2011	94	.143528	.143790	1440	22	16.68	13.50	11	13	☐	
5/27/2011	96	.139987	.140266	1440	26	16.91	13.50	11	14	☐	
6/2/2011	98	.139014	.139722	1440	26	16.91	13.50	29	36	☐	
6/8/2011	100	.143825	.144540	1440	27	16.96	13.50	29	37	☐	

Sample Day	Filter #	Start Weight (grams)	End Weight (grams)	Sample Time (min)	Ambient Temperature (C)	Actual Flow (lpm)	Standard Flow (slpm)	PM10 Actual (ug/m3)	PM10 Standard (ug/m3)	Valid Sample	Comments
6/14/2011	102	.140090	.140490	1440	28	17.02	13.50	16	21	☐	
6/20/2011	104	.138034	.138157	1440	24	16.79	13.50	5	6	☐	
6/26/2011	106	.139909	.140353	1440	31	16.97	13.33	18	23	☐	

New Mexico Copper Corporation

Copper Flat Mine

Air Monitoring Program Quarterly Report
for
Particulate Samplers

Third Quarter 2011
(July through September)

Prepared By:

Class One Technical Services, Inc.
3500 Comanche Rd NE, Suite G
Albuquerque, New Mexico 87107

December 1, 2011

Table Of Contents

New Mexico Copper Corporation – Copper Flat Mine
Third Quarter 2011 Particulate Report

Executive Summary

Data capture for Third Quarter 2011 ranged from 88 percent at Site 1 to 94 percent at Site 2. Site 1 had two invalid runs on 08/19/11 and 08/25/11 due to the date and time not being set correctly. Site 2 had one invalid run on 07/14/11 also due to the date and time not being set correctly.

The Federal 24-hour PM_{10} standard of 150 $\mu g/m^3$ was not exceeded during Third Quarter 2011. The highest PM_{10} concentration of 68 $\mu g/m^3$ was recorded on 09/30/11, by sampler Site 2. The second highest concentration of 66 $\mu g/m^3$ was recorded on 09/30/11 by Site 1.

The table below summarizes the percent data capture and maximum particulate concentrations recorded during Third Quarter 2011 for each sampler.

Sampler	Parameter	24-Hour Max Conc. ($\mu g/m^3$)	Date of Maximum Concentration	Quarterly Percent Data Capture
Site 1	PM_{10}	66	09/30/11	88
Site 2	PM_{10}	68	09/30/11	94

Note: Federal 24-Hour PM_{10} Standard: 150 $\mu g/m^3$

New Mexico Copper Corporation – Copper Flat Mine
Third Quarter 2011 Particulate Report

Introduction

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. During Third Quarter 2011, Class One Technical Services (CTS) conducted quality assurance, instrument repair (as requested), data reduction, and data reporting for each particulate sampler. The daily operations such as filter changes, mass flow readings, flow checks, and general instrument checks were handled entirely by New Mexico Copper Corporation, Copper Flat environmental quality staff. The samplers initiated operations on August 6, 2010.

Each sampler runs once every six days for a full twenty-four hour period from midnight to midnight. All samplers run simultaneously.

During quarterly sampler flow checks, flow rate is adjusted to be within four (4) percent of 16.67 litres 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 (Q_{ACT}).

Actual flow rates are converted into standard flow rates (Q_{STD}) at standard temperature (298 °K) 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 Q_{ACT} and Q_{STD} together with net weight gain are used to determine the 24-hour particulate concentration in micrograms per cubic meter ($\mu g/m^3$).

PM_{10} concentrations based on standard flow rates are reported to comply with the National Ambient Air Quality Standards (NAAQS) promulgated in December 2006. The Environmental Protection Agency implemented the new standard January 1, 2007.

PM_{10}

USEPA Quality Assurance Handbook for Air Pollution Measurement Systems: Volume II, Ambient Air Specific Methods (Section 2.11.0, December 2008) and 40 CFR Part 50, Appendix K (Revised October 2006).

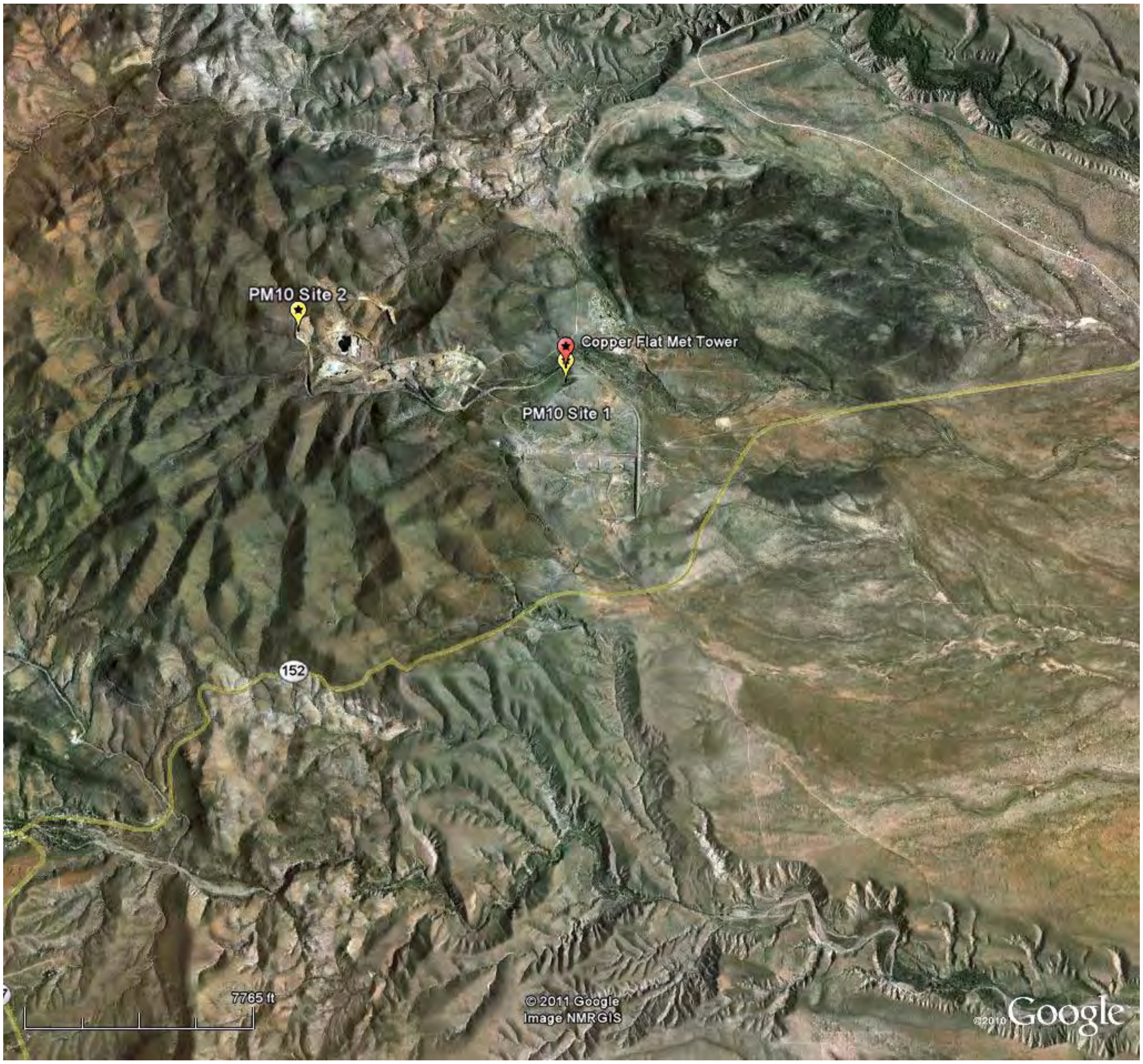
New Mexico Copper Corporation – Copper Flat Mine
Third Quarter 2011 Particulate Report

Copper Flat Mine Particulate Samplers
Coordinates and Elevations

Sampler	Coordinates	Elevation (ft.)
Site 1 (PM_{10})	UTM Coordinates: Easting 265,721 meters Northing 3,650,419 meters	5402
SH02 (PM_{10})	UTM Coordinates: Easting 262,618 meters Northing 3,651,000 meters	5596

Note: Coordinates taken with portable GPS unit set in the NAD 83 mode.

Figure 1: Map of Copper Flat PM_{10} Sampler Locations



New Mexico Copper Corporation – Copper Flat Mine
Third Quarter 2011 Particulate Report

Site 1 PM_{10} Particulate Data Summary

Run Date	Q_{ACT} (cmm)[1]	Filter Pre Weight (g)	Filter Post Weight (g)	24 Hour Q_{ACT} Concentration (ug/m^3)	24 Hour Q_{STD} Concentration (ug/m^3)
7/2/11	16.94	0.139717	0.140507	32	41
7/8/11	17.05	0.140513	0.140857	14	18
7/14/11	16.82	0.141026	0.141343	13	16
7/20/11	16.92	0.140498	0.140911	17	21
7/26/11	16.92	0.139688	0.139981	12	15
8/1/11	16.81	0.137374	0.137734	15	19
8/7/11	17.03	0.137910	0.138242	14	17
8/13/11	16.48	0.139284	0.139680	17	21
8/19/11	16.54	0.137978	0.138131	I(1)	I(1)
8/25/11	16.65	0.138247	0.138380	I(1)	I(1)
8/31/11	16.76	0.137464	0.137777	13	16
9/6/11	16.54	0.138407	0.138477	3	4
9/12/11	16.43	0.137788	0.138167	16	20
9/18/11	16.43	0.137563	0.137814	11	13
9/24/11	16.54	0.137585	0.137947	15	19
9/30/11	16.31	0.139009	0.140307	55	68

[1]Acceptable Actual Flow Rates (Q_{ACT}) for PM_{10}: 15.0 to 18.4 liters per minute (lpm)

I(1) represents invalid or missing data. The number in parentheses refers to the listing under the "Data Capture Summary" heading for Site 1.

	Actual Arithmetic Mean ($\mu g/m^3$)	Standard Arithmetic Mean ($\mu g/m^3$)	Data Capture (percent)
July	17.6	22.2	100
August	14.8	18.3	67
September	20.0	24.8	100
Quarter	***17.6***	***22.0***	***88***

New Mexico Copper Corporation – Copper Flat Mine
Third Quarter 2011 Particulate Report

Quarterly PM_{10} Calculations
Sampler Site 1

Number of Days in the Quarter (N): 92

Number of Strata with Samples (M): 14

Number of Observed Exceedances by Stratum

Stratum #	Observed Exceedances (V)
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	0
11	0
12	0
13	0
14	0

Quarterly PM_{10} Calculations
Sampler Site 1

Number of Actual Samples by Stratum

Stratum#	Number of samples (K)
1	1
2	1
3	1
4	1
5	1
6	1
7	1
8	1
9	1
10	1
11	1
12	1
13	1
14	1

Expected Number of Exceedances for the Quarter: 0

$e_q = V_q [N_q / n_q]$

e_q= Expected number of exceedances for the quarter

V_q= Observed number of exceedances

N_q= Number of days in quarter

n_q= Number of days in quarter with PM_{10} data

Percent Data Capture for the Quarter: 88

References: 40 CFR Part 50, Appendix K (Revised June 18, 1997)
40 CFR Part 58, Appendix B

New Mexico Copper Corporation – Copper Flat Mine
Third Quarter 2011 Particulate Report

Low Volume Sampler Operations and Data Capture Summary

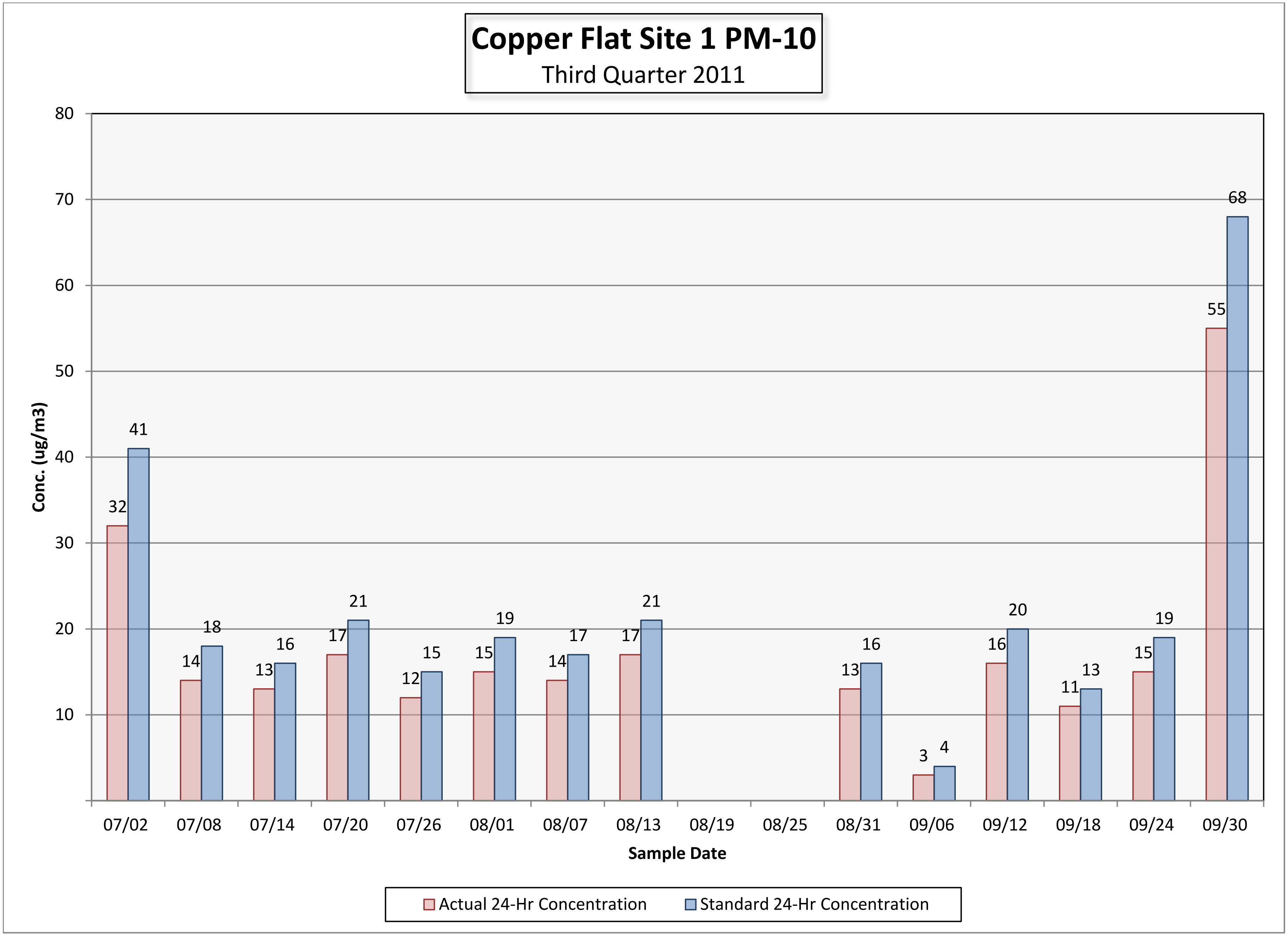
Sampler Site 1

Operations Summary

1) A site visit was performed on 07/15/11 to check flows.
2) A site visit was performed on 08/09/11 to check flows.

Data Capture Summary

1) Sample run dates 08/19/11 and 08/25/11 were not completed due to the date and time for the sample run not being set correctly.


Copper Flat Site 1 PM-10
Third Quarter 2011
Conc. (ug/m3)
80
70
60
50
40
30
20
10
32
41
14
18
13
16
17
21
12
15
15
19
14
17
17
21
13
16
3
4
16
20
11
13
15
19
55
68
07/02
07/08
07/14
07/20
07/26
08/01
08/07
08/13
08/19
08/25
08/31
09/06
09/12
09/18
09/24
09/30
Sample Date
Actual 24-Hr Concentration
Standard 24-Hr Concentration

New Mexico Copper Corporation – Copper Flat Mine
Third Quarter 2011 Particulate Report

Site 2 PM_{10} Particulate Data Summary

Run Date	Q_{ACT} (cmm)[1]	Filter Pre Weight (g)	Filter Post Weight (g)	24 Hour Q_{ACT} Concentration (ug/m³)	24 Hour Q_{STD} Concentration (ug/m³)
7/2/11	16.75	0.139684	0.140438	31	39
7/8/11	16.86	0.140839	0.140893	2	3
7/14/11	16.64	0.141107	0.141178	I(1)	I(1)
7/20/11	16.77	0.139124	0.139288	7	9
7/26/11	16.77	0.138747	0.138886	6	7
8/1/11	16.65	0.138498	0.138662	7	9
8/7/11	16.88	0.137420	0.137690	11	14
8/13/11	16.45	0.137980	0.138160	8	9
8/19/11	16.50	0.136994	0.137177	8	10
8/25/11	16.62	0.138265	0.138521	11	13
8/31/11	16.73	0.138819	0.139088	11	14
9/6/11	16.50	0.136688	0.137030	14	18
9/12/11	16.39	0.138519	0.138828	13	16
9/18/11	16.39	0.138040	0.138261	9	12
9/24/11	16.50	0.137736	0.138014	12	15
9/30/11	16.28	0.140713	0.141971	54	66

[1]Acceptable Actual Flow Rates (Q_{ACT}) for PM_{10}: 15.0 to 18.4 liters per minute (lpm)

I(1) represents invalid or missing data. The number in parentheses refers to the listing under the "Data Capture Summary" heading for Site 2.

	Actual Arithmetic Mean (µg/m³)	Standard Arithmetic Mean (µg/m³)	Data Capture (percent)
July	11.5	14.5	80
August	9.3	11.0	100
September	20.4	25.4	100
Quarter	***13.6***	***13.4***	***94***

New Mexico Copper Corporation – Copper Flat Mine
Third Quarter 2011 Particulate Report

Quarterly PM_{10} Calculations
Sampler Site 2

Number of Days in the Quarter (N): 92

Number of Strata with Samples (M): 15

Number of Observed Exceedances by Stratum

Stratum #	Observed Exceedances (V)
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	0
11	0
12	0
13	0
14	0
15	0

New Mexico Copper Corporation – Copper Flat Mine
Third Quarter 2011 Particulate Report

Quarterly PM_{10} Calculations
Sampler Site 2

Number of Actual Samples by Stratum

Stratum#	Number of samples (K)
1	1
2	1
3	1
4	1
5	1
6	1
7	1
8	1
9	1
10	1
11	1
12	1
13	1
14	1
15	1

Expected Number of Exceedances for the Quarter: 0.0

$e_q = V_q [N_q / n_q]$

e_q= Expected number of exceedances for the quarter

$V_{q=}$ Observed number of exceedances

$N_{q=}$ Number of days in quarter

n_q= Number of days in quarter with PM_{10} data

Percent Data Capture for the Quarter: 94

References: 40 CFR Part 50, Appendix K (Revised June 18, 1997)
40 CFR Part 58, Appendix B

Low Volume Sampler Operations and Data Capture Summary

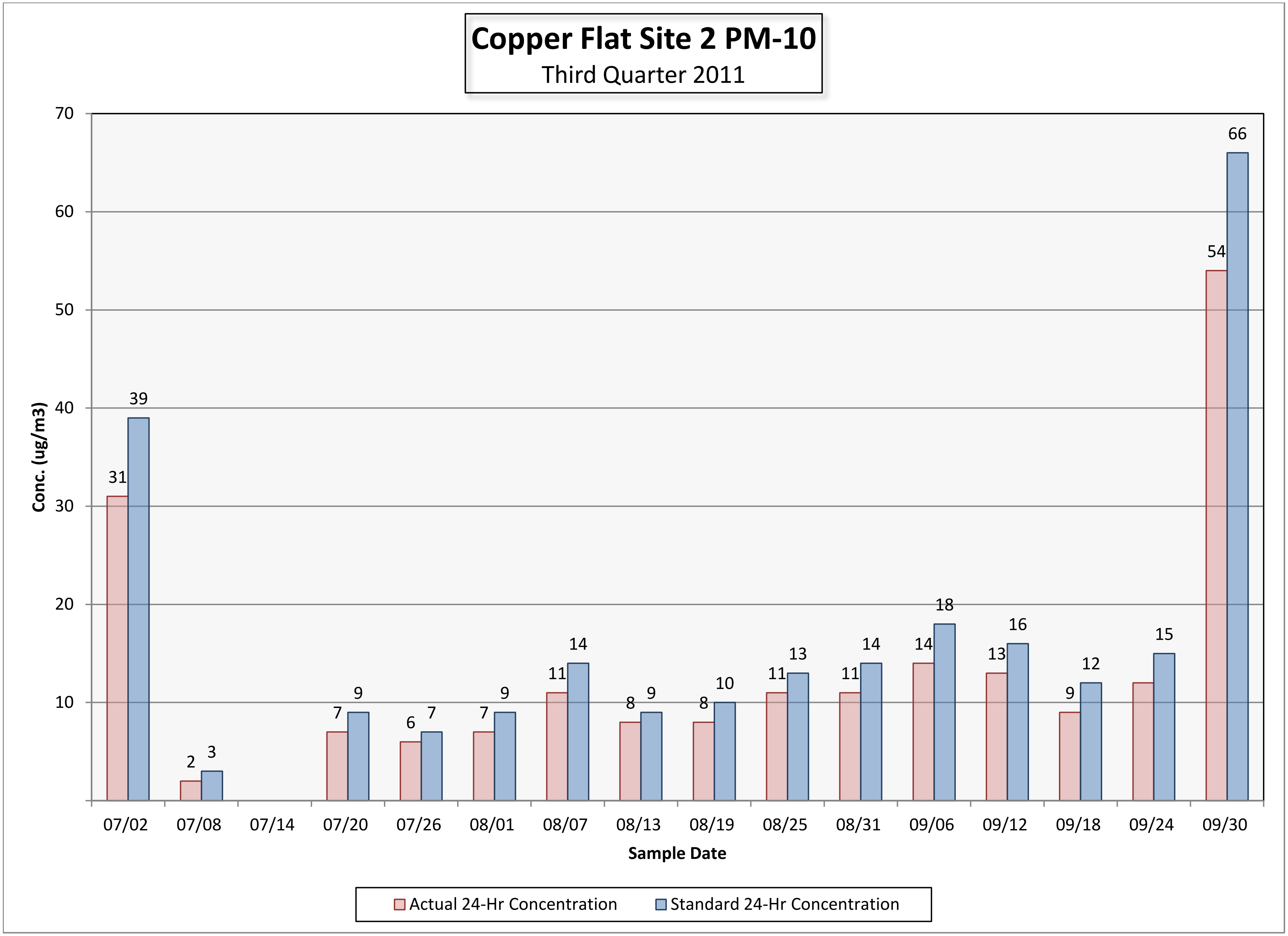
Sampler Site 2

Operations Summary

1) A site visit was performed on 07/15/11 to check flows.
2) A site visit was performed on 08/09/11 to check flows.

Data Capture Summary

1) Sample run date 07/14/11 was not completed due to the date and time for the run being set incorrectly.


Copper Flat Site 2 PM-10
Third Quarter 2011
Conc. (ug/m3)
70
60
50
40
30
20
10
31
39
2
3
7
9
6
7
7
9
11
14
8
9
8
10
11
13
11
14
14
18
13
16
9
12
15
54
66
07/02
07/08
07/14
07/20
07/26
08/01
08/07
08/13
08/19
08/25
08/31
09/06
09/12
09/18
09/24
09/30
Sample Date
Actual 24-Hr Concentration
Standard 24-Hr Concentration

Appendix A

Monthly Particulate Data Reports

New Mexico Copper Corporation - Copper Flat Mine
Particulate Matter 10 Micron (PM10) Report
Micrograms per Cubic Meter

Report Period: Third Quarter 2011

Sampler Site 1

Sample Day	Filter #	Start Weight (grams)	End Weight (grams)	Sample Time (min)	Ambient Temperature (C)	Actual Flow (lpm)	Standard Flow (slpm)	PM10 Actual (ug/m3)	PM10 Standard (ug/m3)	Valid Sample	Comments
7/2/2011	107	.139717	.140507	1440	27	16.94	13.48	32	41	☐	
7/8/2011	109	.140513	.140857	1440	29	17.05	13.48	14	18	☐	
7/14/2011	111	.141026	.141343	1440	25	16.82	13.48	13	16	☐	
7/20/2011	113	.140498	.140911	1440	27	16.92	13.47	17	21	☐	
7/26/2011	115	.139688	.139981	1440	27	16.92	13.47	12	15	☐	
8/1/2011	117	.137374	.137734	1440	25	16.81	13.47	15	19	☐	
8/7/2011	119	.137910	.138242	1440	29	17.03	13.47	14	17	☐	
8/13/2011	121	.139284	.139680	1440	23	16.48	13.30	17	21	☐	
8/19/2011	123	.137978	.138131	1	24	16.54	13.30	9252	#####	☑	No run due to no start time set
8/25/2011	125	.138247	.138380	1	26	16.65	13.30	7989	#####	☑	No run due to date and time not set
8/31/2011	127	.137464	.137777	1440	28	16.76	13.30	13	16	☐	

Sample Day	Filter #	Start Weight (grams)	End Weight (grams)	Sample Time (min)	Ambient Temperature (C)	Actual Flow (lpm)	Standard Flow (slpm)	PM10 Actual (ug/m3)	PM10 Standard (ug/m3)	Valid Sample	Comments
9/6/2011	129	.138407	.138477	1440	24	16.54	13.30	3	4	☐	
9/12/2011	131	.137788	.138167	1440	22	16.43	13.30	16	20	☐	
9/18/2011	133	.137563	.137814	1440	22	16.43	13.30	11	13	☐	
9/24/2011	135	.137585	.137947	1440	24	16.54	13.30	15	19	☐	
9/30/2011	137	.139009	.140307	1440	20	16.31	13.30	55	68	☐	

New Mexico Copper Corporation - Copper Flat Mine
Particulate Matter 10 Micron (PM10) Report
Micrograms per Cubic Meter

Report Period: Third Quarter 2011

Sampler Site 2

Sample Day	Filter #	Start Weight (grams)	End Weight (grams)	Sample Time (min)	Ambient Temperature (C)	Actual Flow (lpm)	Standard Flow (slpm)	PM10 Actual (ug/m3)	PM10 Standard (ug/m3)	Valid Sample	Comments
7/2/2011	108	.139684	.140438	1440	27	16.75	13.33	31	39	☐	
7/8/2011	110	.140839	.140893	1440	29	16.86	13.33	2	3	☐	
7/14/2011	112	.141107	.141178	1	25	16.64	13.33	4268	5326	☑	No run due to no data or time set
7/20/2011	114	.139124	.139288	1440	27	16.77	13.35	7	9	☐	
7/26/2011	116	.138747	.138886	1440	27	16.77	13.35	6	7	☐	
8/1/2011	118	.138498	.138662	1440	25	16.65	13.35	7	9	☐	
8/7/2011	120	.137420	.137690	1440	29	16.88	13.35	11	14	☐	
8/13/2011	122	.137980	.138160	1440	23	16.45	13.27	8	9	☐	
8/19/2011	124	.136994	.137177	1440	24	16.50	13.27	8	10	☐	
8/25/2011	126	.138265	.138521	1440	26	16.62	13.27	11	13	☐	
8/31/2011	128	.138819	.139088	1440	28	16.73	13.27	11	14	☐	
9/6/2011	130	.136688	.137030	1440	24	16.50	13.27	14	18	☐	

Sample Day	Filter #	Start Weight (grams)	End Weight (grams)	Sample Time (min)	Ambient Temperature (C)	Actual Flow (lpm)	Standard Flow (slpm)	PM10 Actual (ug/m3)	PM10 Standard (ug/m3)	Valid Sample	Comments
9/12/2011	132	.138519	.138828	1440	22	16.39	13.27	13	16	☐	
9/18/2011	134	.138040	.138261	1440	22	16.39	13.27	9	12	☐	
9/24/2011	136	.137736	.138014	1440	24	16.50	13.27	12	15	☐	
9/30/2011	138	.140713	.141971	1440	20	16.28	13.27	54	66	☐	

Appendix 4-A

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

Appendix 4-A (Table 1). 2010 Cover Data: Copper Flat - Chihuahuan Desert Grassland Stratum (CDG)

Sample Area - Chihuahuan Desert Grassland

29 Transects — Transect -- % Cover (point counts)

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	Mean Cover	Relative Lifeform	Relative Perennial	Relative Live Veg	Relative Total	S-W Index	S-W Index
Grasses (perennial)	BU-1	BU-2	BU-3	BU-4	BU-5	BU-6	BU-7	BU-8	BU-9	BU-10	BU-11	BU-12	BU-13	BU-14	BU-15	BU-16	BU-17	BD-1	BD-2	BD-3	BD-4	BD-5	BD-6	BD-7	BD-8	BD-9	BD-10	BD-11	BD-12	%	%	%	%	%	peren	all veg
Andropogon hallii																		1.0												0.03	0.1	0.1	0.1	0.0	0.00	0.00
Aristida havardii	2.0	2.0		1.0				1.0	3.0	1.0	2.0	2.0	1.0	7.0	2.0										3.0	5.0				1.10	2.9	2.0	1.7	1.2	0.08	0.07
Aristida purpurea				2.0	1.0											1.0					1.0					1.0				0.21	0.5	0.4	0.3	0.2	0.02	0.02
Aristida ternipes																						1.0		1.0		6.0				0.28	0.7	0.5	0.4	0.3	0.03	0.02
Bothriochloa barbinodis	2.0	1.0	3.0	1.0			1.0	1.0	3.0	3.0	3.0		1.0	5.0	6.0			1.0								3.0				1.17	3.1	2.1	1.8	1.3	0.08	0.07
Bouteloua curtipendula	3.0	22.0	16.0	33.0	35.0	31.0	30.0	4.0	11.0	20.0	33.0	16.0	9.0	23.0	11.0	15.0	9.0	13.0		4.0	14.0	3.0	2.0	4.0	11.0	3.0	2.0	4.0		13.14	34.8	23.7	20.4	14.1	0.34	0.32
Bouteloua eriopoda	30.0	28.0	27.0	4.0			5.0	18.0	10.0	10.0	5.0	22.0	24.0	12.0	21.0			11.0	4.0		9.0	19.0	12.0	23.0	16.0			14.0		11.17	29.6	20.2	17.4	12.0	0.32	0.30
Bouteloua gracilis				11.0	1.0				2.0	11.0			6.0	2.0					1.0	5.0			1.0							1.38	3.7	2.5	2.1	1.5	0.09	0.08
Bouteloua hirsuta			10.0	6.0					7.0				1.0	7.0				2.0	19.0							1.0				1.83	4.8	3.3	2.8	2.0	0.11	0.10
Dasyochloa pulchella																5.0						3.0	6.0					15.0		1.00	2.7	1.8	1.6	1.1	0.07	0.06
Enneapogon desvauxii						1.0																								0.03	0.1	0.1	0.1	0.0	0.00	0.00
Eragrostis curvula																		2.0						1.0						0.10	0.3	0.2	0.2	0.1	0.01	0.01
Eragrostis lehmanniana																										1.0				0.03	0.1	0.1	0.1	0.0	0.00	0.00
Hesperostipa comata								1.0											1.0											0.07	0.2	0.1	0.1	0.1	0.01	0.01
Leptochloa dubia																	1.0													0.03	0.1	0.1	0.1	0.0	0.00	0.00
Lycurus phleoides																		4.0												0.14	0.4	0.2	0.2	0.1	0.01	0.01
Muhlenbergia porteri													2.0				3.0			2.0		3.0	1.0				3.0	1.0		0.52	1.4	0.9	0.8	0.6	0.04	0.04
Panicum obtusum						3.0	3.0								1.0	1.0	12.0													0.69	1.8	1.2	1.1	0.7	0.05	0.05
Piptatherum micranthum														2.0																0.07	0.2	0.1	0.1	0.1	0.01	0.01
Pleuraphis mutica	2.0						21.0		12.0	1.0		27.0	2.0		6.0					14.0	5.0	6.0	7.0		10.0					3.90	10.3	7.0	6.1	4.2	0.19	0.17
Setaria leucopila										8.0			2.0	2.0	6.0		1.0													0.66	1.7	1.2	1.0	0.7	0.05	0.05
Sporobolus contractus											1.0						2.0													0.10	0.3	0.2	0.2	0.1	0.01	0.01
Tridens muticus																						2.0								0.07	0.2	0.1	0.1	0.1	0.01	0.01
Grass Total Canopy	39.0	53.0	56.0	58.0	37.0	35.0	60.0	25.0	48.0	54.0	44.0	67.0	48.0	60.0	53.0	22.0	28.0	34.0	25.0	25.0	29.0	37.0	29.0	29.0	40.0	20.0	5.0	34.0	0.0	37.7	100.0	68.1	58.7	40.6		
Forbs (perennials + some biennials)																																				
Acourtia nana																											1.0			0.03	0.8	0.1	0.1	0.0	0.00	0.00
Ambrosia confertiflora									1.0						1.0								1.0	3.0			1.0			0.24	5.9	0.4	0.4	0.3	0.02	0.02
Artemisia ludoviciana						5.0				2.0				2.0																0.31	7.6	0.6	0.5	0.3	0.03	0.03
Astragalus crassicarpus							1.0																							0.03	0.8	0.1	0.1	0.0	0.00	0.00
Bahia absinthifolia																2.0						1.0				3.0			2.0	0.28	6.7	0.5	0.4	0.3	0.03	0.02
Baileya multiradiata																										1.0				0.03	0.8	0.1	0.1	0.0	0.00	0.00
Boerhaavia coccinea																										1.0				0.03	0.8	0.1	0.1	0.0	0.00	0.00
Chamaesaracha sordida																4.0									2.0		1.0	2.0	1.0	0.34	8.4	0.6	0.5	0.4	0.03	0.03
Chamaesyce albomarginata																											1.0	1.0		0.07	1.7	0.1	0.1	0.1	0.01	0.01
Desmanthus cooleyi																	1.0													0.03	0.8	0.1	0.1	0.0	0.00	0.00
Erigeron flagillaris											1.0																			0.03	0.8	0.1	0.1	0.0	0.00	0.00
Eriogonum effusum							1.0	5.0										3.0				9.0	13.0	14.0	8.0	1.0		4.0		2.00	48.7	3.6	3.1	2.2	0.12	0.11
Eriogonum wrightii																			1.0											0.03	0.8	0.1	0.1	0.0	0.00	0.00
Evolvulus nuttallianus															1.0															0.03	0.8	0.1	0.1	0.0	0.00	0.00
Halimolobos diffusus																							1.0							0.03	0.8	0.1	0.1	0.0	0.00	0.00
Hoffmannseggia glauca																					1.0									0.03	0.8	0.1	0.1	0.0	0.00	0.00
Marrubium vulgare																	1.0													0.03	0.8	0.1	0.1	0.0	0.00	0.00
Pectis longipes																					4.0									0.14	3.4	0.2	0.2	0.1	0.01	0.01
Phemeranthus aurantiacus																								1.0						0.03	0.8	0.1	0.1	0.0	0.00	0.00
Senna bauhinioides																										1.0		1.0		0.07	1.7	0.1	0.1	0.1	0.01	0.01
Sida abutifolia															1.0											1.0				0.07	1.7	0.1	0.1	0.1	0.01	0.01
Solanum elaeagnifolium																		2.0												0.07	1.7	0.1	0.1	0.1	0.01	0.01
Sphaeralcea hastulata									1.0																					0.03	0.8	0.1	0.1	0.0	0.00	0.00
Stephanomeria pauciflora	1.0		1.0																											0.07	1.7	0.1	0.1	0.1	0.01	0.01
Forb Total Canopy	1.0	0.0	1.0	0.0	0.0	5.0	2.0	5.0	2.0	2.0	1.0	0.0	0.0	2.0	3.0	6.0	2.0	5.0	1.0	0.0	5.0	10.0	15.0	18.0	10.0	8.0	4.0	8.0	3.0	4.1	100.0	7.4	6.4	4.4		
Shrubs (+ subshrubs + trees)																																				
Aloysia wrightii								4.0														2.0		3.0	3.0		1.0			0.45	3.3	0.8	0.7	0.5	0.04	0.03
Baccharis emoryi																	2.0													0.07	0.5	0.1	0.1	0.1	0.01	0.01
Brickelia californica						1.0																	1.0							0.07	0.5	0.1	0.1	0.1	0.01	0.01
Calliandra eriophylla																						3.0	2.0							0.17	1.3	0.3	0.3	0.2	0.02	0.02
Celtis leavigata																	5.0													0.17	1.3	0.3	0.3	0.2	0.02	0.02
Dalea formosa									1.0							1.0														0.07	0.5	0.1	0.1	0.1	0.01	0.01
Dasylirion wheeleri			6.0					14.0																						0.69	5.1	1.2	1.1	0.7	0.05	0.05
Fouquieria splendens								2.0																						0.07	0.5	0.1	0.1	0.1	0.01	0.01
Flourensia cernua																						3.0					17.0			0.69	5.1	1.2	1.1	0.7	0.05	0.05
Gutierrezia sarothrae	2.0	2.0				1.0	3.0		3.0	1.0	8.0		5.0	5.0	1.0	4.0	10.0	1.0		7.0	3.0		2.0		1.0	7.0		3.0		2.38	17.5	4.3	3.7	2.6	0.14	0.12
Hymenoclea monogyra																	5.0													0.17	1.3	0.3	0.3	0.2	0.02	0.02
Juniperus monosperma				4.0	22.0																									0.90	6.6	1.6	1.4	1.0	0.07	0.06
Larrea tridentata																												2.0	10.0	0.41	3.0	0.7	0.6	0.4	0.04	0.03
Mimosa aculeaticarpa									1.0				9.0		7.0	4.0		20.0		3.0					3.0					1.62	11.9	2.9	2.5	1.7	0.10	0.09
Opuntia chlorotica																1.0														0.03	0.3	0.1	0.1	0.0	0.00	0.00
Quercus emoryi																			11.0											0.38	2.8	0.7	0.6	0.4	0.03	0.03
Quercus turbinella					1.0																									0.03	0.3	0.1	0.1	0.0	0.00	0.00
Parthenium incanum																						3.0	6.0				3.0		3.0	0.52	3.8	0.9	0.8	0.6	0.04	0.04
Prosopis glandulosa	10.0						1.0		1.0			1.0	1.0			1.0	9.0			18.0	4.0	3.0	3.0	3.0	5.0		4.0	2.0	1.0	2.31	17.0	4.2	3.6	2.5	0.13	0.12
Rhus microphylla		2.0															13.0	1.0						2.0			6.0		1.0	0.86	6.3	1.6	1.3	0.9	0.06	0.06
Rhus trilobata						5.0																								0.17	1.3	0.3	0.3	0.2	0.02	0.02
Thymophylla acerosa																2.0										1.0		4.0	31.0	1.31	9.6	2.4	2.0	1.4	0.09	0.08
Yucca elata																												1.0		0.03	0.3	0.1	0.1	0.0	0.00	0.00
Shrub Total Canopy	12.0	4.0	6.0	4.0	23.0	7.0	4.0	20.0	6.0	1.0	8.0	1.0	15.0	5.0	8.0	13.0	44.0	22.0	11.0	28.0	7.0	14.0	14.0	8.0	12.0	8.0	31.0	12.0	46.0	13.6	100.0	24.5	21.1	14.6		
Perennial Total Canopy	52.0	57.0	63.0	62.0	60.0	47.0	66.0	50.0	56.0	57.0	53.0	68.0	63.0	67.0	64.0	41.0	74.0	61.0	37.0	53.0	41.0	61.0	58.0	55.0	62.0	36.0	40.0	54.0	49.0	55.4	100.0	100.0	86.2	59.7	2.89	
***Annuals (mostly forbs)**																																			S-W	
Aristida adscensionis-G																6.0						1.0	1.0			18.0		1.0		0.93	10.5		1.4	1.0		0.06
Boerhaavia spicata													1.0					1.0					2.0	1.0	1.0					0.21	2.3		0.3	0.2		0.02
Bouteloua aristidoides-G																														0.00	0.0		0.0	0.0		
Bouteloua barbata-G																	1.0			2.0						1.0		1.0		0.17	1.9		0.3	0.2		0.02
Chenopodium album						2.0																								0.07	0.8		0.1	0.1		0.01
Chenopodium neomexicanum																								1.0						0.03	0.4		0.1	0.0		0.00
Chloris virgata-G																	1.0													0.03	0.4		0.1	0.0		0.00
Descurainia pinnata																		2.0		1.0										0.10	1.2		0.2	0.1		0.01
Eragrostis pectinacea-G															1.0		3.0													0.14	1.6		0.2	0.1		0.01
Eriogonum rotundifolium																														0.00	0.0		0.0	0.0		
Linum neomexicanum																									1.0					0.03	0.4		0.1	0.0		0.00
Machaeranthera gracilis																										15.0				0.52	5.8		0.8	0.6		0.04
Pectis filipes	20.0	22.0	5.0	8.0	9.0	1.0	17.0		2.0	15.0	3.0	8.0	4.0	10.0	18.0			8.0		3.0		4.0	8.0	8.0	16.0					6.52	73.3		10.1	7.0		0.23
Phacelia sp.																								1.0						0.03	0.4		0.1	0.0		0.00
Plantago patagonica	1.0																							1.0						0.07	0.8		0.1	0.1		0.01
Tidestromia lanuginosa																												1.0		0.03	0.4		0.1	0.0		0.00
Annual Total Canopy	21.0	22.0	5.0	8.0	9.0	3.0	17.0	0.0	2.0	15.0	3.0	8.0	5.0	10.0	19.0	6.0	5.0	11.0	0.0	6.0	0.0	5.0	11.0	12.0	18.0	34.0	0.0	3.0	0.0	8.9	100.0		13.8	9.6		
Total Plant Canopy	73.0	79.0	68.0	70.0	69.0	50.0	83.0	50.0	58.0	72.0	56.0	76.0	68.0	77.0	83.0	47.0	79.0	72.0	37.0	59.0	41.0	66.0	69.0	67.0	80.0	70.0	40.0	57.0	49.0	64.3			100.0	69.3		3.04
Litter	8.0	8.0	13.0	7.0	7.0	11.0	9.0	8.0	14.0	9.0	11.0	5.0	4.0	8.0	4.0	2.0	5.0	7.0	12.0	10.0	16.0	3.0	6.0	4.0	7.0	9.0	4.0	7.0	4.0	7.7				8.2	Litter	S-W
Cobble	12.0	0.0	6.0	6.0	2.0	2.0	2.0	13.0	12.0	2.0	10.0	5.0	6.0	0.0	1.0	25.0	3.0	2.0	9.0	10.0	17.0	10.0	6.0	8.0	2.0	17.0	16.0	11.0	12.0	7.8				8.4	Cobble	
Gravel	4.0	4.0	3.0	7.0	4.0	1.0	3.0	0.0	2.0	2.0	3.0	2.0	5.0	1.0	1.0	2.0	0.0	1.0	4.0	7.0	4.0	2.0	8.0	1.0	3.0	0.0	6.0	4.0	2.0	3.0				3.2	Gravel	
Rock	4.0	7.0	8.0	4.0	14.0	19.0	1.0	19.0	8.0	7.0	13.0	5.0	5.0	11.0	7.0	3.0	4.0	16.0	14.0	9.0	11.0	18.0	10.0	15.0	7.0	0.0	3.0	2.0	0.0	8.4				9.1	Rock	
Bedrock	0.0	0.0	0.0	0.0	0.0	16.0	0.0	6.0	2.0	6.0	0.0	0.0	1.0	3.0	1.0	1.0	0.0	0.0	13.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7				1.8	Bedrock	
Grand Total Cover	101.0	98.0	98.0	94.0	96.0	99.0	98.0	96.0	96.0	98.0	93.0	93.0	89.0	100.0	97.0	80.0	91.0	98.0	89.0	95.0	89.0	99.0	99.0	95.0	99.0	96.0	69.0	81.0	67.0	92.9				100.0	Grand Total	
																													Bare soil	7.1						

Summary of Cover

	Mean	Median	St.Dev.	Sample adequacy (# of transects)
Perennial Grasses	37.7	37.0	16.3	54.3
Perennial Forbs	4.1	2.0	4.6	357.6
Perennial Shrubs	13.6	11.0	11.5	207.0
Perennials - Total	55.4	57.0	9.7	8.9
Annuals/All Veg/Litter/Rock	8.9	6.0	8.2	245.8
	64.3	68.0	13.4	12.6
	7.7	7.0	3.4	58.3
	7.8	6.0	6.1	177.4
	3.0	3.0	2.1	151.5
	8.4	7.0	5.7	131.8
	1.7	0.0	3.9	1557.2
	92.9	96.0	8.6	2.5

Species Count **84**

* Annuals and biennials. G = grass. W = state-listed noxious weed.

Appendix 4-A (Table 2). 2010 Cover Data: Copper Flat - Chihuahuan Desert Shrubland Stratum (CDS)

Sample Area - Chihuahuan Desert Shrubland

19 Transects — Transect -- % Cover (point counts)

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Mean Cover	Relative Lifeform	Relative Perennial	Relative Live Veg	Relative Total	S-W Index	S-W Index
Grasses (perennial)	BU-19	BU-20	BU-21	BU-22	BU-23	BU-24	BU-25	BU-26	BU-27	BD-13	BD-14	BD-15	BD-16	BD-17	BD-18	BD-19	BD-20	BD-21	BD-22	%	%	%	%	%	peren	all veg
Aristida havardii																1.0				0.05	0.6	0.1	0.1	0.1	0.01	0.01
Aristida purpurea	1.0			1.0																0.11	1.1	0.3	0.2	0.1	0.02	0.01
Aristida ternipes												1.0								0.05	0.6	0.1	0.1	0.1	0.01	0.01
Bothriochloa laguroides	8.0			2.0	1.0					1.0										0.63	6.7	1.7	1.5	0.8	0.07	0.06
Bouteloua curtipendula	3.0	2.0		1.0	17.0		3.0	1.0		4.0			4.0							1.84	19.4	5.0	4.4	2.3	0.15	0.14
Bouteloua eriopoda							5.0						17.0							1.16	12.2	3.1	2.7	1.5	0.11	0.10
Bouteloua gracilis													6.0							0.32	3.3	0.9	0.7	0.4	0.04	0.04
Dasyochloa pulchella				3.0			1.0	1.0	14.0	3.0						13.0				1.84	19.4	5.0	4.4	2.3	0.15	0.14
Enneapogon desvauxii						1.0														0.05	0.6	0.1	0.1	0.1	0.01	0.01
Eragrostis curvula										1.0										0.05	0.6	0.1	0.1	0.1	0.01	0.01
Muhlenbergia porteri				3.0	11.0		2.0	3.0	2.0	2.0			1.0							1.26	13.3	3.4	3.0	1.6	0.12	0.11
Panicum obtusum								1.0												0.05	0.6	0.1	0.1	0.1	0.01	0.01
Pleuraphis mutica		6.0					3.0		3.0				14.0							1.37	14.4	3.7	3.2	1.7	0.12	0.11
Setaria leucopila	1.0				10.0									1.0						0.63	6.7	1.7	1.5	0.8	0.07	0.06
Sporobolus contractus					1.0															0.05	0.6	0.1	0.1	0.1	0.01	0.01
Grass Total Canopy	13.0	8.0	0.0	10.0	40.0	1.0	14.0	6.0	19.0	11.0	0.0	1.0	42.0	1.0	0.0	14.0	0.0	0.0	0.0	9.5	100.0	25.7	22.5	12.0		
Forbs (perennials + some biennials)																										
Acourtia nana										1.0								1.0	1.0	0.16	2.0	0.4	0.4	0.2	0.02	0.02
Ambrosia confertiflora												1.0								0.05	0.7	0.1	0.1	0.1	0.01	0.01
Bahia absinthifolia	1.0			1.0		1.0			4.0	3.0				4.0	1.0	1.0			1.0	0.89	11.4	2.4	2.1	1.1	0.09	0.08
Baileya multiradiata		1.0							1.0			1.0								0.16	2.0	0.4	0.4	0.2	0.02	0.02
Boerhaavia coccinea									2.0											0.11	1.3	0.3	0.2	0.1	0.02	0.01
Chaetopappa ericoides	2.0						1.0													0.16	2.0	0.4	0.4	0.2	0.02	0.02
Chamaesaracha sordida								1.0	1.0							1.0				0.16	2.0	0.4	0.4	0.2	0.02	0.02
Chamaesyce albomarginata	1.0	1.0			1.0	1.0			3.0		15.0	19.0	4.0		1.0	4.0				2.63	33.6	7.1	6.2	3.3	0.19	0.17
Eriogonum effusum						1.0	2.0		5.0	8.0		1.0								0.89	11.4	2.4	2.1	1.1	0.09	0.08
Eriogonum sp.		2.0		3.0																0.26	3.4	0.7	0.6	0.3	0.04	0.03
Eriogonum wrightii						5.0		9.0												0.74	9.4	2.0	1.7	0.9	0.08	0.07
Hoffmannseggia glauca			5.0	2.0						1.0	1.0	1.0		1.0	2.0	2.0				0.79	10.1	2.1	1.9	1.0	0.08	0.07
Mentzelia pumila												1.0								0.05	0.7	0.1	0.1	0.1	0.01	0.01
Pectis longipes																				0.00	0.0	0.0	0.0	0.0		
Phemeranthus aurantiacus									1.0											0.05	0.7	0.1	0.1	0.1	0.01	0.01
Solanum elaeagnifolium		2.0			1.0					1.0	3.0		1.0							0.42	5.4	1.1	1.0	0.5	0.05	0.05
Sphaeralcea hastulata									2.0											0.11	1.3	0.3	0.2	0.1	0.02	0.01
Zinnia grandiflora								2.0	1.0				1.0							0.21	2.7	0.6	0.5	0.3	0.03	0.03
Forb Total Canopy	4.0	6.0	5.0	6.0	2.0	8.0	3.0	12.0	20.0	14.0	19.0	24.0	6.0	5.0	4.0	8.0	0.0	1.0	2.0	7.8	100.0	21.3	18.6	9.9		
Shrubs (+ subshrubs + trees)																										
Atriplex canescens			1.0					5.0												0.32	1.6	0.9	0.7	0.4	0.04	0.04
Baccharis pteronioides				2.0	6.0											1.0				0.47	2.4	1.3	1.1	0.6	0.06	0.05
Chilopsis linearis					1.0															0.05	0.3	0.1	0.1	0.1	0.01	0.01
Ephedra trifurca								1.0												0.05	0.3	0.1	0.1	0.1	0.01	0.01
Ericameria nauseosa		1.0																		0.05	0.3	0.1	0.1	0.1	0.01	0.01
Fallugia paradoxa				1.0																0.05	0.3	0.1	0.1	0.1	0.01	0.01
Flourensia cernua	5.0		9.0	1.0			2.0				7.0			10.0	8.0	7.0	14.0	15.0	31.0	5.74	29.4	15.6	13.6	7.2	0.29	0.27
Gutierrezia sarothrae	3.0	1.0	2.0	7.0	4.0	1.0		8.0	4.0	2.0	2.0	12.0		4.0			1.0	4.0		2.89	14.8	7.9	6.9	3.7	0.20	0.18
Hymenoclea monogyra					13.0															0.68	3.5	1.9	1.6	0.9	0.07	0.07
Larrea tridentata	3.0			1.0			3.0								1.0	2.0	10.0			1.05	5.4	2.9	2.5	1.3	0.10	0.09
Lycium pallidum		4.0	1.0																	0.26	1.3	0.7	0.6	0.3	0.04	0.03
Lycium torreyi																	2.0			0.11	0.5	0.3	0.2	0.1	0.02	0.01
Parthenium incanum	5.0						10.0	1.0	2.0											0.95	4.9	2.6	2.2	1.2	0.09	0.09
Prosopis glandulosa		10.0	5.0			3.0		8.0	9.0	14.0	12.0	5.0	4.0	30.0	5.0	10.0	4.0	2.0		6.37	32.6	17.3	15.1	8.0	0.30	0.29
Thymophylla acerosa	3.0						4.0										1.0			0.42	2.2	1.1	1.0	0.5	0.05	0.05
Yucca elata								1.0												0.05	0.3	0.1	0.1	0.1	0.01	0.01
Shrub Total Canopy	19.0	16.0	18.0	12.0	24.0	4.0	19.0	24.0	15.0	16.0	21.0	17.0	4.0	44.0	14.0	20.0	32.0	21.0	31.0	19.5	100.0	53.0	46.3	24.7		
Perennial Total Canopy	36.0	30.0	23.0	28.0	66.0	13.0	36.0	42.0	54.0	41.0	40.0	42.0	52.0	50.0	18.0	42.0	32.0	22.0	33.0	36.8	100.0	100.0	87.4	46.5	**3.01**	
***Annuals (mostly forbs)**																									**S-W**	
Amaranthus palmeri					1.0															0.05	1.0		0.1	0.1		0.01
Amaranthus powellii									1.0											0.05	1.0		0.1	0.1		0.01
Aristida adscensionis-G									2.0											0.11	2.0		0.2	0.1		0.01
Boerhaavia spicata					2.0							2.0								0.21	4.0		0.5	0.3		0.03
Bouteloua aristidoides-G					3.0															0.16	3.0		0.4	0.2		0.02
Bouteloua barbata-G					4.0	13.0		5.0		2.0		5.0			1.0	2.0				1.68	31.7		4.0	2.1		0.13
Chamaesyce sp.									1.0											0.05	1.0		0.1	0.1		0.01
Chenopodium leptophyllum									1.0											0.05	1.0		0.1	0.1		0.01
Chenopodium neomexicanum								1.0		5.0						1.0				0.37	6.9		0.9	0.5		0.04
Chenopodium sp.								1.0												0.05	1.0		0.1	0.1		0.01
Descurainia pinnata																				0.00	0.0		0.0	0.0		
Eriogonum cf. pharnaceoides										1.0									1.0	0.11	2.0		0.2	0.1		0.01
Eriogonum rotundifolium	2.0																			0.11	2.0		0.2	0.1		0.01
Guilleminia densa														4.0						0.21	4.0		0.5	0.3		0.03
Kallstroemia parviflora					2.0															0.11	2.0		0.2	0.1		0.01
Machaeranthera tanacetifolia					6.0															0.32	5.9		0.7	0.4		0.04
Muhlenbergia depauperata-G																1.0				0.05	1.0		0.1	0.1		0.01
Pectis filipes		1.0			1.0															0.11	2.0		0.2	0.1		0.01
Salsola tragus						1.0		2.0		1.0		1.0			1.0					0.32	5.9		0.7	0.4		0.04
Solanum rostratum												1.0								0.05	1.0		0.1	0.1		0.01
Tidestromia lanuginosa		2.0				1.0		1.0	11.0	5.0		1.0								1.11	20.8		2.6	1.4		0.10
Verbesina encelioides												1.0								0.05	1.0		0.1	0.1		0.01
Annual Total Canopy	2.0	3.0	0.0	0.0	19.0	15.0	0.0	10.0	16.0	14.0	0.0	11.0	0.0	4.0	2.0	4.0	0.0	0.0	1.0	5.3	100.0		12.6	6.7		
Total Plant Canopy	38.0	33.0	23.0	28.0	85.0	28.0	36.0	52.0	70.0	55.0	40.0	53.0	52.0	54.0	20.0	46.0	32.0	22.0	34.0	42.2			100.0	53.2		**3.30**
Litter	6.0	5.0	4.0	6.0	8.0	4.0	4.0	6.0	3.0	2.0	3.0	3.0	5.0	7.0	1.0	2.0	2.0	7.0	5.0	4.4				5.5	Litter	**S-W**
Cobble	18.0	5.0	18.0	29.0	0.0	11.0	29.0	0.0	14.0	15.0	39.0	35.0	26.0	22.0	22.0	48.0	43.0	29.0	33.0	22.9				29.0	Cobble	
Gravel	8.0	26.0	3.0	9.0	0.0	5.0	8.0	10.0	5.0	4.0	2.0	3.0	4.0	6.0	2.0	1.0	4.0	5.0	3.0	5.7				7.2	Gravel	
Rock	5.0	6.0	4.0	0.0	2.0	1.0	15.0	0.0	0.0	0.0	0.0	1.0	2.0	0.0	0.0	0.0	0.0	3.0	2.0	2.2				2.7	Rock	
Bedrock	0.0	26.0	0.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9				2.4	Bedrock	
Grand Total Cover	75.0	101.0	52.0	72.0	95.0	49.0	92.0	78.0	92.0	76.0	84.0	95.0	89.0	89.0	45.0	97.0	81.0	66.0	77.0	79.2				100.0	Grand Total	
																			Bare soil	20.8						

Summary of Cover

	Mean	Median	St.Dev.	Sample adequacy (# of transects)
Perennial Grasses	9.5	6.0	12.7	540.6
Perennial Forbs	7.8	6.0	6.8	229.4
Perennial Shrubs	19.5	19.0	9.3	68.1
Perennials - Total	36.8	36.0	13.2	38.8
Annuals/All Veg/Litter/Rock	5.3	2.0	6.5	456.4
	42.2	38.0	17.0	49.1
	4.4	4.0	2.0	61.6
	22.9	22.0	13.7	106.7
	5.7	4.0	5.6	292.7
	2.2	1.0	3.6	848.5
	1.9	0.0	6.3	3293.3
	79.2	81.0	16.5	13.1

Species Count **69**

* Annuals and biennials. G = grass. W = state-listed noxious weed.

Appendix 4-A (Table 3). 2010 Cover Data: Copper Flat - Disturbed Area/Waste Rock Pile Stratum

Sample Area - Disturbed Area/Waste Rock Pile

25 Transects — Transect -- % Cover (point counts)

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	BUH-18 25	Mean Cover	Relative Lifeform	Relative Perennial	Relative Live Veg	Relative Total	S-W Index	S-W Index
Grasses (perennial)																									BU-18	%	%	%	%	%	peren	all veg
Aristida divaricata																							1.0	1.0		0.08	0.4	0.3	0.2	0.1	0.02	0.01
Aristida havardii				2.0	3.0			2.0	1.0			3.0									1.0	4.0	1.0	1.0		0.72	3.9	2.3	1.9	0.9	0.09	0.07
Aristida purpurea		1.0				3.0	3.0	4.0		1.0					3.0	2.0						2.0	1.0	1.0		0.84	4.5	2.7	2.2	1.1	0.10	0.08
Bothriochloa barbinodis	1.0	1.0		5.0	12.0	10.0	6.0	11.0	13.0	14.0		3.0			3.0	3.0			1.0					6.0	3.0	3.68	19.7	11.8	9.6	4.7	0.25	0.22
Bouteloua curtipendula				2.0	14.0	2.0	4.0	7.0		2.0		18.0	19.0	1.0	11.0	31.0	1.0		14.0			2.0	1.0	5.0	5.0	5.56	29.8	17.8	14.4	7.1	0.31	0.28
Bouteloua eriopoda								1.0				17.0	5.0	8.0	2.0	8.0	1.0									1.68	9.0	5.4	4.4	2.1	0.16	0.14
Bouteloua hirsuta				2.0		4.0	6.0		2.0	1.0		4.0	1.0			4.0										0.96	5.1	3.1	2.5	1.2	0.11	0.09
Dasyochloa pulchella						1.0							2.0	13.0	3.0		17.0	8.0		4.0	1.0		4.0		1.0	2.16	11.6	6.9	5.6	2.8	0.18	0.16
Enneapogon desvauxii													4.0								1.0		1.0			0.24	1.3	0.8	0.6	0.3	0.04	0.03
Eragrostis lehmanniana											1.0								1.0							0.08	0.4	0.3	0.2	0.1	0.02	0.01
Hesperostipa comata						1.0																				0.04	0.2	0.1	0.1	0.1	0.01	0.01
Leptochloa dubia					1.0							1.0														0.08	0.4	0.3	0.2	0.1	0.02	0.01
Muhlenbergia porteri					5.0							2.0	2.0					5.0					1.0	3.0	1.0	0.76	4.1	2.4	2.0	1.0	0.09	0.08
Panicum obtusum							2.0												2.0			8.0				0.48	2.6	1.5	1.2	0.6	0.06	0.05
Pleuraphis mutica							1.0					1.0		7.0				7.0		7.0						0.92	4.9	2.9	2.4	1.2	0.10	0.09
Setaria leucopila					2.0														1.0			1.0		1.0		0.20	1.1	0.6	0.5	0.3	0.03	0.03
Sporobolus contractus																2.0										0.08	0.4	0.3	0.2	0.1	0.02	0.01
Sporobolus cryptandrus																							2.0			0.08	0.4	0.3	0.2	0.1	0.02	0.01
Sporobolus giganteus															1.0											0.04	0.2	0.1	0.1	0.1	0.01	0.01
Grass Total Canopy	1.0	2.0	0.0	11.0	37.0	21.0	22.0	25.0	16.0	18.0	1.0	49.0	33.0	29.0	23.0	50.0	19.0	20.0	19.0	11.0	3.0	17.0	12.0	18.0	10.0	18.7	100.0	59.8	48.5	23.9		
Forbs (perennials + some biennials)																																
Acourtia nana																									1.0	0.04	1.1	0.1	0.1	0.1	0.01	0.01
Ambrosia confertiflora												1.0							1.0						1.0	0.12	3.2	0.4	0.3	0.2	0.02	0.02
Bahia absinthifolia													1.0		2.0	2.0				4.0	2.0		2.0	1.0		0.56	15.1	1.8	1.5	0.7	0.07	0.06
Baileya multiradiata															2.0											0.08	2.2	0.3	0.2	0.1	0.02	0.01
Chaetopappa ericoides															1.0	1.0	1.0									0.12	3.2	0.4	0.3	0.2	0.02	0.02
Chamaesaracha sordida															2.0			1.0								0.12	3.2	0.4	0.3	0.2	0.02	0.02
Chamaesyce albomarginata																			1.0	5.0	1.0		5.0	1.0		0.52	14.0	1.7	1.3	0.7	0.07	0.06
Dalea jamesii															1.0	1.0										0.08	2.2	0.3	0.2	0.1	0.02	0.01
Dalea lanata				3.0											1.0											0.16	4.3	0.5	0.4	0.2	0.03	0.02
Eriogonum effusum							4.0					1.0	2.0	8.0	1.0		1.0			2.0				2.0	9.0	1.20	32.3	3.8	3.1	1.5	0.13	0.11
Hoffmannseggia glauca									1.0	1.0										5.0			1.0	1.0		0.36	9.7	1.2	0.9	0.5	0.05	0.04
Mentzelia pumila																	1.0									0.04	1.1	0.1	0.1	0.1	0.01	0.01
Phemeranthus aurantiacus														1.0												0.04	1.1	0.1	0.1	0.1	0.01	0.01
Solanum elaeagnifolium												1.0						1.0				1.0				0.12	3.2	0.4	0.3	0.2	0.02	0.02
Stephanomeria pauciflora								1.0															1.0			0.08	2.2	0.3	0.2	0.1	0.02	0.01
Zinnia grandilfora																1.0		1.0								0.08	2.2	0.3	0.2	0.1	0.02	0.01
Forb Total Canopy	0.0	0.0	0.0	3.0	0.0	0.0	4.0	1.0	1.0	1.0	0.0	3.0	3.0	9.0	10.0	5.0	3.0	3.0	2.0	16.0	3.0	1.0	9.0	5.0	11.0	3.7	100.0	11.9	9.7	4.8		
Shrubs (+ subshrubs + trees)																																
Baccharis pteronioides								1.0																	3.0	0.16	1.8	0.5	0.4	0.2	0.03	0.02
Brickellia californica		1.0			2.0	1.0	3.0		1.0	3.0																0.44	5.0	1.4	1.1	0.6	0.06	0.05
Calliandra eriophylla							4.0																			0.16	1.8	0.5	0.4	0.2	0.03	0.02
Dalea formosa													15.0	1.0	1.0				2.0					12.0		1.24	14.0	4.0	3.2	1.6	0.13	0.11
Fallugia paradoxa	6.0				2.0																		1.0			0.36	4.1	1.2	0.9	0.5	0.05	0.04
Gutierrezia sarothrae				2.0	2.0	5.0	4.0			2.0		4.0	2.0	3.0	5.0	1.0	3.0		2.0	1.0		12.0	6.0	2.0	1.0	2.28	25.8	7.3	5.9	2.9	0.19	0.17
Hymenoclea monogyra					1.0	5.0																			2.0	0.32	3.6	1.0	0.8	0.4	0.05	0.04
Larrea tridentata																									3.0	0.12	1.4	0.4	0.3	0.2	0.02	0.02
Lycium pallidum																		2.0								0.08	0.9	0.3	0.2	0.1	0.02	0.01
Mimosa aculeaticarpa				2.0						2.0		7.0	5.0													0.64	7.2	2.0	1.7	0.8	0.08	0.07
Parthenium incanum														4.0												0.16	1.8	0.5	0.4	0.2	0.03	0.02
Prosopis glandulosa				1.0	1.0			4.0				3.0	3.0	5.0	6.0	4.0	5.0	3.0	3.0	9.0		14.0	1.0	1.0	8.0	2.84	32.1	9.1	7.4	3.6	0.22	0.19
Thymophylla acerosa														1.0												0.04	0.5	0.1	0.1	0.1	0.01	0.01
Shrub Total Canopy	6.0	1.0	0.0	5.0	8.0	11.0	11.0	5.0	1.0	7.0	0.0	14.0	25.0	14.0	12.0	5.0	8.0	5.0	7.0	10.0	0.0	26.0	8.0	15.0	17.0	8.8	100.0	28.3	22.9	11.3		
Perennial Total Canopy	7.0	3.0	0.0	19.0	45.0	32.0	37.0	31.0	18.0	26.0	1.0	66.0	61.0	52.0	45.0	60.0	30.0	28.0	28.0	37.0	6.0	44.0	29.0	38.0	38.0	31.2	100.0	100.0	81.1	40.0	**3.03**	
***Annuals (mostly forbs)**																															**S-W**	
Amaranthus hybridus																									1.0	0.04	0.5		0.1	0.1		0.01
Amaranthus powellii																				1.0						0.04	0.5		0.1	0.1		0.01
Aristida adscensionis-G						1.0			1.0				1.0							2.0		6.0	2.0	2.0		0.60	8.2		1.6	0.8		0.06
Boerhaavia spicata												2.0		1.0	1.0		1.0									0.20	2.7		0.5	0.3		0.03
Bouteloua aristidoides-G						1.0																10.0				0.44	6.0		1.1	0.6		0.05
Bouteloua barbata-G						3.0	1.0				1.0								3.0	10.0	5.0		2.0		4.0	1.16	15.9		3.0	1.5		0.11
Chamaesyce sp.													1.0													0.04	0.5		0.1	0.1		0.01
Chenopodium neomexicanum														1.0	2.0		1.0	1.0		1.0	2.0					0.32	4.4		0.8	0.4		0.04
Eriogonum rotundifolium																	1.0	1.0			1.0					0.12	1.6		0.3	0.2		0.02
Ipomopsis longiflora								1.0											1.0							0.08	1.1		0.2	0.1		0.01
Machaeranthera gracilis						2.0									2.0											0.16	2.2		0.4	0.2		0.02
Machaeranthera tanacetifolia															1.0		1.0		8.0		44.0		6.0		1.0	2.44	33.5		6.3	3.1		0.17
Pectis angustifolia									2.0																	0.08	1.1		0.2	0.1		0.01
Pectis filipes							4.0	1.0		3.0		9.0	1.0	9.0												1.08	14.8		2.8	1.4		0.10
Salsola tragus																								7.0	1.0	0.32	4.4		0.8	0.4		0.04
Tidestromia lanuginosa																				2.0					1.0	0.12	1.6		0.3	0.2		0.02
Verbesina encelioides																							1.0			0.04	0.5		0.1	0.1		0.01
Annual Total Canopy	0.0	0.0	0.0	0.0	0.0	7.0	5.0	2.0	3.0	3.0	1.0	11.0	3.0	11.0	6.0	0.0	4.0	2.0	12.0	16.0	52.0	16.0	11.0	9.0	8.0	7.3	100.0		18.9	9.3		
Total Plant Canopy	7.0	3.0	0.0	19.0	45.0	39.0	42.0	33.0	21.0	29.0	2.0	77.0	64.0	63.0	51.0	60.0	34.0	30.0	40.0	53.0	58.0	60.0	40.0	47.0	46.0	38.5			100.0	49.3		**3.34**
Litter	1.0	0.0	0.0	3.0	16.0	8.0	17.0	14.0	7.0	12.0	1.0	4.0	4.0	5.0	3.0	10.0	1.0	5.0	7.0	3.0	1.0	5.0	1.0	4.0	7.0	5.6				7.1	Litter	**S-W**
Cobble	57.0	41.0	0.0	36.0	17.0	21.0	20.0	30.0	31.0	28.0	58.0	4.0	14.0	20.0	22.0	18.0	28.0	33.0	13.0	20.0	6.0	9.0	13.0	26.0	24.0	23.6				30.1	Cobble	
Gravel	10.0	17.0	0.0	12.0	5.0	9.0	5.0	5.0	9.0	7.0	21.0	1.0	1.0	1.0	5.0	5.0	7.0	1.0	2.0	1.0	0.0	3.0	5.0	4.0	2.0	5.5				7.1	Gravel	
Rock	5.0	8.0	0.0	14.0	10.0	8.0	11.0	6.0	9.0	7.0	6.0	6.0	4.0	1.0	5.0	2.0	2.0	1.0	1.0	0.0	0.0	0.0	6.0	3.0	1.0	4.6				5.9	Rock	
Bedrock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	2.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4				0.5	Bedrock	
Grand Total Cover	80.0	69.0	0.0	84.0	93.0	85.0	95.0	88.0	77.0	83.0	88.0	98.0	89.0	91.0	86.0	95.0	72.0	70.0	63.0	77.0	65.0	77.0	65.0	84.0	80.0	78.2				100.0	Grand Total	
																								Bare soil		21.8						

Summary of Cover	Mean	Median	St.Dev.	Sample adequacy (# of transects)
Perennial Grasses	18.7	18.0	13.5	152.8
Perennial Forbs	3.7	3.0	4.2	371.1
Perennial Shrubs	8.8	8.0	7.0	182.2
Perennials - Total	31.2	31.0	18.6	104.3
Annuals/All Veg/Litter/Rock	7.3	4.0	10.6	622.6
	38.5	40.0	21.0	86.8
	5.6	4.0	4.9	228.1
	23.6	21.0	14.3	107.4
	5.5	5.0	5.2	264.3
	4.6	5.0	3.9	208.4
	0.4	0.0	1.3	3554.0
	78.2	83.0	19.1	17.5

Species Count **65**

* Annuals and biennials. G = grass. W = state-listed noxious weed.

Appendix 4-A (Table 4). 2010 Cover Data: Copper Flat - Tailing Dam Stratum (TD)

Sample Area - Tailing Dam

10 Transects — Transect -- % Cover (point counts)

Species	1	2	3	4	5	6	7	8	9	10	Mean Cover	Relative Lifeform	Relative Perennial	Relative Live Veg	Relative Total	S-W Index	S-W Index
Grasses (perennial)											%	%	%	%	%	peren	all veg
Aristida havardii		1.0					2.0				0.30	1.5	0.9	0.9	0.3	0.04	0.04
Aristida purpurea		3.0		1.0				1.0			0.50	2.4	1.5	1.5	0.5	0.06	0.06
Bothriochloa laguroides	8.0	12.0	20.0	18.0	12.0	19.0	16.0	23.0	21.0	24.0	17.30	84.0	50.7	50.3	17.7	0.34	0.35
Bouteloua curtipendula	4.0	4.0	3.0	1.0				1.0			1.30	6.3	3.8	3.8	1.3	0.12	0.12
Dasyochloa pulchella		1.0									0.10	0.5	0.3	0.3	0.1	0.02	0.02
Eragrostis intermedia	1.0						3.0	4.0			0.80	3.9	2.3	2.3	0.8	0.09	0.09
Muhlenbergia porteri	3.0										0.30	1.5	0.9	0.9	0.3	0.04	0.04
Grass Totals	16.0	21.0	23.0	20.0	12.0	19.0	21.0	29.0	21.0	24.0	20.6	100.0	60.4	59.9	21.1		
Forbs (perennials + some biennials)																	
Astragalus sp.					1.0						0.10	9.1	0.3	0.3	0.1	0.02	0.02
Chamaesaracha sordida	1.0										0.10	9.1	0.3	0.3	0.1	0.02	0.02
Chamaesyce albomarginata					1.0		2.0				0.30	27.3	0.9	0.9	0.3	0.04	0.04
Chamaesyce sp.	1.0										0.10	9.1	0.3	0.3	0.1	0.02	0.02
Hoffmannseggia glauca								1.0			0.10	9.1	0.3	0.3	0.1	0.02	0.02
Mentzelia pumila	2.0				1.0					1.0	0.40	36.4	1.2	1.2	0.4	0.05	0.05
Forb Totals	4.0	0.0	0.0	0.0	3.0	0.0	2.0	1.0	0.0	1.0	1.1	100.0	3.2	3.2	1.1		
Shrubs (+ subshrubs + trees)																	
Baccharis pteronioides	1.0	3.0	2.0						1.0	1.0	0.80	6.5	2.3	2.3	0.8	0.09	0.09
Brickellia californica			9.0								0.90	7.3	2.6	2.6	0.9	0.10	0.10
Dalea formosa				2.0	4.0	17.0		3.0			2.60	21.0	7.6	7.6	2.7	0.20	0.20
Fallugia paradoxa				1.0			1.0				0.20	1.6	0.6	0.6	0.2	0.03	0.03
Gutierrezia sarothrae	5.0	4.0				1.0		1.0		1.0	1.20	9.7	3.5	3.5	1.2	0.12	0.12
Prosopis glandulosa	9.0	5.0	2.0	1.0	14.0	6.0	12.0	4.0	3.0	10.0	6.60	53.2	19.4	19.2	6.8	0.32	0.32
Rhus microphylla			1.0								0.10	0.8	0.3	0.3	0.1	0.02	0.02
Shrub Totals	15.0	12.0	14.0	4.0	18.0	24.0	13.0	8.0	4.0	12.0	12.4	100.0	36.4	36.0	12.7		
Perennial Totals	35.0	33.0	37.0	24.0	33.0	43.0	36.0	38.0	25.0	37.0	34.1	100.0	100.0	99.1	34.9	1.74	
***Annuals (mostly forbs)**																S-W	
Chenopodium neomexicanum	1.0										0.10	33.3		0.3	0.1		0.02
Machaeranthera gracilis			1.0								0.10	33.3		0.3	0.1		0.02
Salsola tragus	1.0										0.10	33.3		0.3	0.1		0.02
Annual Totals	2.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	100.0		0.9	0.3		
Total Live Vegetation	37.0	33.0	38.0	24.0	33.0	43.0	36.0	38.0	25.0	37.0	34.4			100.0	35.2		1.79
Litter	7.0	5.0	5.0	0.0	7.0	6.0	5.0	5.0	4.0	12.0	5.6				5.7		S-W
Cobble	16.0	31.0	24.0	19.0	16.0	20.0	14.0	25.0	18.0	19.0	20.2				20.7		
Gravel	33.0	17.0	20.0	52.0	29.0	22.0	36.0	29.0	48.0	22.0	30.8				31.5		
Rock	6.0	10.0	12.0	5.0	8.0	5.0	5.0	4.0	5.0	7.0	6.7				6.9		
Bedrock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				0.0		
Grand Total Cover	99.0	96.0	99.0	100.0	93.0	96.0	96.0	101.0	100.0	97.0	97.7				100.0		
										Bare soil	2.3						

Species Count **23**

Summary of Cover

	Mean	Median	St.Dev.	Sample adequacy (# of transects)
Perennial Grasses	20.6	21.0	4.6	16.4
Perennial Forbs	1.1	0.5	1.4	583.1
Perennial Shrubs	12.4	12.5	6.1	81.7
Perennials - Total	34.1	35.5	5.8	9.7
Annuals/All Veg/Litter/Rock				
Annuals	0.3	0.0	0.7	1700.7
All Veg	34.4	36.5	5.9	10.0
Litter	5.6	5.0	3.0	95.7
Cobble	20.2	19.0	5.1	21.6
Gravel	30.8	29.0	11.8	49.0
Rock	6.7	5.5	2.6	50.0
Bedrock	0.0	0.0	0.0	
Grand Total	97.7	98.0	2.5	0.2

*Annuals and biennials. G = grass. W = state-listed noxious weed.

Appendix 4-A (Table 5). 2010 Cover Data: Copper Flat - Pit Stratum

Sample Area - Pit

10 Transects

Species	Transect -- % Cover (point counts) 1	2	3	4	5	6	7	8	9	10	Mean Cover %	Relative Lifeform %	Relative Perennial %	Relative Live Veg %	Relative Total %	S-W Index peren	S-W Index all veg
Grasses (perennial)																	
Aristida havardii					2.0						0.20	12.5	4.5	4.5	0.5	0.14	0.14
Bothriochloa laguroides					12.0						1.20	75.0	27.3	27.3	3.2	0.35	0.35
Bouteloua curtipendula					1.0						0.10	6.3	2.3	2.3	0.3	0.09	0.09
Bouteloua gracilis								1.0			0.10	6.3	2.3	2.3	0.3	0.09	0.09
Grass Totals	0.0	0.0	0.0	0.0	15.0	0.0	0.0	1.0	0.0	0.0	1.6	100.0	36.4	36.4	4.3		
Forbs (perennials + some biennials)																	
Mentzelia pumila					1.0						0.10	14.3	2.3	2.3	0.3	0.09	0.09
Pectis longipes					5.0						0.50	71.4	11.4	11.4	1.3	0.25	0.25
Solanum elaeagnifolium					1.0						0.10	14.3	2.3	2.3	0.3	0.09	0.09
Forb Totals	0.0	0.0	0.0	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.7	100.0	15.9	15.9	1.9		
Shrubs (+ subshrubs + trees)																	
Brickellia californica					19.0						1.90	90.5	43.2	43.2	5.1	0.36	0.36
Gutierrezia sarothrae					1.0						0.10	4.8	2.3	2.3	0.3	0.09	0.09
Tamarix chinensis-W*						1.0					0.10	4.8	2.3	2.3	0.3	0.09	0.09
Shrub Totals	0.0	0.0	0.0	0.0	20.0	1.0	0.0	0.0	0.0	0.0	2.1	100.0	47.7	47.7	5.6		
Perennial Totals	0.0	0.0	0.0	0.0	42.0	1.0	0.0	1.0	0.0	0.0	4.4	100.0	100.0	100.0	11.8	1.62	
Total Live Vegetation	0.0	0.0	0.0	0.0	42.0	1.0	0.0	1.0	0.0	0.0	4.4			100.0	11.8		1.62
Litter	0.0	0.0	0.0	0.0	17.0	4.0	0.0	0.0	0.0	0.0	2.1				5.6		
Cobble	60.0	41.0	34.0	62.0	17.0	7.0	6.0	3.0	6.0	10.0	24.6				65.8		
Gravel	7.0	5.0	4.0	7.0	10.0	0.0	1.0	3.0	2.0	3.0	4.2				11.2		
Rock	4.0	3.0	1.0	0.0	5.0	1.0	0.0	2.0	2.0	3.0	2.1				5.6		
Bedrock	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				0.0		
Grand Total Cover	71.0	49.0	39.0	69.0	91.0	13.0	7.0	9.0	10.0	16.0	37.4				100.0		
										Bare soil	62.6						

Summary of Cover	Mean	Median	St.Dev.	Sample adequacy (# of transects)
Perennial Grasses	1.6	0.0	4.7	2922.4
Perennial Forbs	0.7	0.0	2.2	3359.9
Perennial Shrubs	2.1	0.0	6.3	3021.3
Perennials - Total	4.4	0.0	13.2	3032.1
Total Live Vegetation (S-W)	4.4	0.0	13.2	3032.1
Litter	2.1	0.0	5.4	2208.6
Cobble	24.6	13.5	23.0	292.9
Gravel	4.2	3.5	3.1	181.2
Rock	2.1	2.0	1.7	210.8
Bedrock	0.0	0.0	0.0	
Grand Total	37.4	27.5	31.0	231.5

Species Count
10

*Annuals and biennials. G = grass. W = state-listed noxious weed.

Appendix 4-A (Table 6). 2010 Cover Data: Copper Flat - Arroyo Stratum

Sample Area - Arroyo

3 Transects

Species	Diver-sion 1	Arroyo 2 2	Arroyo 1 3	Mean Cover	Relative Lifeform	Relative Perennial	Relative Live Veg	Relative Total	S-W Index	S-W Index
Grasses (perennial)				%	%	%	%	%	peren	all veg
Bouteloua curtipendula			1.0	0.33	5.6	1.3	1.3	0.4	0.06	0.06
Muhlenbergia porteri			1.0	0.33	5.6	1.3	1.3	0.4	0.06	0.06
Panicum obtusum	7.0		9.0	5.33	88.9	21.3	21.3	6.8	0.33	0.33
Grass Totals	7.0	0.0	11.0	6.0	100.0	24.0	24.0	7.7		
Shrubs (+ subshrubs + trees)										
Baccharis emoryi	5.0	21.0	13.0	13.00	68.4	52.0	52.0	16.6	0.34	0.34
Brickellia californica		1.0		0.33	1.8	1.3	1.3	0.4	0.06	0.06
Celtis leavigata	1.0			0.33	1.8	1.3	1.3	0.4	0.06	0.06
Hymenoclea monogyra			15.0	5.00	26.3	20.0	20.0	6.4	0.32	0.32
Rhus microphylla			1.0	0.33	1.8	1.3	1.3	0.4	0.06	0.06
Shrub Totals	6.0	22.0	29.0	19.0	100.0	76.0	76.0	24.3		
Perennial Totals	13.0	22.0	40.0	25.0	100.0	100.0	100.0	31.9	1.28	
Total Live Vegetation	13.0	22.0	40.0	25.0			100.0	31.9		1.28
Litter	45.0	46.0	46.0	45.7				58.3	Litter	S-W
Cobble	0.0	3.0	0.0	1.0				1.3	Cobble	
Gravel	1.0	16.0	1.0	6.0				7.7	Gravel	
Rock	2.0	0.0	0.0	0.7				0.9	Rock	
Bedrock	0.0	0.0	0.0	0.0				0.0	Bedrock	
Grand Total Cover	61.0	87.0	87.0	78.3				100.0	Grand Total	
			Bare soil	21.7						

Summary of Cover	Mean	Median	St.Dev.	Sample adequacy (# of transects)
Grass Totals	6.0	7.0	5.6	734.2
Shrub Totals	19.0	22.0	11.8	328.3
Perennial Totals	25.0	22.0	13.7	257.8
Perennials - Total				
Total Live Vegetation	0.0	0.0	0.0	
Litter	25.0	22.0	13.7	257.8
Cobble	45.7	46.0	0.6	0.1
Gravel	1.0	0.0	1.7	2557.9
Rock	6.0	1.0	8.7	1776.3
Bedrock	0.7	0.0	1.2	2557.9
Grand Total Cover	0.0	0.0	0.0	
Bare soil	78.3	87.0	15.0	31.3

Species Count
8

*Annuals and biennials. G = grass. W = state-listed noxious weed.

Appendix 4-B

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

Appendix 4-B (Table 1). 2010 Production Data: Copper Flat - Chihuahuan Desert Grassland Stratum (CDG)

Sample Area - Chihuahuan Desert Grassland (CDG)

29 Transects — Transect - lbs/ac (based on 2 (two) 1m^2 quadrats/transect)

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	Species Mean	Relative Lifeform	Relative Perennial	Relative Total	S-W Index	S-W Index
Grasses (perennials)	BU-1	BU-2	BU-3	BU-4	BU-5	BU-6	BU-7	BU-8	BU-9	BU-10	BU-11	BU-12	BU-13	BU-14	BU-15	BU-16	BU-17	BD-1	BD-2	BD-3	BD-4	BD-5	BD-6	BD-7	BD-8	BD-9	BD-10	BD-11	BD-12		%	%	%	peren	all veg
Aristida havardii					46.8			27.2		11.2	317.5			113.7											123.5	9.4				22.4	2.4	1.8	1.6	0.07	0.06
Aristida purpurea				50.0																						32.1				2.8	0.3	0.2	0.2	0.01	0.01
Bothriochloa laguroides										14.7				26.8											50.8	180.2				9.4	1.0	0.7	0.7	0.04	0.03
Bouteloua curtipendula		775.6		1156.0	727.4	707.8	1024.5	804.1	496.4	697.5	748.8	318.9	124.0	464.3	260.0	153.0	203.0	553.0		385.3	1316.2	116.0		58.0	380.0	85.6		131.6		403.0	42.3	31.8	28.1	0.36	0.36
Bouteloua eriopoda	873.7	1245.2		260.5				209.6	761.3	408.1		395.6	1198.0		868.8						175.7	599.4	233.3	420.6	249.0			107.9		276.1	29.0	21.8	19.3	0.33	0.32
Bouteloua gracilis					16.1					65.1			62.4	29.9				13.8		70.5										8.9	0.9	0.7	0.6	0.03	0.03
Bouteloua hirsuta				12.0				193.6	34.3		6.2		55.3	154.8				9.8	55.8	42.8					44.6					21.0	2.2	1.7	1.5	0.07	0.06
Dasyochloa pulchella																74.0						235.5	101.7			22.3		482.6		31.6	3.3	2.5	2.2	0.09	0.08
Elymus longifolius																	19.2													0.7	0.1	0.1	0.0	0.00	0.00
Enneapogon desvauxii						23.6																						6.7		1.0	0.1	0.1	0.1	0.01	0.01
Festuca sp.					5.4																									0.2	0.0	0.0	0.0	0.00	0.00
Leptochloa dubia														11.2																0.4	0.0	0.0	0.0	0.00	0.00
Muhlenbergia porteri																	118.7			9.8										4.4	0.5	0.4	0.3	0.02	0.02
Panicum obtusum																	522.7				23.2									18.8	2.0	1.5	1.3	0.06	0.06
Piptatherum micranthum					10.7									21.4																1.1	0.1	0.1	0.1	0.01	0.01
Pleuraphis mutica							753.7					1928.1								595.9			234.2							121.1	12.7	9.6	8.4	0.22	0.21
Scleropogon brevifolius													18.3																	0.6	0.1	0.0	0.0	0.00	0.00
Setaria leucopila										265.8				93.7			89.7			7.6			5.4							15.9	1.7	1.3	1.1	0.06	0.05
Sporobolus contractus																	67.4									7.6				2.6	0.3	0.2	0.2	0.01	0.01
Tridens muticus																		187.8				23.6	3.6		92.8					10.6	1.1	0.8	0.7	0.04	0.04
Grass Totals	873.7	2020.8	0.0	1478.5	806.4	731.4	1778.2	1234.5	1292.0	1462.4	1072.5	2642.6	1458.0	915.8	1128.8	227.0	1020.7	764.4	55.8	1111.9	1515.1	974.5	578.2	478.6	940.7	337.2	0.0	728.8	0.0	952.7	100.0	75.3	66.5		
Forbs (perennials + some biennials)																																			
Ambrosia confertiflora									54.0									6.2					43.3	10.3						3.9	3.5	0.3	0.3	0.02	0.02
Artemisia franserioides																									6.7					0.2	0.2	0.0	0.0	0.00	0.00
Artemisia ludoviciana						122.7																								4.2	3.8	0.3	0.3	0.02	0.02
Astragalus crassicarpus							15.6			24.5																				1.4	1.2	0.1	0.1	0.01	0.01
Bahia absinthifolia																12.9						6.7	17.4			35.7	7.6	31.2	47.7	5.5	4.9	0.4	0.4	0.02	0.02
Baileya multiradiata																										3.1		15.6		0.6	0.6	0.1	0.0	0.00	0.00
Calliandra humilis																					20.1									0.7	0.6	0.1	0.0	0.00	0.00
Chamaesaracha coronopus																17.0														0.6	0.5	0.0	0.0	0.00	0.00
Chamaesaracha sordida								0.5														120.9					18.7		14.7	5.3	4.8	0.4	0.4	0.02	0.02
Chamaesyce albomarginata								9.8	5.4	41.0	24.1					35.2				9.4	15.6					3.4	94.5	29.0		9.2	8.2	0.7	0.6	0.04	0.03
Dalea lanata															12.5								10.7			8.5				1.1	1.0	0.1	0.1	0.01	0.01
Desmanthus cooleyi				36.6																										1.3	1.1	0.1	0.1	0.01	0.01
Erigeron flagillaris																												15.2		0.5	0.5	0.0	0.0	0.00	0.00
Eriogonum effusum	109.3			58.0				194.0										162.3				45.1	138.3	438.0	179.3			79.8	16.5	49.0	43.7	3.9	3.4	0.13	0.12
Eriogonum wrightii																				1.8	29.9									1.1	1.0	0.1	0.1	0.01	0.01
Evolvulus nuttallianus				14.7																										0.5	0.5	0.0	0.0	0.00	0.00
Halimolobos diffusus						11.2																								0.4	0.3	0.0	0.0	0.00	0.00
Lepidium cf. montanum																							5.4							0.2	0.2	0.0	0.0	0.00	0.00
Melampodium leucanthum																5.4														0.2	0.2	0.0	0.0	0.00	0.00
Pectis longipes																		22.3			95.0									4.0	3.6	0.3	0.3	0.02	0.02
Senna bauhinioides											2.7												12.9				18.3	16.5		1.7	1.6	0.1	0.1	0.01	0.01
Sida abutifolia																						29.4	4.9			3.6				1.3	1.2	0.1	0.1	0.01	0.01
Solanum elaeagnifolium										36.1							132.0	88.8				43.7	29.9	12.9						11.8	10.6	0.9	0.8	0.04	0.04
Sphaeralcea grossulariifolia																														0.0	0.0	0.0	0.0		
Sphaeralcea hastulata							12.0	26.3																						1.3	1.2	0.1	0.1	0.01	0.01
Stephanomeria paucilfora														66.5								12.0								2.7	2.4	0.2	0.2	0.01	0.01
Tragia sp.										59.2																				2.0	1.8	0.2	0.1	0.01	0.01
Zinnia grandiflora																							13.8		9.8			9.4		1.1	1.0	0.1	0.1	0.01	0.01
Forb Totals	109.3	0.0	0.0	109.3	0.5	133.9	27.6	230.6	59.4	160.8	26.8	0.0	0.0	66.5	12.5	70.5	132.0	279.6	0.0	11.2	160.6	257.8	276.6	461.2	195.8	54.3	139.1	196.7	78.9	112.1	100.0	8.9	7.8		
Shrubs (+ subshrubs + trees)																																			
Aloysia wrightii								13.4							18.3										4.5					1.2	0.6	0.1	0.1	0.01	0.01
Brickellia californica						42.8																								1.5	0.7	0.1	0.1	0.01	0.01
Dalea formosa									54.0																			12.5		2.3	1.1	0.2	0.2	0.01	0.01
Dasylirion wheeleri								733.7																						25.3	12.6	2.0	1.8	0.08	0.07
Fouquieria splendens								3.6																						0.1	0.1	0.0	0.0	0.00	0.00
Flourensia cernua												154.8															1004.0			40.0	19.9	3.2	2.8	0.11	0.10
Gutierrezia sarothrae					6.7		43.7	79.8		47.3	76.3		99.5	252.9			72.3			11.6	25.0		132.0			9.4	6.7	17.8		30.4	15.1	2.4	2.1	0.09	0.08
Hymenoclea monogyra																	334.5													11.5	5.7	0.9	0.8	0.04	0.04
Larrea tridentata																													70.0	2.4	1.2	0.2	0.2	0.01	0.01
Mimosa aculeaticarpa																		169.9					68.2							8.2	4.1	0.6	0.6	0.03	0.03
Opuntia sp.																				45.9										1.6	0.8	0.1	0.1	0.01	0.01
Parthenium incanum																							27.7				2.2		77.2	3.7	1.8	0.3	0.3	0.02	0.02
Prosopis glandulosa	858.1																			249.3				8.5	155.7		12.5	9.4	363.5	57.1	28.5	4.5	4.0	0.14	0.13
Rhus microphylla																	51.7													1.8	0.9	0.1	0.1	0.01	0.01
Thymophylla acerosa																												24.5	368.4	13.5	6.8	1.1	0.9	0.05	0.04
Shrub Totals	858.1	0.0	0.0	0.0	6.7	42.8	43.7	830.5	54.0	47.3	76.3	154.8	99.5	252.9	18.3	0.0	458.5	169.9	0.0	306.8	25.0	0.0	227.9	8.5	160.2	9.4	1025.4	64.2	879.1	200.7	100.0	15.9	14.0		
Perennial Totals	1841.1	2020.8	0.0	1587.8	813.6	908.1	1849.5	2295.6	1405.4	1670.5	1175.6	2797.4	1557.5	1235.2	1159.6	297.5	1611.2	1213.9	55.8	1429.9	1700.7	1232.3	1082.7	948.3	1296.7	400.9	1164.5	989.7	958.0	1265.5	100.0	100.0	88.3	2.48	
***Annuals (mostly forbs)**																																		S-W	
Aristida adscensionis-G													28.5						8.5				34.8			25.4				3.4	2.0		0.2		0.01
Boerhaavia spicata																							25.4							0.9	0.5		0.1		0.00
Boerhaavia sp.																25.4						15.6				242.2				9.8	5.8		0.7		0.03
Bouteloua aristidoides-G																54.9										4.9				2.1	1.2		0.1		0.01
Bouteloua barbata-G															8.0											3.6				0.4	0.2		0.0		0.00
Chenopodium neomexicanum							8.5																		78.5					3.0	1.8		0.2		0.01
Chloris virgata-G																	18.7													0.6	0.4		0.0		0.00
Eragrostis pectinacea-G																	9.8													0.3	0.2		0.0		0.00
Eriogonum rotundifolium																									4.0					0.1	0.1		0.0		0.00
Machaeranthera gracilis																										261.0				9.0	5.4		0.6		0.03
Pectis angustifolia													14.7																	0.5	0.3		0.0		0.00
Pectis filipes	700.2	515.6		194.5	353.2	17.8	244.9	152.1		86.5	39.3	75.4	55.8		198.5		74.5	79.4		261.4		174.4	93.7	142.3	432.2					134.2	79.9		9.4		0.22
Plantago patagonica	96.3														9.4															3.6	2.2		0.3		0.02
Annual Totals	796.5	515.6	0.0	194.5	353.2	17.8	253.4	152.1	0.0	86.5	39.3	75.4	99.0	0.0	215.9	80.3	103.0	79.4	8.5	261.4	0.0	190.0	153.9	142.3	514.7	537.1	0.0	0.0	0.0	167.9	100.0		11.7		
																																			2.65
Grand Total Production	2637.6	2536.4	0.0	1782.3	1166.8	925.9	2102.9	2447.7	1405.4	1757.0	1214.9	2872.8	1656.5	1235.2	1375.5	377.8	1714.2	1293.3	64.3	1691.3	1700.7	1422.3	1236.6	1090.6	1811.4	938.0	1164.5	989.7	958.0	1433.4			100.0		S-W

Summary of Production

	Mean	Median	St.Dev.	Sample adequacy (# of quadrats)
Perennial Grasses	952.7	940.7	627.3	125.4
Perennial Forbs	112.1	78.9	112.4	290.7
Perennial Shrubs	200.7	54.0	305.4	670.0
Perennials - Total	1265.5	1232.3	620.5	69.6
Annuals/Biennials	167.9	99.0	200.8	413.8
Grand Total Production	1433.4	1375.5	687.4	66.5

Species Count
76

* Annuals and biennials. G = grass. W = state-listed noxious weed.

Appendix 4-B (Table 2). 2010 Production Data: Copper Flat - Chihuahuan Desert Shrubland Stratum (CDS)

Sample Area - Chihuahuan Desert Shrubland (CDS)

19 Transects — Transect - lbs/ac (based on 2 (two) 1m² quadrats/transect)

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Species Mean	Relative Lifeform	Relative Perennial	Relative Total	S-W Index	S-W Index
Grasses (perennials)	BU-19	BU-20	BU-21	BU-22	BU-23	BU-24	BU-25	BU-26	BU-27	BD-13	BD-14	BD-15	BD-16	BD-17	BD-18	BD-19	BD-20	BD-21	BD-22		%	%	%	peren	all veg
Bothriochloa laguroides	245.8			100.4												6.7				18.6	7.1	1.7	1.5	0.07	0.06
Bouteloua curtipendula	31.7				395.2		16.5													23.3	9.0	2.1	1.8	0.08	0.07
Bouteloua eriopoda									33.5				130.2							8.6	3.3	0.8	0.7	0.04	0.03
Bouteloua gracilis												50.8	51.3							5.4	2.1	0.5	0.4	0.03	0.02
Dasyochloa pulchella							70.0		371.1	58.0				12.0		282.3			0.4	41.8	16.0	3.8	3.3	0.13	0.11
Enneapogon desvauxii									32.1											1.7	0.6	0.2	0.1	0.01	0.01
Muhlenbergia porteri				7.1	586.9				566.4											61.1	23.5	5.6	4.8	0.16	0.15
Panicum obtusum						50.4		279.6								4.9				17.6	6.8	1.6	1.4	0.07	0.06
Piptatherum micranthum									3.6											0.2	0.1	0.0	0.0	0.00	0.00
Pleuraphis mutica		395.2											773.8							61.5	23.6	5.7	4.8	0.16	0.15
Setaria leucopila	11.2				219.0			67.4		17.0				69.6		6.2				20.5	7.9	1.9	1.6	0.08	0.07
Grass Totals	288.7	395.2	0.0	107.5	1201.1	50.4	86.5	347.0	1006.7	75.0	0.0	50.8	955.3	81.6	0.0	300.1	0.0	0.0	0.4	260.3	100.0	24.0	20.4		
Forbs (perennials + some biennials)																									
Acourtia nana		3.6									9.8						169.3	2.7		9.8	5.7	0.9	0.8	0.04	0.04
Astragalus sp.																4.9				0.3	0.1	0.0	0.0	0.00	0.00
Bahia absinthifolia				38.4		17.0			22.3	192.7		2.2		103.5	44.2	23.6	6.7	2.7	4.5	24.1	14.0	2.2	1.9	0.08	0.08
Baileya multiradiata																4.5				0.2	0.1	0.0	0.0	0.00	0.00
Chaetopappa ericoides													22.8							1.2	0.7	0.1	0.1	0.01	0.01
Chamaesaracha coronopus							36.6						5.8							2.2	1.3	0.2	0.2	0.01	0.01
Chamaesaracha sordida							25.4		48.2											3.9	2.2	0.4	0.3	0.02	0.02
Chamaesyce albomarginata								71.4	113.7		235.5	40.1		92.3		73.6	145.8			40.7	23.6	3.7	3.2	0.12	0.11
Eriogonum effusum				189.1			55.3		52.2	252.9		89.2								33.6	19.5	3.1	2.6	0.11	0.10
Eriogonum wrightii				16.5		76.3	29.9			55.3				8.5				61.5	18.3	14.0	8.1	1.3	1.1	0.06	0.05
Hoffmannseggia glauca			17.8	5.8		47.3		40.1	45.1	8.5		7.6		19.2	18.7	3.6				11.2	6.5	1.0	0.9	0.05	0.04
Mentzelia pumila												355.9								18.7	10.9	1.7	1.5	0.07	0.06
Phemeranthus aurantiacus									4.0											0.2	0.1	0.0	0.0	0.00	0.00
Solanum elaeagnifolium								169.5												8.9	5.2	0.8	0.7	0.04	0.03
Sphaeralcea angustifolia															8.9					0.5	0.3	0.0	0.0	0.00	0.00
Sphaeralcea hastulata									18.3											1.0	0.6	0.1	0.1	0.01	0.01
Zinnia grandiflora									23.2				10.7							1.8	1.0	0.2	0.1	0.01	0.01
Forb Totals	0.0	3.6	17.8	249.8	0.0	140.6	147.2	281.0	327.0	509.4	245.3	495.0	39.3	223.5	71.8	110.2	321.8	66.9	22.8	172.3	100.0	15.9	13.5		
Shrubs (+ subshrubs + trees)																									
Atriplex canescens																	121.8			6.4	1.0	0.6	0.5	0.03	0.03
Baccharis pteronioides					260.9											111.9				19.6	3.0	1.8	1.5	0.07	0.06
Chilopsis linearis					89.2															4.7	0.7	0.4	0.4	0.02	0.02
Flourensia cernua	203.8	63.3		225.2							220.3					720.3	44.6	681.0	363.9	132.8	20.3	12.2	10.4	0.26	0.24
Gutierrezia sarothrae	146.7		86.1		190.4			662.8	182.0	14.3	103.0		119.0	571.8		157.4			118.2	123.8	18.9	11.4	9.7	0.25	0.23
Hymenoclea monogyra					335.7															17.7	2.7	1.6	1.4	0.07	0.06
Larrea tridentata		212.3	32.1													223.0	1173.0			86.3	13.2	7.9	6.8	0.20	0.18
Lycium torreyi																	4.9			0.3	0.0	0.0	0.0	0.00	0.00
Parthenium incanum	30.8	10.7					180.2		59.3											14.8	2.3	1.4	1.2	0.06	0.05
Prosopis glandulosa			35.2		32.6			1810.8	1050.3	18.7		396.1		529.8	169.5		189.1			222.7	34.1	20.5	17.5	0.32	0.30
Thymophylla acerosa	116.4						47.7													8.6	1.3	0.8	0.7	0.04	0.03
Yucca elata									310.0											16.3	2.5	1.5	1.3	0.06	0.06
Shrub Totals	497.7	286.3	153.4	225.2	908.8	0.0	227.9	2473.6	1601.6	33.0	323.3	396.1	119.0	1101.6	169.5	1212.6	1533.4	681.0	482.1	654.0	100.0	60.2	51.3		
Perennial Totals	786.4	685.1	171.2	582.5	2109.9	191.0	461.6	3101.6	2935.3	617.4	568.6	941.9	1113.6	1406.7	241.3	1622.9	1855.2	747.9	505.3	1086.6	100.0	100.0	85.3	2.84	
***Annuals (mostly forbs)**																								S-W	
Amaranthus palmeri					7.7															0.4	0.2		0.0		0.00
Amaranthus powellii												3.6								0.2	0.1		0.0		0.00
Aristida adscensionis-G												20.1				17.4				2.0	1.1		0.2		0.01
Boerhaavia sp.															8.0					0.4	0.2		0.0		0.00
Bouteloua barbata-G						148.5				7.1			3.1		15.6					9.2	4.9		0.7		0.04
Chamaesyce sp.												4.9								0.3	0.1		0.0		0.00
Chenopodium neomexicanum															15.6					0.8	0.4		0.1		0.00
Descurainia pinnata												3.6								0.2	0.1		0.0		0.00
Eriogonum rotundifolium						37.9				155.7								27.2	15.2	12.4	6.6		1.0		0.05
Kallstroemia parviflora					4.5							119.1								6.5	3.5		0.5		0.03
Machaeranthera gracilis																20.1				1.1	0.6		0.1		0.01
Machaeranthera tanacetifolia					397.4															20.9	11.2		1.6		0.07
Pectis angustifolia						37.9														2.0	1.1		0.2		0.01
Pectis filipes		77.6											7.6							4.5	2.4		0.4		0.02
Salsola tragus								445.1				133.8								30.5	16.3		2.4		0.09
Solanum rostratum												11.2								0.6	0.3		0.0		0.00
Tidestromia lanuginosa		5.4						365.3	65.6	97.2										28.1	15.0		2.2		0.08
Verbesina encelioides								590.5				692.2								67.5	36.0		5.3		0.16
Annual Totals	0.0	83.0	0.0	0.0	409.6	224.3	0.0	1400.9	65.6	260.0	0.0	988.5	10.7	0.0	39.2	37.5	0.0	27.2	15.2	187.5	100.0		14.7		
																									3.13
Grand Total Production	786.4	768.1	171.2	582.5	2519.5	415.3	461.6	4502.5	3000.9	877.4	568.6	1930.4	1124.3	1406.7	280.5	1660.4	1855.2	775.1	520.5	1274.1			100.0		S-W

Summary of Production	Mean	Median	St.Dev.	Sample adequacy (# of quadrats)
Perennial Grasses	260.3	81.6	377.7	632.8
Perennial Forbs	172.3	140.6	161.3	263.6
Perennial Shrubs	654.0	396.1	661.5	307.6
Perennials - Total	1086.6	747.9	873.0	194.1
Annuals/Biennials	187.5	27.2	378.1	1223.0
Grand Total Production	1274.1	786.4	1104.5	226.0

Species Count **58**

* Annuals and biennials. G = grass. W = state-listed noxious weed.

Appendix 4-B (Table 3). 2010 Production Data: Copper Flat - Disturbed Area/Waste Rock Pile

Sample Area - Disturbed Area/Waste Rock Pile

25 Transects — Transect - lbs/ac (based on 2 (two) 1m^2 quadrats/transect)

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	BUH-18 25	Species Mean	Relative Lifeform	Relative Perennial	Relative Total	S-W Index	S-W Index
Grasses (perennials)																									BU-18		%	%	%	peren	all veg
Aristida havardii		34.3		11.6								91.9			22.3								40.1	4.5		8.2	2.0	1.0	0.9	0.05	0.04
Aristida purpurea					11.6				17.8	13.8						7.6						6.2				2.3	0.5	0.3	0.2	0.02	0.01
Bothriochloa laguroides				46.8	198.5	1397.3	39.3	294.8	48.6	816.6		448.2			119.5	371.5			175.3					505.3		178.5	42.7	21.6	19.4	0.33	0.32
Bouteloua curtipendula					395.2		63.8			166.4		230.6	75.4	30.1	218.1	553.0			193.6			212.3				85.5	20.5	10.4	9.3	0.23	0.22
Bouteloua eriopoda												395.2		168.6		89.7										26.1	6.3	3.2	2.8	0.11	0.10
Bouteloua hirsuta				84.3			47.3	24.5	21.4	5.4			15.2			144.5										13.7	3.3	1.7	1.5	0.07	0.06
Dasyochloa pulchella												15.2		116.0	59.8	59.8	407.2	60.2	6.2	157.0		135.6	44.2	36.1	3.6	44.0	10.5	5.3	4.8	0.16	0.15
Enneapogon desvauxii													14.3			14.3										1.1	0.3	0.1	0.1	0.01	0.01
Eragrostis intermedia					127.1																					5.1	1.2	0.6	0.6	0.03	0.03
Muhlenbergia porteri													646.3				8.0	7.1								26.5	6.3	3.2	2.9	0.11	0.10
Panicum obtusum																						53.1				2.1	0.5	0.3	0.2	0.02	0.01
Pleuraphis mutica														42.4				245.8								11.5	2.8	1.4	1.3	0.06	0.05
Setaria leucopila																								12.0	207.8	8.8	2.1	1.1	1.0	0.05	0.04
Sporobolus contractus						23.2																				0.9	0.2	0.1	0.1	0.01	0.01
Sporobolus cryptandrus																12.0										0.5	0.1	0.1	0.1	0.00	0.00
Sporobolus giganteus															75.4											3.0	0.7	0.4	0.3	0.02	0.02
Grass Totals	0.0	34.3	0.0	142.7	732.4	1420.5	150.4	319.3	87.8	1002.2	0.0	1181.1	751.2	357.1	495.1	1252.4	415.2	313.1	375.1	157.0	0.0	407.2	84.3	557.9	211.4	417.9	100.0	50.6	45.5		
Forbs (perennials + some biennials)																															
Acourtia nana																									18.7	0.7	0.8	0.1	0.1	0.01	0.01
Bahia absinthifolia											3.1		22.3	37.0		23.2	14.7	14.7	13.8	66.9	6.7			8.0		8.4	8.6	1.0	0.9	0.05	0.04
Baileya multiradiata															78.0				80.7		74.0		1.8			9.4	9.6	1.1	1.0	0.05	0.05
Boerhaavia sp.															37.5		125.3					129.3				11.7	11.9	1.4	1.3	0.06	0.06
Calliandra humilis				112.0			78.9																			7.6	7.8	0.9	0.8	0.04	0.04
Chaetopappa ericoides																7.6										0.3	0.3	0.0	0.0	0.00	0.00
Chamaesaracha coronopus															10.7											0.4	0.4	0.1	0.0	0.00	0.00
Chamaesaracha sordida														12.0				17.4								1.2	1.2	0.1	0.1	0.01	0.01
Chamaesyce albomarginata																10.3						8.5	56.6			3.0	3.1	0.4	0.3	0.02	0.02
Dalea jamesii																25.0										1.0	1.0	0.1	0.1	0.01	0.01
Dalea lanata				91.4											45.0											5.5	5.6	0.7	0.6	0.03	0.03
Desmanthus cooleyi																32.1										1.3	1.3	0.2	0.1	0.01	0.01
Eriogonum effusum					3.6		85.6							132.9	19.6		13.8	105.3		31.7		24.1			99.5	20.6	21.0	2.5	2.2	0.09	0.09
Evolvulus nuttallianus												23.6		10.7												1.4	1.4	0.2	0.1	0.01	0.01
Glandularia bipinnatifida												7.6														0.3	0.3	0.0	0.0	0.00	0.00
Hoffmannseggia glauca										16.9					13.8		4.9		16.1	129.8		27.2				8.3	8.5	1.0	0.9	0.05	0.04
Janusia gracilis						16.5																				0.7	0.7	0.1	0.1	0.01	0.01
Machaeranthera pinnatifida						29.0	10.3										10.7									2.0	2.0	0.2	0.2	0.01	0.01
Mentzelia pumila								55.3									39.3					12.5				4.3	4.4	0.5	0.5	0.03	0.03
Pectis longipes					2.2		1.3																			0.1	0.1	0.0	0.0	0.00	0.00
Portulaca pilosa						1.3																				0.1	0.1	0.0	0.0	0.00	0.00
Sida abutifolia												5.8				2.2										0.3	0.3	0.0	0.0	0.00	0.00
Solanum elaeagnifolium					1.3	71.8						69.6									6.7				11.6	6.4	6.6	0.8	0.7	0.04	0.03
Sphaeralcea grossulariifolia						5.8																				0.2	0.2	0.0	0.0	0.00	0.00
Sphaeralcea hastulata							4.5																			0.2	0.2	0.0	0.0	0.00	0.00
Stephanomeria paucilfora						23.6							16.1													1.6	1.6	0.2	0.2	0.01	0.01
Thymophylla pentachaeta																								5.4		0.2	0.2	0.0	0.0	0.00	0.00
Zinnia grandiflora																17.8										0.7	0.7	0.1	0.1	0.01	0.01
Forb Totals	0.0	0.0	0.0	203.4	7.1	148.0	180.6	56.2	0.0	17.8	3.1	106.6	38.4	192.6	204.6	118.2	208.7	137.4	110.6	228.4	87.4	201.6	58.4	13.4	129.8	98.1	100.0	11.9	10.7		
Shrubs (+ subshrubs + trees)																															
Dalea formosa						91.9							137.8		3.6	45.5			190.0			38.8				20.3	6.5	2.5	2.2	0.09	0.08
Flourensia cernua																									325.1	13.0	4.2	1.6	1.4	0.07	0.06
Gutierrezia sarothrae					34.3		30.3	11.2		92.3			245.3	82.5	102.6		117.7					451.8	41.0	45.1	58.0	52.5	16.9	6.4	5.7	0.18	0.16
Hymenoclea monogyra																									266.3	10.7	3.4	1.3	1.2	0.06	0.05
Larrea tridentata																		31.7								1.3	0.4	0.2	0.1	0.01	0.01
Lycium pallidum																		94.1								3.8	1.2	0.5	0.4	0.02	0.02
Menodora scabra														2.7				17.8								0.8	0.3	0.1	0.1	0.01	0.01
Mimosa aculeaticarpa				246.6								276.5														20.9	6.7	2.5	2.3	0.09	0.09
Prosopis glandulosa										115.5			2742.0								50.0	1114.6	29.4		487.0	181.5	58.5	22.0	19.8	0.33	0.32
Thymophylla acerosa														25.9												1.0	0.3	0.1	0.1	0.01	0.01
Yucca elata																109.7										4.4	1.4	0.5	0.5	0.03	0.03
Shrub Totals	0.0	0.0	0.0	246.6	34.3	91.9	30.3	11.2	0.0	207.8	0.0	276.5	3125.1	111.1	106.2	155.2	117.7	143.6	190.0	0.0	50.0	1605.2	70.4	45.1	1136.4	310.2	100.0	37.5	33.8		
Perennial Totals	0.0	34.3	0.0	592.7	773.8	1660.4	361.3	386.7	87.8	1227.8	3.1	1564.2	3914.7	660.8	805.9	1525.8	741.6	594.1	675.7	385.4	137.4	2214.0	213.1	616.4	1477.6	826.2	100.0	100.0	90.0	**2.72** (S-W)	
***Annuals (mostly forbs)**																															
Amaranthus palmeri																						21.0				0.8	0.9		0.1		0.01
Aristida adscensionis-G						51.7	37.5		60.2											19.2		198.5	27.7			15.8	17.3		1.7		0.07
Boerhaavia spicata																									6.7	0.3	0.3		0.0		0.00
Bouteloua barbata-G						11.2					8.9								50.0	109.7	10.7				23.6	8.6	9.4		0.9		0.04
Chamaesyce sp.																22.8										0.9	1.0		0.1		0.01
Chenopodium neomexicanum														11.2			32.6	4.5	11.2	58.4	15.6					5.3	5.8		0.6		0.03
Descurainia pinnata																									1.8	0.1	0.1		0.0		0.00
Eragrostis pectinacea-G													21.4													0.9	0.9		0.1		0.01
Eriogonum rotundifolium																	31.2									1.2	1.4		0.1		0.01
Machaeranthera gracilis															4.5								4.5			0.4	0.4		0.0		0.00
Machaeranthera tanacetifolia															10.3				45.5		931.7	32.6				40.8	44.6		4.4		0.14
Pectis angustifolia							161.9																			6.5	7.1		0.7		0.03
Pectis filipes												170.8		30.3												8.0	8.8		0.9		0.04
Plantago patagonica							6.2																			0.2	0.3		0.0		0.00
Tidestromia lanuginosa																				16.5						0.7	0.7		0.1		0.01
Verbesina encelioides																						23.2				0.9	1.0		0.1		0.01
Annual Totals	0.0	0.0	0.0	0.0	0.0	62.9	205.6	0.9	60.2	0.0	8.9	170.8	21.4	41.5	14.8	22.8	63.8	4.5	106.7	203.8	958.0	275.3	32.2	0.0	32.1	91.4	100.0		10.0		**2.95** (S-W)
Grand Total Production	0.0	34.3	0.0	592.7	773.8	1723.3	566.9	387.6	148.0	1227.8	12.0	1735.0	3936.1	702.3	820.7	1548.6	805.4	598.6	782.4	589.2	1095.4	2489.3	245.3	616.4	1509.7	917.6			100.0		

Summary of Production	Mean	Median	St.Dev.	Sample adequacy (# of quadrats)
Perennial Grasses	417.9	319.3	418.9	294.1
Perennial Forbs	98.1	106.6	81.7	203.1
Perennial Shrubs	310.2	91.9	693.7	1464.0
Perennials - Total	826.2	616.4	881.8	333.5
Annuals/Biennials	91.4	22.8	196.4	1350.1
Grand Total Production	917.6	702.3	890.2	275.5

Species Count **74**

* Annuals and biennials. G = grass. W = state-listed noxious weed.

Appendix 4-B (Table 4). 2010 Production Data: Copper Flat - Tailing Dam (TD)

Sample Area - Tailing Dam (TD)

10 Transects	Transect - lbs/ac (based on 2 (two) $1m^2$ quadrats/transect)										Species	Relative	Relative	Relative	S-W	S-W
Species	1	2	3	4	5	6	7	8	9	10	Mean	Lifeform	Perennial	Total	Index	Index
Grasses (perennials)												%	%	%	peren	all veg
Aristida havardii							51.3				5.1	1.3	0.6	0.6	0.03	0.03
Aristida purpurea		18.7	37.5								5.6	1.4	0.7	0.7	0.03	0.03
Bothriochloa laguroides	114.6	190.9	518.7	163.7		1236.3	621.7	169.9	178.0	413.9	360.8	90.9	44.7	43.9	0.36	0.36
Bouteloua curtipendula		245.3									24.5	6.2	3.0	3.0	0.11	0.10
Muhlenbergia porteri	8.9										0.9	0.2	0.1	0.1	0.01	0.01
Grass Totals	123.5	454.9	556.2	163.7	0.0	1236.3	673.0	169.9	178.0	413.9	396.9	100.0	49.2	48.3		
Forbs (perennials + some biennials)																
Chamaesyce albomarginata	29.9										3.0	83.7	0.4	0.4	0.02	0.02
Eriogonum effusum								4.0			0.4	11.2	0.0	0.0	0.00	0.00
Mentzelia pumila								1.8			0.2	5.0	0.0	0.0	0.00	0.00
Forb Totals	29.9	0.0	0.0	0.0	0.0	0.0	0.0	5.8	0.0	0.0	3.6	100.0	0.4	0.4		
Shrubs (+ subshrubs + trees)																
Baccharis pteronioides			67.4								6.7	1.7	0.8	0.8	0.04	0.04
Brickellia californica			340.3								34.0	8.4	4.2	4.1	0.13	0.13
Dalea formosa					37.5	83.0		15.6			13.6	3.3	1.7	1.7	0.07	0.07
Gutierrezia sarothrae		131.6				46.4			172.6		35.1	8.6	4.3	4.3	0.14	0.13
Hymenoclea monogyra						438.9					43.9	10.8	5.4	5.3	0.16	0.16
Prosopis glandulosa			239.9	67.4		351.9	1650.2	406.8		19.6	273.6	67.2	33.9	33.3	0.37	0.37
Shrub Totals	0.0	131.6	647.6	67.4	37.5	920.2	1650.2	422.4	172.6	19.6	406.9	100.0	50.4	49.5		
Perennial Totals	153.4	586.5	1203.8	231.1	37.5	2156.5	2323.2	598.1	350.6	433.5	807.4	100.0	100.0	98.2	**1.47** S-W	
***Annuals (mostly forbs)**																
Aristida adscensionis-G					0.4						0.0	0.3		0.0		0.00
Digitaria sp. - G	11.1										1.1	7.6		0.1		0.01
Eragrostis pectinacea-G	66.9									5.4	7.2	49.6		0.9		0.04
Salsola kali	62.0										6.2	42.5		0.8		0.04
Annual Totals	140.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	5.4	14.6	100.0		1.8		
																1.55 S-W
Grand Total Production	293.4	586.5	1203.8	231.1	37.9	2156.5	2323.2	598.1	350.6	438.9	822.0			100.0		

Summary of Production	Mean	Median	St.Dev.	Sample adequacy (# of quadrats)
Perennial Grasses	396.9	296.0	364.5	283.4
Perennial Forbs	3.6	0.0	9.4	2342.3
Perennial Shrubs	406.9	152.1	533.9	578.4
Perennials - Total	807.4	510.0	821.2	347.5
Annuals/Biennials	14.6	0.0	44.1	3073.9
Grand Total Production	822.0	512.7	809.5	325.9

Species Count
18

* Annuals and biennials. G = grass. W = state-listed noxious weed.

Appendix 4-B (Table 5). 2010 Production Data: Copper Flat - Pit

Sample Area - Pit

10 Transects — Transect - lbs/ac (based on 2 (two) 1m² quadrats/transect)

Species	1	2	3	4	5	6	7	8	9	10	Species Mean	Relative Lifeform %	Relative Perennial %	Relative Total %	S-W Index peren	S-W Index all veg
Grasses (perennials)																
Aristida purpurea					7.1						0.7	0.7	0.3	0.3	0.02	0.02
Bothriochloa laguroides					553.5						55.4	57.4	22.4	22.3	0.34	0.33
Bouteloua curtipendula					91.0						9.1	9.4	3.7	3.7	0.12	0.12
Panicum obtusum					313.5						31.4	32.5	12.7	12.6	0.26	0.26
Grass Totals	0.0	0.0	0.0	0.0	965.1	0.0	0.0	0.0	0.0	0.0	96.5	100.0	39.0	38.9		
Shrubs (+ subshrubs + trees)																
Brickellia californica					1505.2						150.5	99.8	60.9	60.7	0.30	0.30
Gutierrezia sarothrae					3.1						0.3	0.2	0.1	0.1	0.01	0.01
Shrub Totals	0.0	0.0	0.0	0.0	1508.3	0.0	0.0	0.0	0.0	0.0	150.8	100.0	61.0	60.8		
Perennial Totals	0.0	0.0	0.0	0.0	2473.4	0.0	0.0	0.0	0.0	0.0	247.3	100.0	100.0	99.7	1.05 S-W	
***Annuals (mostly forbs)**																
Pectis angustifolia					4.9						0.5	64.5		0.2		0.01
Polanisia dodecandra					2.7						0.3	35.5		0.1		0.01
Annual Totals	0.0	0.0	0.0	0.0	7.6	0.0	0.0	0.0	0.0	0.0	0.8	100.0		0.3		1.07 S-W
Grand Total Production	0.0	0.0	0.0	0.0	2481.0	0.0	0.0	0.0	0.0	0.0	248.1			100.0		

Species Count: 8

Summary of Production

	Mean	Median	St.Dev.	Sample adequacy (# of quadrats)
Perennial Grasses	96.5	0.0	305.2	3359.9
Perennial Shrubs	150.8	0.0	477.0	3359.9
Perennials - Total	247.3	0.0	782.2	3359.9
Annuals/Biennials	0.8	0.0	2.4	3359.9
Grand Total Production	248.1	0.0	784.6	3359.9

* Annuals and biennials. G = grass. W = state-listed noxious weed.

Appendix 4-C

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

Appendix 4-C (Table 1). 2010 Shrub Density Data: Copper Flat - Chihuahuan Desert Grassland Stratum (CDG)

Sample Area: Chihuahuan Desert Grassland (CDG)

29 Transects — Transect - Stem Counts

Species	Size	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	Total count	Density stems/ac	Density by species*		Stand Composition - % of Total: Small/Large		Sp. Total		
Shrubs		BU-1	BU-2	BU-3	BU-4	BU-5	BU-6	BU-7	BU-8	BU-9	BU-10	BU-11	BU-12	BU-13	BU-14	BU-15	BU-16	BU-17	BD-1	BD-2	BD-3	BD-4	BD-5	BD-6	BD-7	BD-8	BD-9	BD-10	BD-11	BD-12									
Aloysia wrightii	small								27	1	1												3	1	6	3		3			45	62.8	65.6		2.6		2.8		
	large																								1	1					2	2.8			0.1				
Atriplex canescens	small	1																													1	1.4	1.4		0.1		0.1		
	large																														0	0.0			0.0				
Baccharis emoryi	small																	2													2	2.8	2.8		0.1		0.1		
	large																														0	0.0			0.0				
Baccharis pteronioides	small			1							1							3													5	7.0	7.0		0.3		0.3		
	large																														0	0.0			0.0				
Brickellia californica	small					2	27		1		1	1								1				1							34	47.5	47.5		2.0		2.0		
	large																														0	0.0			0.0				
Calliandra eriophylla	small									6													15	8	15						44	61.4	61.4		2.6		2.6		
	large																														0	0.0			0.0				
Celtis laevigata	small																	1													1	1.4	4.2		0.1		0.2		
	large																	2													2	2.8			0.1				
Dalea formosa	small								1	5				1			16												20		43	60.0	60.0		2.5		2.5		
	large																														0	0.0			0.0				
Dasylirion wheeleri	small			3					29										1												33	46.1	46.1		1.9		1.9		
	large																														0	0.0			0.0				
Ephedra trifurca	small	2																				1						1			4	5.6	5.6		0.2		0.2		
	large																														0	0.0			0.0				
Ericameria nauseosa	small																														0	0.0	0.0		0.0		0.0		
	large																														0	0.0			0.0				
Eriogonum wrightii	small																			3											3	4.2	4.2		0.2		0.2		
	large																														0	0.0			0.0				
Fallugia paradoxa	small										1							3													4	5.6	5.6		0.2		0.2		
	large																														0	0.0			0.0				
Flourensia cernua	small												1										8					39			48	67.0	68.4		2.8		2.9		
	large																											1			1	1.4			0.1				
Fouquieria splendens	small																														0	0.0	1.4		0.0		0.1		
	large								1																						1	1.4			0.1				
Gutierrezia sarothrae	small	19	14	20	13	8	21	55	7	20	23	101	11	47	30	2	54	81	1	1	66	112	1	9	1	1	33	3	21	1	776	1083.3	1083.3		45.5		45.5		
	large																														0	0.0			0.0				
Hymenoclea monogyra	small																	50													50	69.8	69.8		2.9		2.9		
	large																														0	0.0			0.0				
Juniperus monosperma	small				2																										2	2.8	7.0		0.1		0.3		
	large				1	2																									3	4.2			0.2				
Larrea tridentata	small																												1	11	12	16.8	19.5		0.7		0.8		
	large																												1	1	2	2.8			0.1				
Menodora scabra	small								4																						4	5.6	5.6		0.2		0.2		
	large																														0	0.0			0.0				
Mimosa aculeaticarpa	small									1				8		47	5		77		2			2		3			2		147	205.2	210.8		8.6		8.9		
	large													1		1	1									1					4	5.6			0.2				
Opuntia chlorotica	small												1				1			2											4	5.6	5.6		0.2		0.2		
	large																														0	0.0			0.0				
Parthenium incanum	small								3					12			25						37	32	4			20	9	76	218	304.3	304.3		12.8		12.8		
	large																														0	0.0			0.0				
Prosopis glandulosa	small	17		5						9			2	13		1	5				5	18	29	5	10	8		9	13	1	150	209.4	247.1		8.8		10.4		
	large	1						2									1	5			12			3		2		1			27	37.7			1.6				
Quercus turbinella	small																														0	0.0	1.4		0.0		0.1		
	large					1																									1	1.4			0.1				
Rhus microphylla	small		1												1			6	1	1										1	11	15.4	33.5	**Density**	0.6		1.4		
	large		1															9							1			2			13	18.1			0.8				
Rhus trilobata	small					1						2																			3	4.2	7.0	**All Shrubs**	0.2		0.3		
	large						2																								2	2.8		**per ac**	0.1				
Yucca elata	small																2												2		4	5.6	5.6	2381.7	0.2		0.2		
	large																														0	0.0			0.0	100.0			
Shrub Totals	small	39	15	29	15	11	48	55	72	42	27	104	15	81	31	50	108	146	80	8	73	131	93	58	36	15	33	75	68	90	1648	2300.7	2381.7	**per ha**	96.6		100.0		
	large	1	1	0	1	3	2	2	1	0	0	0	0	1	0	1	2	16	0	0	12	0	0	3	2	4	0	4	1	1	58	81.0		5885.2	3.4	100.0			
Trees																																		**All Trees**					
	small																														0	0.0	0.0	**per ac**	0.0		0.0		
	large																														0	0.0		0.0	0.0	0.0			
Tree Totals	small	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0		0.0		0.0		
	large	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0		**per ha**	0.0	0.0		**Species**	
																															1706	2381.7		0.0				**count**	Sample
Density (stems/acre)	**small**	1579.0	607.3	1174.1	607.3	445.3	1943.3	2226.7	2915.0	1700.4	1093.1	4210.5	607.3	3279.4	1255.1	2024.3	4372.5	5911.0	3238.9	323.9	2955.5	5303.7	3765.2	2348.2	1457.5	607.3	1336.0	3036.5	2753.0	3643.7	small	2300.7	2381.7	**Shrubs + Trees**				**27**	adequacy
	large	40.5	40.5	0.0	40.5	121.5	81.0	81.0	40.5	0.0	0.0	0.0	0.0	40.5	0.0	40.5	81.0	647.8	0.0	0.0	485.8	0.0	0.0	121.5	81.0	161.9	0.0	161.9	40.5	40.5	large	81.0		⇦					(# of belt
Total Density	**per ac**	1619.4	647.8	1174.1	647.8	566.8	2024.3	2307.7	2955.5	1700.4	1093.1	4210.5	607.3	3319.9	1255.1	2064.8	4453.5	6558.7	3238.9	323.9	3441.3	5303.7	3765.2	2469.6	1538.5	769.2	1336.0	3198.4	2793.5	3684.2	ac	2381.7	**Mean Grand Total Density**			2064.8	1557.3		transects)
by transect	**per ha**	4001.6	1600.7	2901.2	1600.7	1400.6	5002.0	5702.3	7303.0	4201.7	2701.1	10404.3	1500.6	8203.4	3101.3	5102.1	11004.5	16206.6	8003.3	800.3	8503.5	13105.4	9303.8	6102.5	3801.6	1900.8	3301.3	7903.2	6902.8	9103.7	ha	5885.2	⇦			**Median**	**St.Dev.**		123.7

* Stems/acre of small and large combined; small means < 1 meter in height or diameter (breadth); large means >= 1 meter in height or breadth (for trees small means less than 2 meters in height).

Appendix 4-C (Table 2). 2010 Shrub Density Data: Copper Flat - Chihuahuan Desert Shrubland Stratum (CDS)

Sample Area: Chihuahuan Desert Shrubland (CDS)

19 Transects — Transect - Stem Counts

Species	Size	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Total count	Density stems/ac	Density by species*		Stand Composition - % of Total Small/Large		Sp. Total
Shrubs		BU-19	BU-20	BU-21	BU-22	BU-23	BU-24	BU-25	BU-26	BU-27	BD-13	BD-14	BD-15	BD-16	BD-17	BD-18	BD-19	BD-20	BD-21	BD-22							
Aloysia wrightii	small							4													4	8.5	8.5		0.3		0.3
	large																				0	0.0			0.0		
Atriplex canescens	small		1	3																	4	8.5	10.7		0.3		0.3
	large																	1			1	2.1			0.1		
Baccharis pteronioides	small				7	15							1								23	49.0	53.3		1.5		1.6
	large																2				2	4.3			0.1		
Brickellia californica	small																				0	0.0	0.0		0.0		0.0
	large																				0	0.0			0.0		
Calliandra eriophylla	small																				0	0.0	0.0		0.0		0.0
	large																				0	0.0			0.0		
Chilopsis linearis	small																				0	0.0	2.1		0.0		0.1
	large					1															1	2.1			0.1		
Dalea formosa	small							4													4	8.5	8.5		0.3		0.3
	large																				0	0.0			0.0		
Ephedra trifurca	small													1							1	2.1	2.1		0.1		0.1
	large																				0	0.0			0.0		
Ericameria nauseosa	small																				0	0.0	0.0		0.0		0.0
	large																				0	0.0			0.0		
Fallugia paradoxa	small				11																11	23.4	23.4		0.7		0.7
	large																				0	0.0			0.0		
Flourensia cernua	small	51	3	10	3			5	2			4			3	16	4	12	25	81	219	466.7	594.5		14.4		18.3
	large	13										8			8		4	9	11	7	60	127.9			3.9		
Gutierrezia sarothrae	small	93	29	41	58	23	9	5	64	13	40	27	86	41	28	8	20	10	17	2	614	1308.3	1308.3		40.3		40.3
	large																				0	0.0			0.0		
Hymenoclea monogyra	small		4			135															139	296.2	298.3		9.1		9.2
	large																		1		1	2.1			0.1		
Larrea tridentata	small	30	9	16	3			15								5	5	12		1	96	204.6	240.8		6.3		7.4
	large	3	4															10			17	36.2			1.1		
Lycium pallidum	small			7																	7	14.9	14.9		0.5		0.5
	large																				0	0.0			0.0		
Lycium torreyi	small	1									2							8			11	23.4	25.6		0.7		0.8
	large																	1			1	2.1			0.1		
Menodora scabra	small							4													4	8.5	8.5		0.3		0.3
	large																				0	0.0			0.0		
Parthenium incanum	small	28	3		5			78		22							1				137	291.9	291.9	**Density**	9.0		9.0
	large																				0	0.0			0.0		
Prosopis glandulosa	small	4	1	2		1	8	5	5	15	9	4		11	20	16	3		2	1	107	228.0	351.6	**All Shrubs**	7.0		10.8
	large		6			2	1		4	2	7	4	3	1	17	2	6	2	1		58	123.6		**per ac**	3.8		
Yucca elata	small									1				2							3	6.4	6.4	3249.5	0.2		0.2
	large																				0	0.0			0.0	100.0	
Shrub Totals	small	207	50	79	87	174	17	120	71	51	51	35	87	55	51	45	33	42	44	85	1384	2949.1	3249.5	**per ha**	90.8		100.0
	large	16	10	0	0	3	1	0	4	2	7	12	3	1	25	2	12	23	13	7	141	300.4		8029.6	9.2	100.0	
Trees																								**All Trees**			
	small																				0	0.0	0.0	**per ac**	0.0		0.0
	large																				0	0.0		0.0	0.0	0.0	
Tree Totals	small	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0		0.0		0.0
	large	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0		**per ha**	0.0	0.0	
																					1525	3249.5		0.0			
Density (stems/acre)	**small**	8380.6	2024.3	3198.4	3522.3	7044.6	688.3	4858.3	2874.5	2064.8	2064.8	1417.0	3522.3	2226.7	2064.8	1821.9	1336.0	1700.4	1781.4	3441.3	small	2949.1	3249.5	**Shrubs + Trees**			
	large	647.8	404.9	0.0	0.0	121.5	40.5	0.0	161.9	81.0	283.4	485.8	121.5	40.5	1012.2	81.0	485.8	931.2	526.3	283.4	large	300.4		⇦			
Total Density	**per ac**	9028.4	2429.2	3198.4	3522.3	7166.0	728.7	4858.3	3036.5	2145.8	2348.2	1902.8	3643.7	2267.2	3076.9	1902.8	1821.9	2631.6	2307.7	3724.7	ac	3249.5	**Mean Grand Total Density**			2631.6	1955.2
by transect	**per ha**	22309.1	6002.5	7903.2	8703.6	17707.2	1800.7	12004.9	7503.1	5302.2	5802.4	4701.9	9003.7	5602.3	7603.1	4701.9	4501.8	6502.7	5702.3	9203.8	ha	8029.6	⇦			**Median**	**St.Dev.**

Species count 17

Sample adequacy (# of belt transects) 108.9

* Stems/acre of small and large combined; small means < 1 meter in height or diameter (breadth); large means >= 1 meter in height or breadth (for trees small means less than 2 meters in height).

Appendix 4-C (Table 3). 2010 Shrub Density Data: Copper Flat - Disturbed Area/Waste Rock Pile

Sample Area Disturbed Area/Waste Rock Pile

25 Transects — Transect - Stem Counts (Transect 25: BUH-18 / BU-18)

Species	Size	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Total count	Density stems/ac	Density by species*		Stand Composition - % of Total Small/Large		Sp. Total
Shrubs																																	
Baccharis pteronioides	small																									3	3	4.9	8.1		0.2		0.3
	large																									2	2	3.2			0.1		
Brickellia californica	small	2	12		1	12	19	22	9	2	4	1											1				85	137.7	145.7		5.0		5.2
	large										5																5	8.1			0.3		
Dalea formosa	small									1				162		3	32			20					103		321	519.8	519.8		18.7		18.7
	large																										0	0.0			0.0		
Ericameria nauseosa	small					2					1																3	4.9	4.9		0.2		0.2
	large																										0	0.0			0.0		
Fallugia paradoxa	small				1	9																		1			11	17.8	19.4		0.6		0.7
	large	1																									1	1.6			0.1		
Flourensia cernua	small																									7	7	11.3	22.7		0.4		0.8
	large																				1					6	7	11.3			0.4		
Gutierrezia sarothrae	small				13	17	14	91	7	1	14		43	32	17	68	29	52	29	21	2	3	193	133	51	11	841	1361.9	1361.9		49.0		49.0
	large																										0	0.0			0.0		
Hymenoclea monogyra	small					7	42																			19	68	110.1	110.1		4.0		4.0
	large																										0	0.0			0.0		
Larrea tridentata	small																		1							1	2	3.2	6.5		0.1		0.2
	large																									2	2	3.2			0.1		
Lycium pallidum	small																		61								61	98.8	98.8		3.6		3.6
	large																										0	0.0			0.0		
Lycium torreyi	small																										0	0.0	3.2		0.0		0.1
	large																									2	2	3.2			0.1		
Menodora scabra	small												1	3	9				10								23	37.2	37.2		1.3		1.3
	large																										0	0.0			0.0		
Mimosa aculeaticarpa	small				15						2		26	11													54	87.4	92.3		3.1		3.3
	large				1								1	1													3	4.9			0.2		
Opuntia chlorotica	small																								1		1	1.6	1.6		0.1		0.1
	large																										0	0.0			0.0		
Opuntia phaeacantha	small					1																					1	1.6	1.6		0.1		0.1
	large																										0	0.0			0.0		
Parthenium incanum	small													1	70		1		3								75	121.5	121.5		4.4		4.4
	large																										0	0.0			0.0		
Prosopis glandulosa	small	1			3						1		11	11	15	17	7	5	8	13	6	2	5	4	4	2	115	186.2	208.9		6.7		7.5
	large				1				1									1	1		2		6			2	14	22.7			0.8		
Rhus microphylla	small																2										2	3.2	4.9	**Density**	0.1		0.2
	large																				1						1	1.6			0.1		
Senecio flaccidus	small					2																					2	3.2	3.2	**All Shrubs**	0.1		0.1
	large																										0	0.0		**per ac**	0.0		
Yucca elata	small																3	1									4	6.5	6.5	2779.0	0.2		0.2
	large																										0	0.0			0.0	100.0	
Shrub Totals	small	3	12	0	33	50	75	113	16	4	22	1	81	220	111	88	74	58	112	54	8	5	199	138	159	43	1679	2719.0	2779.0	**per ha**	97.8		100.0
	large	1	0	0	2	0	0	0	1	0	5	0	1	1	0	0	0	1	1	0	4	0	6	0	0	14	37	59.9		6866.8	2.2	100.0	
Trees																														**All Trees**			
	small																										0	0.0	0.0	**per ac**	0.0		0.0
	large																										0	0.0		0.0	0.0	0.0	
Tree Totals	small	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0		0.0		0.0
	large	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0		**per ha**	0.0	0.0	
																											1716	2779.0		0.0			
Density (stems/acre)	**small**	121.5	485.8	0.0	1336.0	2024.3	3036.5	4574.9	647.8	161.9	890.7	40.5	3279.4	8906.9	4493.9	3562.8	2996.0	2348.2	4534.4	2186.2	323.9	202.4	8056.7	5587.1	6437.3	1740.9	small	2719.0	2779.0	**Shrubs + Trees**			
	large	40.5	0.0	0.0	81.0	0.0	0.0	0.0	40.5	0.0	202.4	0.0	40.5	40.5	0.0	0.0	0.0	40.5	40.5	0.0	161.9	0.0	242.9	0.0	0.0	566.8	large	59.9		⇦			
Total Density	**per ac**	161.9	485.8	0.0	1417.0	2024.3	3036.5	4574.9	688.3	161.9	1093.1	40.5	3319.9	8947.4	4493.9	3562.8	2996.0	2388.7	4574.9	2186.2	485.8	202.4	8299.6	5587.1	6437.3	2307.7	ac	2779.0	**Mean Grand Total Density**			2307.7	2554.8
by transect	**per ha**	400.2	1200.5	0.0	3501.4	5002.0	7503.1	11304.6	1700.7	400.2	2701.1	100.0	8203.4	22109.0	11104.5	8803.6	7403.0	5902.4	11304.6	5402.2	1200.5	500.2	20508.4	13805.6	15906.5	5702.3	ha	6866.8	⇦			**Median**	**St.Dev.**

Species count 20

Sample adequacy (# of belt transects) 247.4

* Stems/acre of small and large combined; small means < 1 meter in height or diameter (breadth); large means >= 1 meter in height or breadth (for trees small means less than 2 meters in height).

Appendix 4-C (Table 4). 2010 Shrub Density Data: Copper Flat - Tailing Dam (TD)

Sample Area TD

10 Transects

Species	Size	Transect - Stem Counts 1	2	3	4	5	6	7	8	9	10	Total count	Density stems/ac	Density by species*		Stand Composition - % of Total Small/Large		Sp. Total		
Shrubs																				
Baccharis pteronioides	small	3	5	22				2	2	1	2	37	149.8	174.1		7.7		8.9		
	large		1	2	2						1	6	24.3			1.2				
Brickellia californica	small	4		13								17	68.8	81.0		3.5		4.1		
	large			3								3	12.1			0.6				
Dalea formosa	small		1		38	31	84	3	37			194	785.4	785.4		40.2		40.2		
	large											0	0.0			0.0				
Fallugia paradoxa	small							1				1	4.0	12.1		0.2		0.6		
	large				1	1						2	8.1			0.4				
Gutierrezia sarothrae	small	34	36	18	2	9	4	12	8	10	6	139	562.8	562.8		28.8		28.8		
	large											0	0.0			0.0				
Prosopis glandulosa	small	4	5	8	3		5	2	10	6	1	44	178.1	332.0	**Density**	9.1		17.0		
	large	4	3		2	7	3	6	5	1	7	38	153.8			7.9				
Rhus microphylla	small											0	0.0	4.0	**All Shrubs**	0.0		0.2		
	large			1								1	4.0		**per ac**	0.2				
Shrub SP.	small											0	0.0	0.0	1951.4	0.0		0.0		
	large											0	0.0			0.0	100.0			
Shrub Totals	small	45	47	61	43	40	93	20	57	17	9	432	1749.0	1951.4	**per ha**	89.6		100.0		
	large	4	4	6	5	8	3	6	5	1	8	50	202.4		4822.0	10.4	100.0			
Trees															**All Trees**					
	small											0	0.0	0.0	**per ac**	0.0		0.0		
	small											0	0.0		0.0	0.0	0.0			
Tree Totals	small	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0		0.0		0.0		
	large	0	0	0	0	0	0	0	0	0	0	0	0.0		**per ha**	0.0	0.0		**Species**	
												482	1951.4		0.0				**count**	Sample
Density (stems/acre)	**small**	1821.9	1902.8	2469.6	1740.9	1619.4	3765.2	809.7	2307.7	688.3	364.4	small	1749.0	1951.4	**Shrubs + Trees**				**7**	adequacy
	large	161.9	161.9	242.9	202.4	323.9	121.5	242.9	202.4	40.5	323.9	large	202.4		⇦					(# of belt
Total Density	**per ac**	1983.8	2064.8	2712.6	1943.3	1943.3	3886.7	1052.6	2510.1	728.7	688.3	ac	1951.4	**Mean Grand Total Density**			1963.6	974.6		transects)
by transect	**per ha**	4902.0	5102.1	6702.7	4802.0	4802.0	9603.9	2601.1	6202.5	1800.7	1700.7	ha	4822.0	⇦			**Median**	**St.Dev.**		83.8

* Stems/acre of small and large combined; small means < 1 meter in height or diameter (breadth); large means >= 1 meter in height or breadth (for trees small means less than 2 meters in height).

Appendix 4-C (Table 5). 2010 Shrub Density Data: Copper Flat - Pit

Sample Area Pit

10 Transects — Transect - Stem Counts

Species	Size	1	2	3	4	5	6	7	8	9	10	Total count	Density stems/ac	Density by species*		Stand Composition - % of Total Small/Large		Sp. Total
Shrubs																		
Brickellia californica	small			3		15						18	72.9	133.6		25.0		45.8
	large					15						15	60.7			20.8		
Eriogonum wrightii	small								1			1	4.0	4.0		1.4		1.4
	large											0	0.0			0.0		
Fallugia paradoxa	small	1										1	4.0	4.0		1.4		1.4
	large											0	0.0			0.0		
Gutierrezia sarothrae	small					25						25	101.2	101.2		34.7		34.7
	large											0	0.0			0.0		
Prosopis glandulosa	small					1						1	4.0	4.0	**Density**	1.4		1.4
	large											0	0.0			0.0		
Tamarix chinensis	small						6		4			10	40.5	44.5	**All Shrubs**	13.9		15.3
	large						1					1	4.0		**per ac**	1.4		
Shrub Sp	small											0	0.0	0.0	291.5	0.0		0.0
	large											0	0.0			0.0	100.0	
Shrub Totals	small	1	0	3	0	41	6	0	5	0	0	56	226.7	291.5	**per ha**	77.8		100.0
	large	0	0	0	0	15	1	0	0	0	0	16	64.8		720.3	22.2	100.0	
Trees															**All Trees**			
	small											0	0.0	0.0	**per ac**	0.0		0.0
	small											0	0.0		0.0	0.0	0.0	
Tree Totals	small	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0		0.0		0.0
	large	0	0	0	0	0	0	0	0	0	0	0	0.0		**per ha**	0.0	0.0	
												72	291.5		0.0			
Density (stems/acre)	**small**	40.5	0.0	121.5	0.0	1659.9	242.9	0.0	202.4	0.0	0.0	small	226.7	291.5	**Shrubs + Trees**			
	large	0.0	0.0	0.0	0.0	607.3	40.5	0.0	0.0	0.0	0.0	large	64.8		⇦			
Total Density	**per ac**	40.5	0.0	121.5	0.0	2267.2	283.4	0.0	202.4	0.0	0.0	ac	291.5	**Mean Grand Total Density**			20.2	701.4
by transect	**per ha**	100.0	0.0	300.1	0.0	5602.3	700.3	0.0	500.2	0.0	0.0	ha	720.3	⇦			**Median**	**St.Dev.**

Species count 6

Sample adequacy (# of belt transects) 1945.5

* Stems/acre of small and large combined; small means < 1 meter in height or diameter (breadth); large means >= 1 meter in height or breadth (for trees small means less than 2 meters in height).

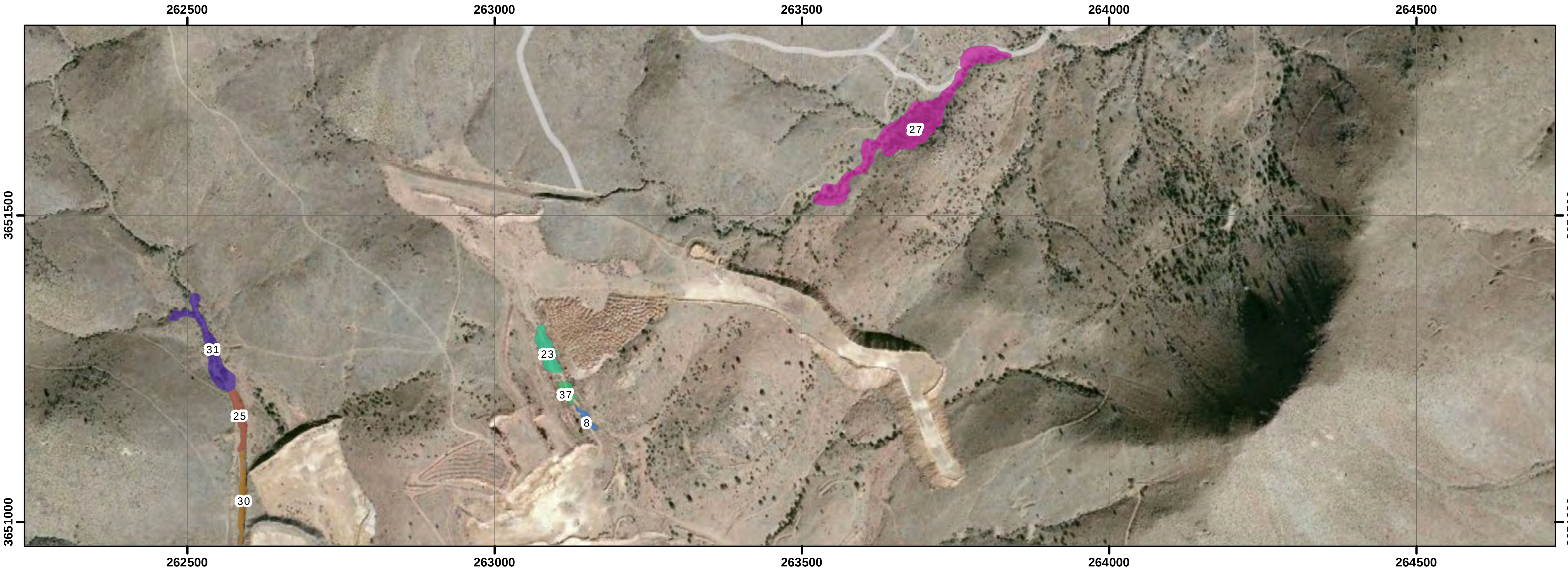
Appendix 4-C (Table 6). 2010 Shrub Density Data: Copper Flat - Arroyo

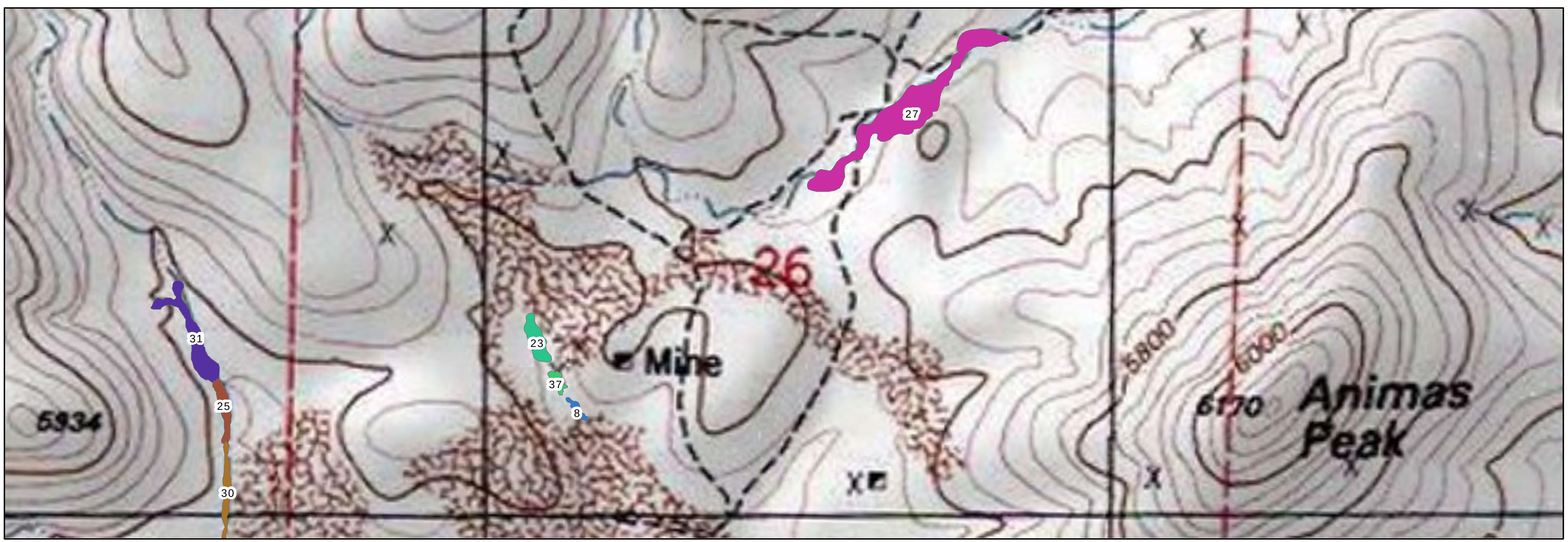
Sample Area	Arroyo	Diver-	Arroyo	Arroyo									
3 Transects		sion	2	2	Total	Density	Density by		Stand Composition - % of Total				
Species	**Size**	**1**	**2**	**3**	**count**	**stems/ac**	**species***		**Small/Large**		**Sp. Total**		
Shrubs													
Amorpha fruticosa	small			1	1	13.5	13.5		0.2		0.2		
	large				0	0.0			0.0				
Baccharis emoryi	small	16	23	22	61	823.2	1862.4		13.7		31.0		
	large	14	21	42	77	1039.1			17.3				
Celtis leavigata	small	6			6	81.0	81.0		1.3		1.3		
	large				0	0.0			0.0				
Gutierrezia sarothrae	small			9	9	121.5	121.5		2.0		2.0		
	large				0	0.0			0.0				
Hymenoclea monogyra	small			266	266	3589.8	3711.2		59.8		61.8		
	large			9	9	121.5			2.0				
Prosopis glandulosa	small			2	2	27.0	27.0	**Density**	0.4		0.4		
	large				0	0.0			0.0				
Rhus microphylla	small				0	0.0	27.0	**All Shrubs**	0.0		0.4		
	large			2	2	27.0		**per ac**	0.4				
Rhus trilobata	small			2	2	27.0	27.0	6005.4	0.4		0.4		
	large				0	0.0			0.0	100.0			
Shrub Totals	small	31	24	302	357	4817.8	6005.4	**per ha**	80.2		100.0		
	large	14	21	53	88	1187.6		14839.4	19.8	100.0			
Trees								**All Trees**					
	small				0	0.0	0.0	**per ac**	0.0		0.0		
	small				0	0.0		0.0	0.0	0.0			
Tree Totals	small	0	0	0	0	0.0	0.0		0.0		0.0		
	large	0	0	0	0	0.0		**per ha**	0.0	0.0		**Species**	
					445	6005.4		0.0				**count**	Sample
Density (stems/acre)	**small**	1255.1	971.7	12226.8	small	4817.8	6005.4	**Shrubs + Trees**				**9**	adequacy
	large	566.8	850.2	2145.8	large	1187.6		⇦					(# of belt
Total Density	**per ac**	1821.9	1821.9	14372.5	ac	6005.4	**Mean Grand Total Density**			1821.9	7246.1		transects)
by transect	**per ha**	4501.8	4501.8	35514.5	ha	14839.4	⇦			**Median**	**St.Dev.**		1241.3

* Stems/acre of small and large combined; small means < 1 meter in height or diameter (breadth); large means >= 1 meter in height or breadth (for trees small means less than 2 meters in height).

Appendix 4-D

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





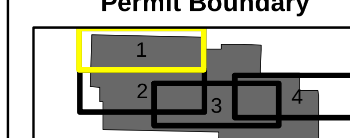
Detailed Riparian Vegetation Mapping: Permit Area Map 1 of 4

Legend

H&O Vegetation Type

- 1, AP-Br-B6
- 2, AP5
- 3, B-BB5
- 4, B-Br5
- 5, B-HM5
- 6, B-SC5
- 7, B-SU-HM5
- 8, B5
- 9, B5S
- 10, BB-AP-SU5
- 11, BB-B-SU5
- 12, BB-B5
- 13, BB5
- 14, C/B-BB3
- 15, C/BB-B3
- 16, C/HM-B3
- 17, C/SC3
- 18, HM-B-BB5
- 19, HM-B5
- 20, HM-BB5
- 21, HM-Qu5S
- 22, HM-SC-Br5
- 23, HM/Br4
- 24, HM5
- 25, HM5S
- 26, MH
- 27, Qu-C4
- 28, Qu-HM4
- 29, Qu-HM5
- 30, Qu-HM5S
- 31, Qu/HM3S
- 32, Qu4
- 33, RB-HM5
- 34, SC/SC3
- 35, SC5
- 36, SC6
- 37, TW-SC/B3
- 38, TW/B3
- 39, VA-HM/B-BB3
- 40, VA/B-Br3

Permit Boundary



Map Frames

0 500 1,000 Feet

N

Map scale = 1 : 7,000

Parametrix

Map created by Chad McKenna, Parametrix, Inc. November 11, 2011.

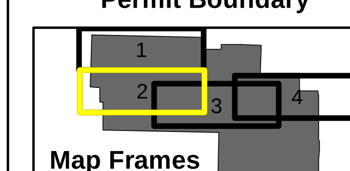
Detailed Riparian Vegetation Mapping: Permit Area Map 2 of 4

Legend

H&O Vegetation Type

- 1, AP-Br-B6
- 2, AP5
- 3, B-BB5
- 4, B-Br5
- 5, B-HM5
- 6, B-SC5
- 7, B-SU-HM5
- 8, B5
- 9, B5S
- 10, BB-AP-SU5
- 11, BB-B-SU5
- 12, BB-B5
- 13, BB5
- 14, C/B-BB3
- 15, C/BB-B3
- 16, C/HM-B3
- 17, C/SC3
- 18, HM-B-BB5
- 19, HM-B5
- 20, HM-BB5
- 21, HM-Qu5S
- 22, HM-SC-Br5
- 23, HM/Br4
- 24, HM5
- 25, HM5S
- 26, MH
- 27, Qu-C4
- 28, Qu-HM4
- 29, Qu-HM5
- 30, Qu-HM5S
- 31, Qu/HM3S
- 32, Qu4
- 33, RB-HM5
- 34, SC/SC3
- 35, SC5
- 36, SC6
- 37, TW-SC/B3
- 38, TW/B3
- 39, VA-HM/B-BB3
- 40, VA/B-Br3

Permit Boundary



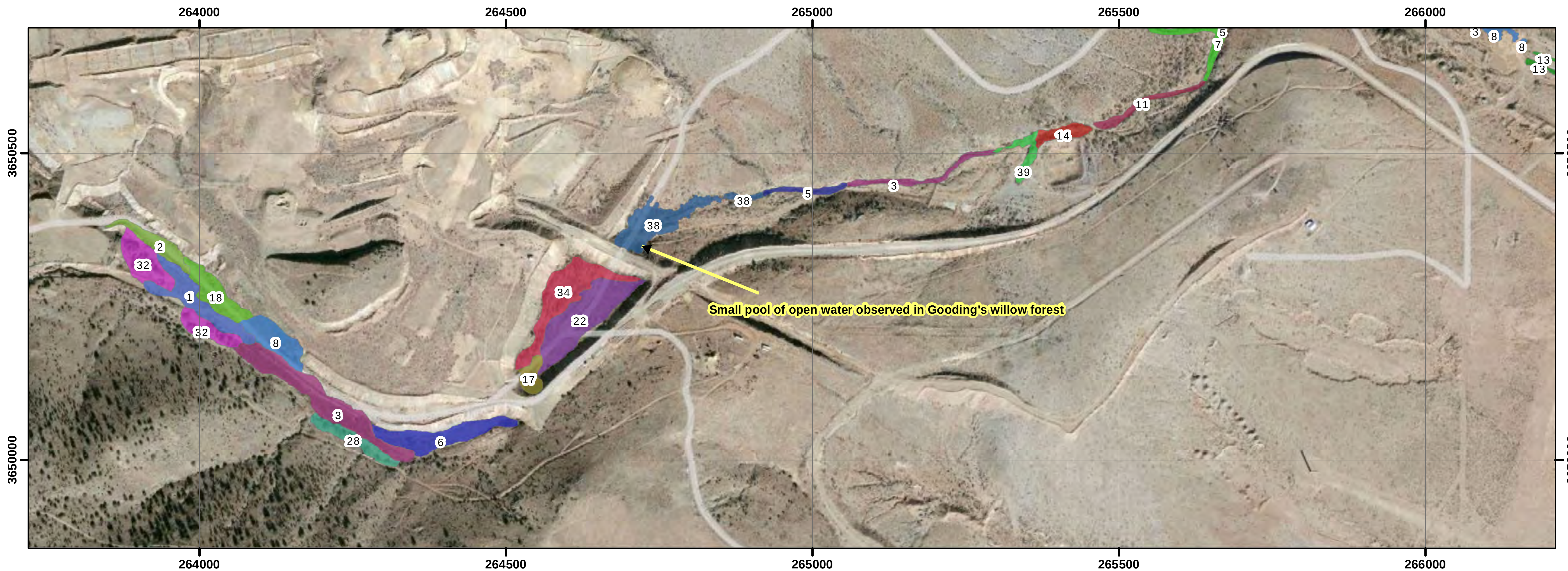
0 500 1,000 Feet

Map scale = 1 : 7,000

N

Parametrix

Map created by Chad McKenna, Parametrix, Inc. November 11, 2011.



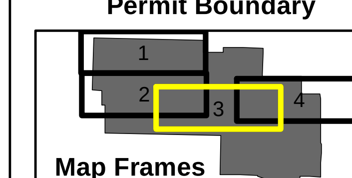
Detailed Riparian Vegetation Mapping: Permit Area Map 3 of 4

Legend

H&O Vegetation Type

- 1, AP-Br-B6
- 2, AP5
- 3, B-BB5
- 4, B-Br5
- 5, B-HM5
- 6, B-SC5
- 7, B-SU-HM5
- 8, B5
- 9, B5S
- 10, BB-AP-SU5
- 11, BB-B-SU5
- 12, BB-B5
- 13, BB5
- 14, C/B-BB3
- 15, C/BB-B3
- 16, C/HM-B3
- 17, C/SC3
- 18, HM-B-BB5
- 19, HM-B5
- 20, HM-BB5
- 21, HM-Qu5S
- 22, HM-SC-Br5
- 23, HM/Br4
- 24, HM5
- 25, HM5S
- 26, MH
- 27, Qu-C4
- 28, Qu-HM4
- 29, Qu-HM5
- 30, Qu-HM5S
- 31, Qu/HM3S
- 32, Qu4
- 33, RB-HM5
- 34, SC/SC3
- 35, SC5
- 36, SC6
- 37, TW-SC/B3
- 38, TW/B3
- 39, VA-HM/B-BB3
- 40, VA/B-Br3

Permit Boundary



Map Frames

0 500 1,000 Feet

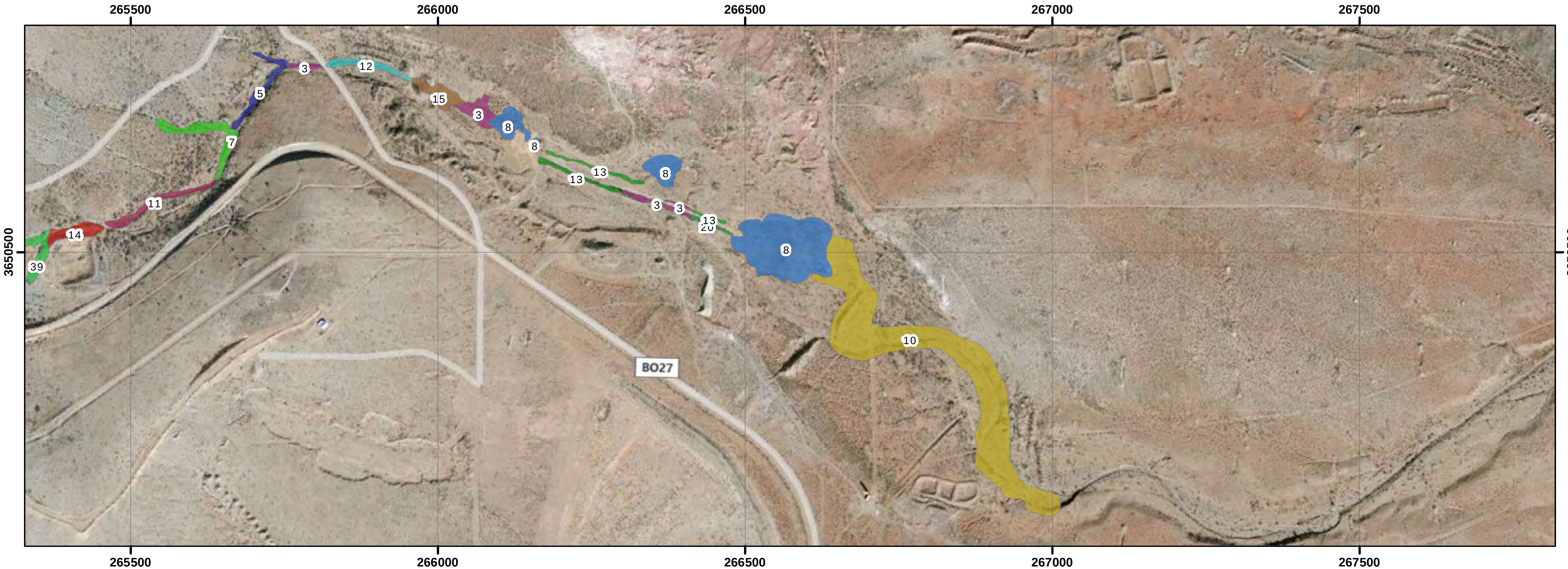
Map scale = 1 : 7,000

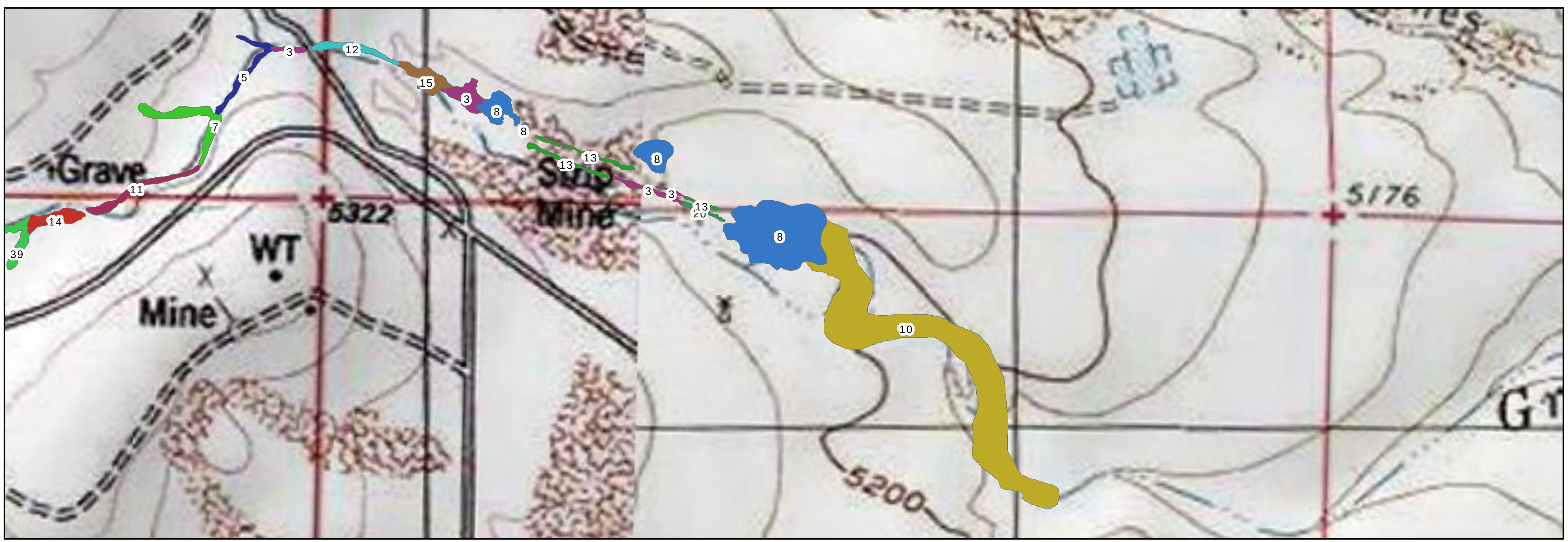
N

Parametrix

Map created by Chad McKenna, Parametrix, Inc. November 11, 2011.

Detailed Riparian Vegetation Mapping: Permit Area Map 4 of 4



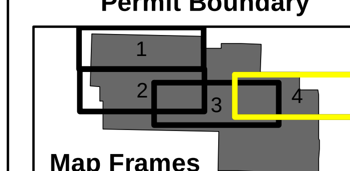


Legend

H&O Vegetation Type

- 1, AP-Br-B6
- 2, AP5
- 3, B-BB5
- 4, B-Br5
- 5, B-HM5
- 6, B-SC5
- 7, B-SU-HM5
- 8, B5
- 9, B5S
- 10, BB-AP-SU5
- 11, BB-B-SU5
- 12, BB-B5
- 13, BB5
- 14, C/B-BB3
- 15, C/BB-B3
- 16, C/HM-B3
- 17, C/SC3
- 18, HM-B-BB5
- 19, HM-B5
- 20, HM-BB5
- 21, HM-Qu5S
- 22, HM-SC-Br5
- 23, HM/Br4
- 24, HM5
- 25, HM5S
- 26, MH
- 27, Qu-C4
- 28, Qu-HM4
- 29, Qu-HM5
- 30, Qu-HM5S
- 31, Qu/HM3S
- 32, Qu4
- 33, RB-HM5
- 34, SC/SC3
- 35, SC5
- 36, SC6
- 37, TW-SC/B3
- 38, TW/B3
- 39, VA-HM/B-BB3
- 40, VA/B-Br3

Permit Boundary



Map Frames

Parametrix

Map created by Chad McKenna, Parametrix, Inc. November 11, 2011.

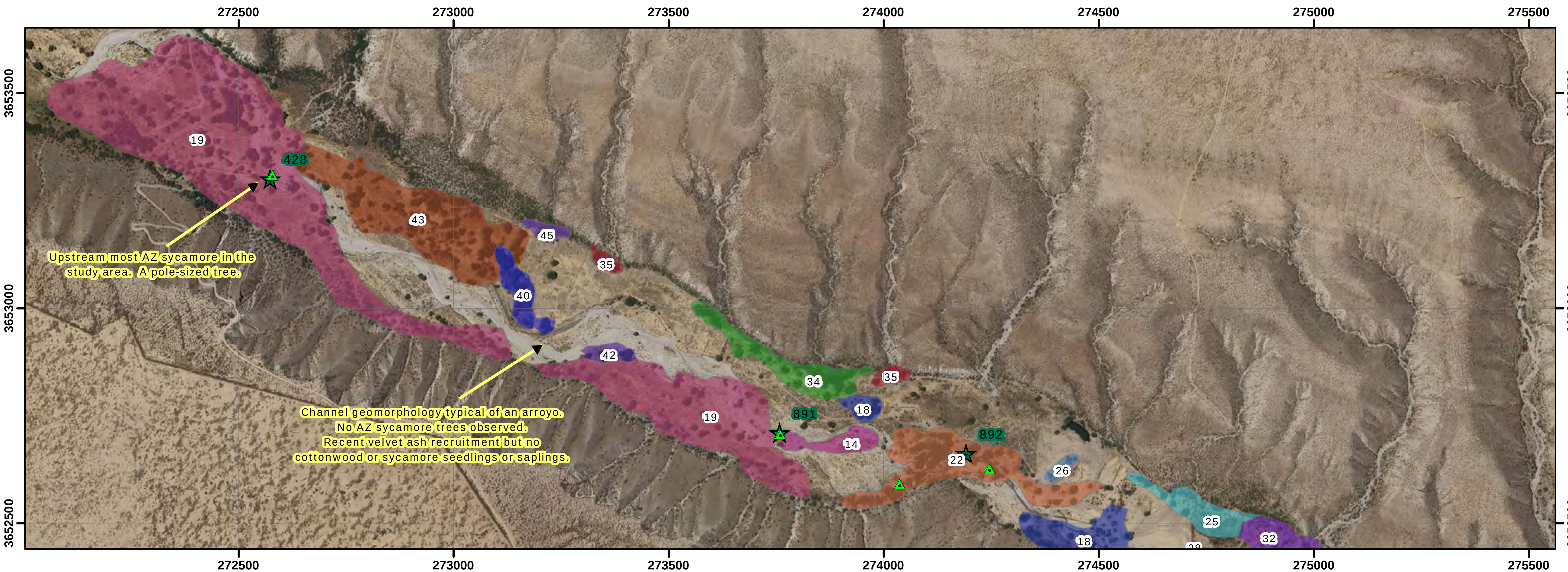
0 500 1,000 Feet

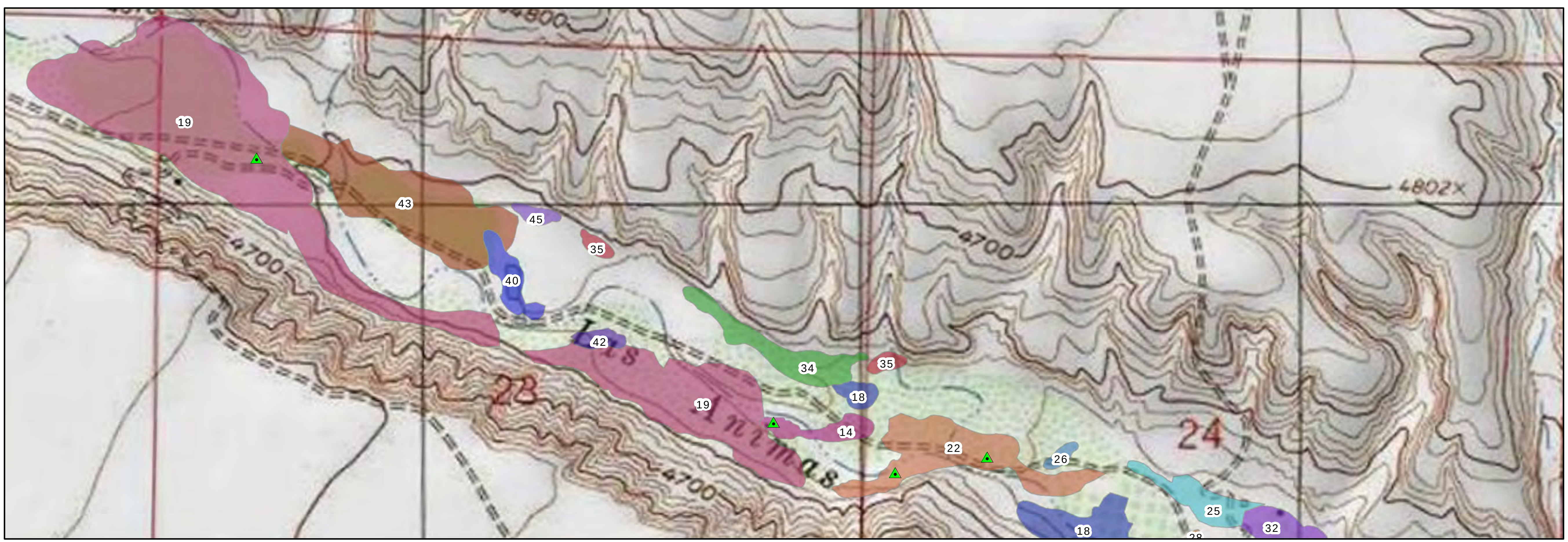
Map scale = 1 : 7,000

N

Appendix 4-E

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





Detailed Riparian Vegetation Mapping: Las Animas Creek Map 1 of 4

Legend

AZ Sycamore Recruitment

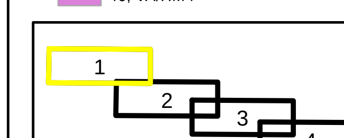
- Pole or Cluster of Poles
- Sapling or Cluster of Saplings
- Seedling
- AZ Sycamore Reference Trees
- Stream Flow Observed

AZ Sycamore Recruitment Zone

- AZ Sycamore Recruitment Zone

H&O Vegetation Type

- <all other values>
- 1, AS-C/NLH-BB1
- 2, AS-NLH/HM-Qu1
- 3, AS-VA/HM-NLH1
- 4, AS-VA/HM1
- 5, AS-VA/HM2
- 6, AS-VA2
- 7, AS-VA4
- 8, AS/BB-Cu2
- 9, AS/BB1
- 10, AS/HM-SB1
- 11, AS/NLH1S
- 12, AS4
- 13, C-AS/VA1
- 14, C-AS4
- 15, C-Cu4
- 16, C-TW-AS/B-CW3
- 17, C-TW-AS/CW-B3
- 18, C-VA2
- 19, C-VA4
- 20, C/B-NLH-TW3
- 21, C/B-VA-BB3
- 22, C/BB1
- 23, C/HM-BB2
- 24, C/HM-NLH1
- 25, C4
- 26, Cu
- 27, LW/BB3
- 28, MB4
- 29, NLH-HM-GO3
- 30, NLH-LW2
- 31, NLH-SE-Qu3
- 32, NLH-VA-LW2
- 33, NLH-VA/LLS1
- 34, NLH-VA2
- 35, NLH-VA4
- 36, NLH/BB-HM1
- 37, SB/SB3
- 38, SC/SC3
- 39, SE-VA3
- 40, TW-C4
- 41, TW-NLH4
- 42, TW4
- 43, VA-LW4
- 44, VA-NLH/HM1
- 45, VA-NLH4
- 46, VA/HM4



Map Frames

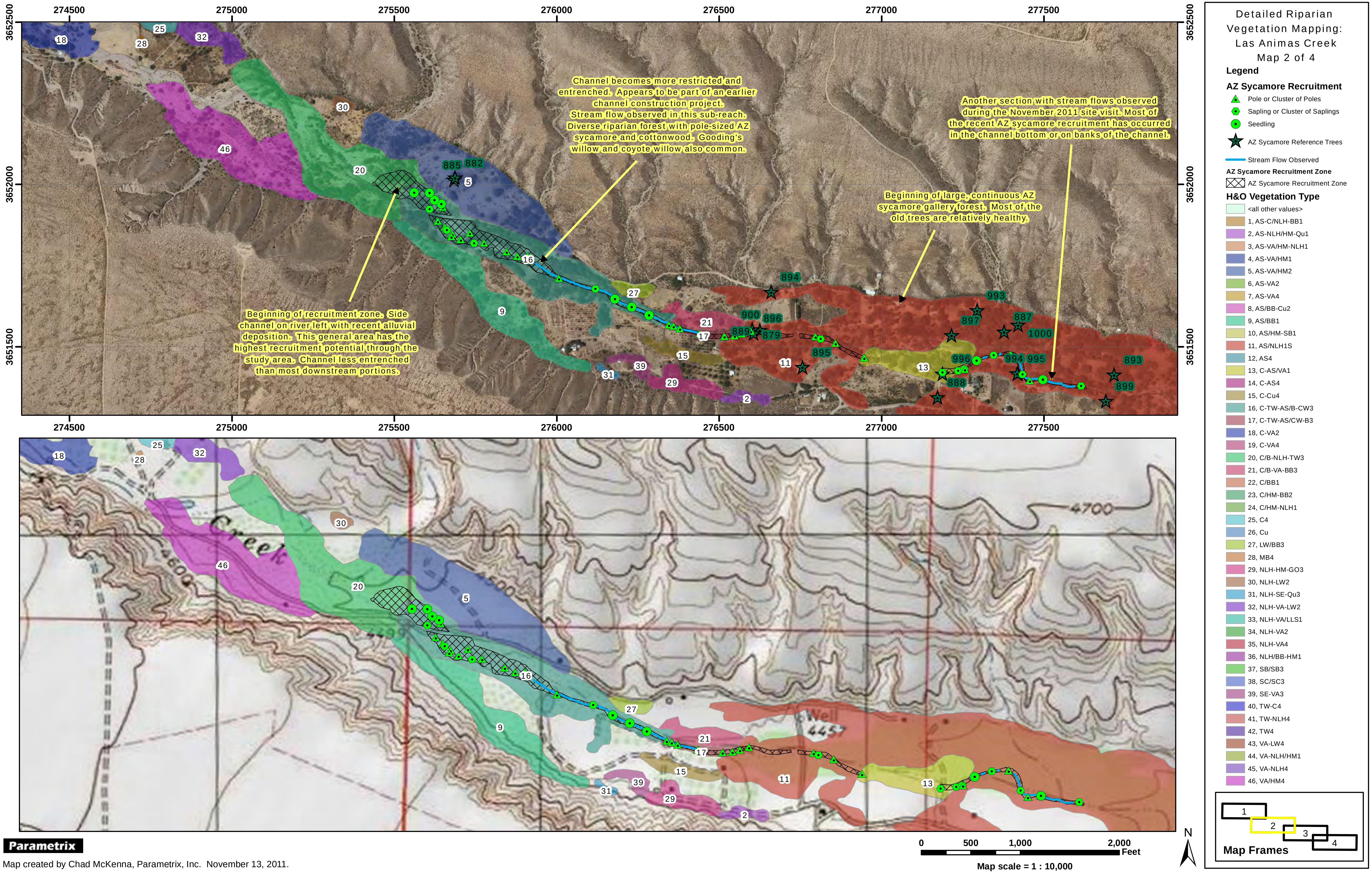
0 500 1,000 2,000 Feet

Map scale = 1 : 10,000

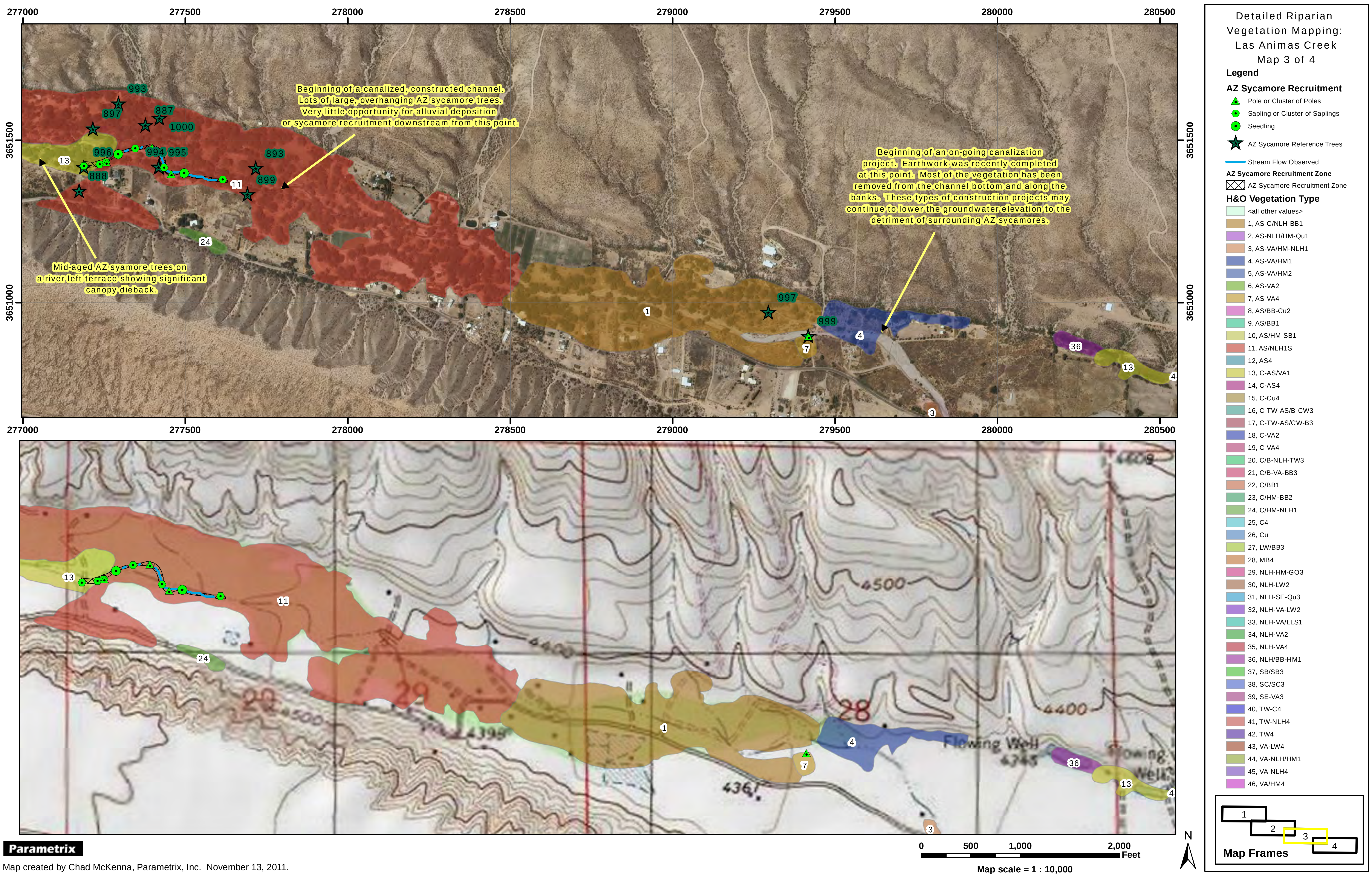
N

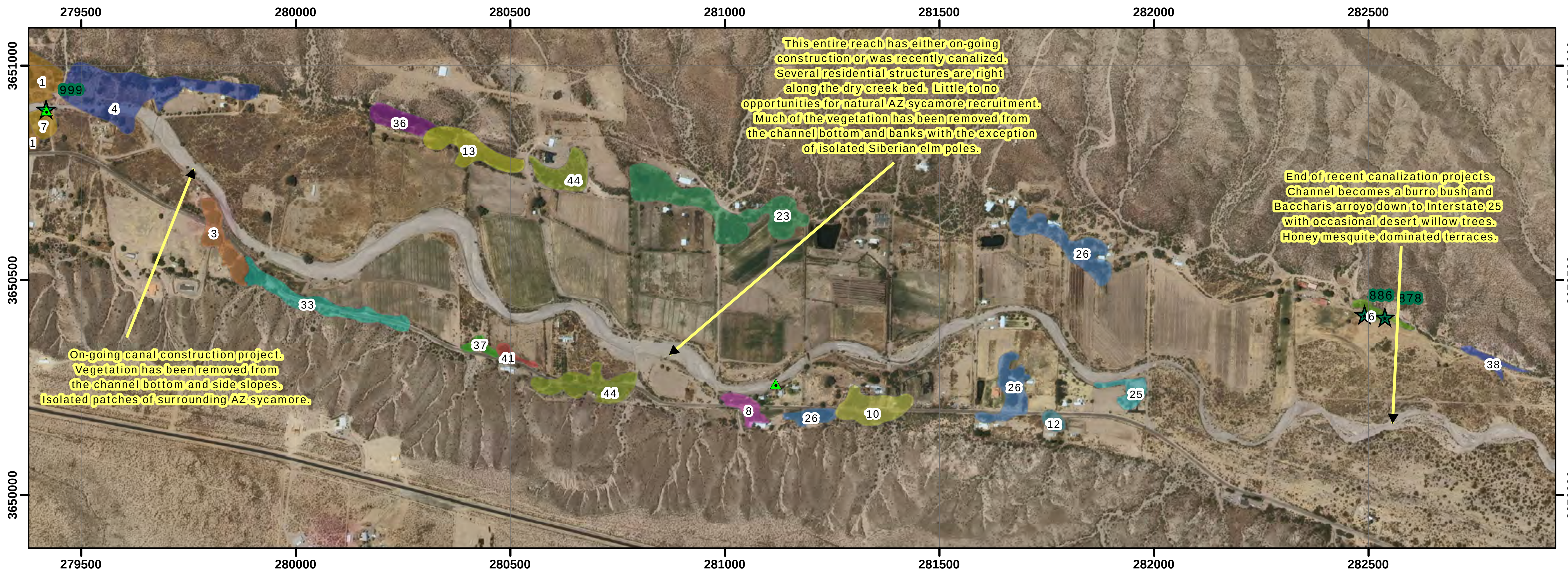
Parametrix

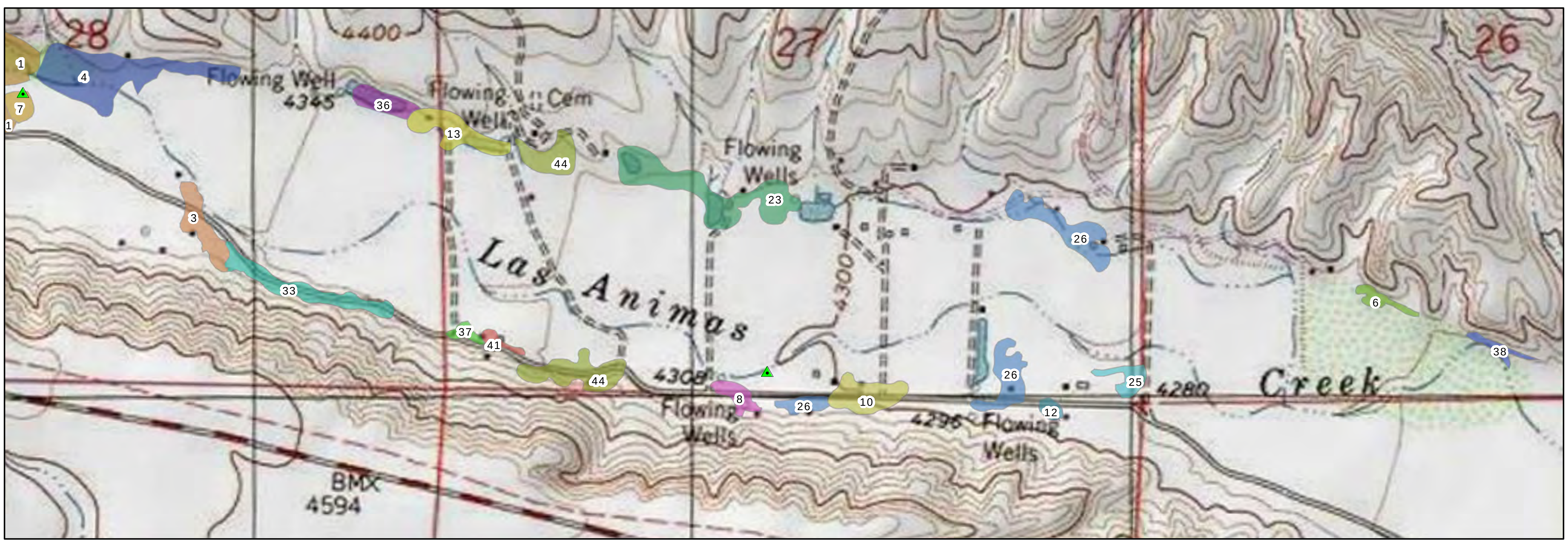
Map created by Chad McKenna, Parametrix, Inc. November 13, 2011.



Map created by Chad McKenna, Parametrix, Inc. November 13, 2011.


Detailed Riparian Vegetation Mapping: Las Animas Creek Map 3 of 4
Legend
AZ Sycamore Recruitment
Pole or Cluster of Poles
Sapling or Cluster of Saplings
Seedling
AZ Sycamore Reference Trees
Stream Flow Observed
AZ Sycamore Recruitment Zone
AZ Sycamore Recruitment Zone
H&O Vegetation Type
<all other values>
1, AS-C/NLH-BB1
2, AS-NLH/HM-Qu1
3, AS-VA/HM-NLH1
4, AS-VA/HM1
5, AS-VA/HM2
6, AS-VA2
7, AS-VA4
8, AS/BB-Cu2
9, AS/BB1
10, AS/HM-SB1
11, AS/NLH1S
12, AS4
13, C-AS/VA1
14, C-AS4
15, C-Cu4
16, C-TW-AS/B-CW3
17, C-TW-AS/CW-B3
18, C-VA2
19, C-VA4
20, C/B-NLH-TW3
21, C/B-VA-BB3
22, C/BB1
23, C/HM-BB2
24, C/HM-NLH1
25, C4
26, Cu
27, LW/BB3
28, MB4
29, NLH-HM-GO3
30, NLH-LW2
31, NLH-SE-Qu3
32, NLH-VA-LW2
33, NLH-VA/LLS1
34, NLH-VA2
35, NLH-VA4
36, NLH/BB-HM1
37, SB/SB3
38, SC/SC3
39, SE-VA3
40, TW-C4
41, TW-NLH4
42, TW4
43, VA-LW4
44, VA-NLH/HM1
45, VA-NLH4
46, VA/HM4
Map Frames
1
2
3
4
Beginning of a canalized, constructed channel. Lots of large, overhanging AZ sycamore trees. Very little opportunity for alluvial deposition or sycamore recruitment downstream from this point.
Beginning of an on-going canalization project. Earthwork was recently completed at this point. Most of the vegetation has been removed from the channel bottom and along the banks. These types of construction projects may continue to lower the groundwater elevation to the detriment of surrounding AZ sycamores.
Mid-aged AZ syamore trees on a river left terrace showing significant canopy dieback.
277000
277500
278000
278500
279000
279500
280000
280500
3651500
3651000
993
897
887
1000
996
994
995
893
888
899
997
999
13
11
24
1
4
7
36
3
4500
4400
4395
4361
29
28
Flowing Well
4745
N
0
500
1,000
2,000
Feet
Map scale = 1 : 10,000
Parametrix
Map created by Chad McKenna, Parametrix, Inc. November 13, 2011.





Detailed Riparian Vegetation Mapping: Las Animas Creek Map 4 of 4

Legend

AZ Sycamore Recruitment

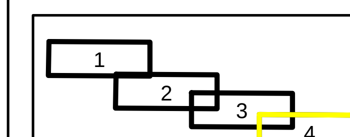
- Pole or Cluster of Poles
- Sapling or Cluster of Saplings
- Seedling
- AZ Sycamore Reference Trees
- Stream Flow Observed

AZ Sycamore Recruitment Zone

- AZ Sycamore Recruitment Zone

H&O Vegetation Type

- <all other values>
- 1, AS-C/NLH-BB1
- 2, AS-NLH/HM-Qu1
- 3, AS-VA/HM-NLH1
- 4, AS-VA/HM1
- 5, AS-VA/HM2
- 6, AS-VA2
- 7, AS-VA4
- 8, AS/BB-Cu2
- 9, AS/BB1
- 10, AS/HM-SB1
- 11, AS/NLH1S
- 12, AS4
- 13, C-AS/VA1
- 14, C-AS4
- 15, C-Cu4
- 16, C-TW-AS/B-CW3
- 17, C-TW-AS/CW-B3
- 18, C-VA2
- 19, C-VA4
- 20, C/B-NLH-TW3
- 21, C/B-VA-BB3
- 22, C/BB1
- 23, C/HM-BB2
- 24, C/HM-NLH1
- 25, C4
- 26, Cu
- 27, LW/BB3
- 28, MB4
- 29, NLH-HM-GO3
- 30, NLH-LW2
- 31, NLH-SE-Qu3
- 32, NLH-VA-LW2
- 33, NLH-VA/LLS1
- 34, NLH-VA2
- 35, NLH-VA4
- 36, NLH/BB-HM1
- 37, SB/SB3
- 38, SC/SC3
- 39, SE-VA3
- 40, TW-C4
- 41, TW-NLH4
- 42, TW4
- 43, VA-LW4
- 44, VA-NLH/HM1
- 45, VA-NLH4
- 46, VA/HM4



Map Frames

0 500 1,000 2,000 Feet

Map scale = 1 : 10,000

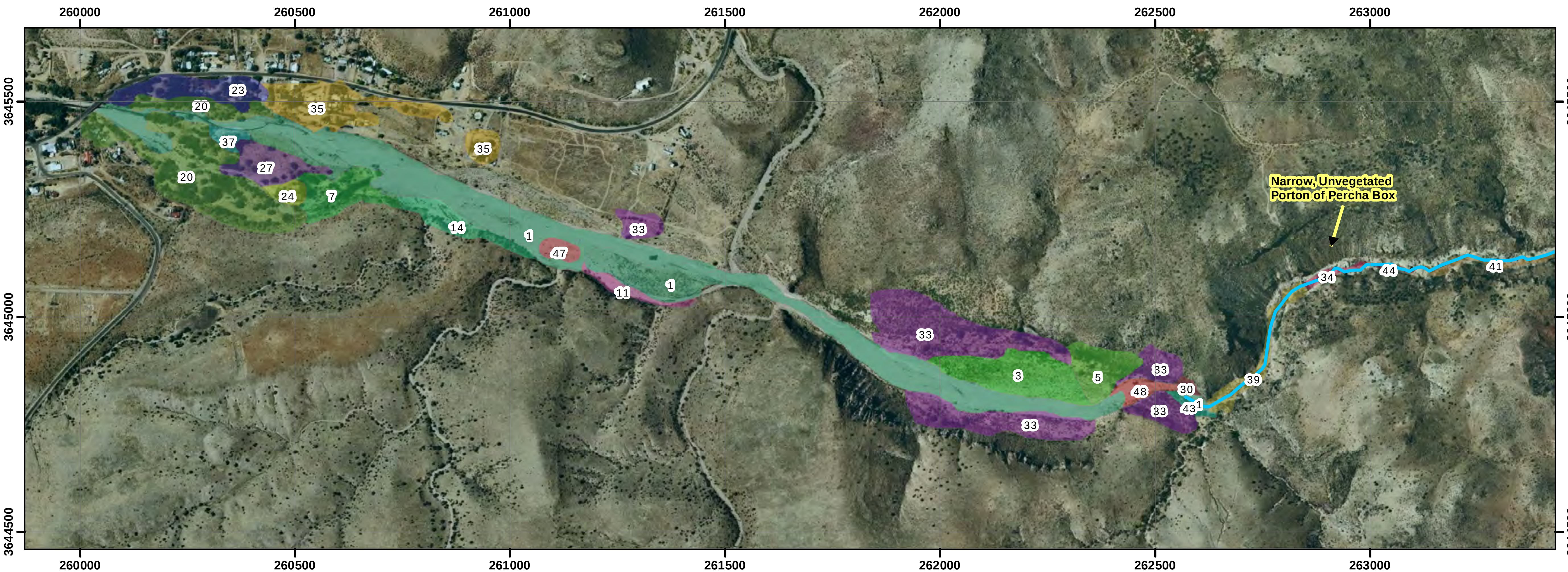
N

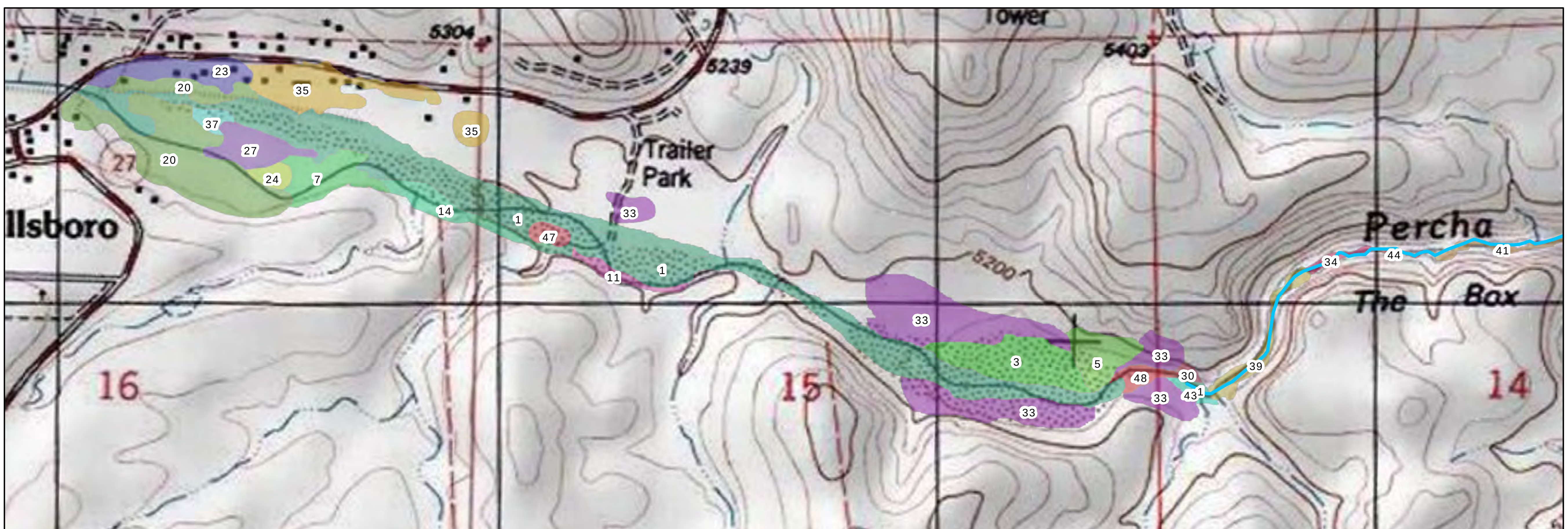
Parametrix

Map created by Chad McKenna, Parametrix, Inc. November 13, 2011.

Appendix 4-F

Hink and Ohmart Vegetation Mapping in the Percha Creek Study Area





Detailed Riparian Vegetation Mapping: Percha Creek

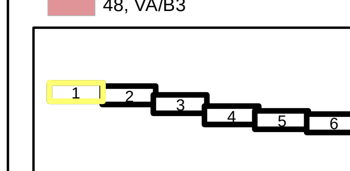
Map 1 of 6

Legend

Stream Flow Observed

H&O Riparian Type

- 1, B5
- 2, BB-B5
- 3, BB-DW5
- 4, BB5
- 5, C-NLH/DW-HM3
- 6, C-NLH/HM-BB3
- 7, C-SE/CW3S
- 8, C-TW/B-BB3
- 9, C-TW/B2
- 10, C-TW/B3
- 11, C-VA/B3S
- 12, C/B3
- 13, C/BB4
- 14, C/CW3S
- 15, C/LW-B4
- 16, C/NLH-BB2
- 17, C/NLH-HM2
- 18, C/NLH-LW-B2
- 19, C/NLH1
- 20, C/SE-VA3
- 21, C/TW-NLH1
- 22, C2
- 23, C4
- 24, CW5
- 25, DW/BB3S
- 26, HM-BB5
- 27, NLH-LW/TH3S
- 28, NLH-LW4
- 29, NLH-VA/BB3
- 30, NLH-VA/CW-B3
- 31, NLH-VA4
- 32, NLH/BB3
- 33, NLH4
- 34, NO VEG
- 35, PP-Ce/NLH4
- 36, SE-C/TW3
- 37, SE/TH3
- 38, TW-C/B1
- 39, TW-C/CW-B3
- 40, TW-C/TW-B-CW3S
- 41, TW-C/TW-B3
- 42, TW-NLH/B3
- 43, TW-NLH4
- 44, TW/CW3
- 45, TW/TW-B3
- 46, TW/TW-CW-B3
- 47, VA-DW-LW/B3S
- 48, VA/B3



Parametrix

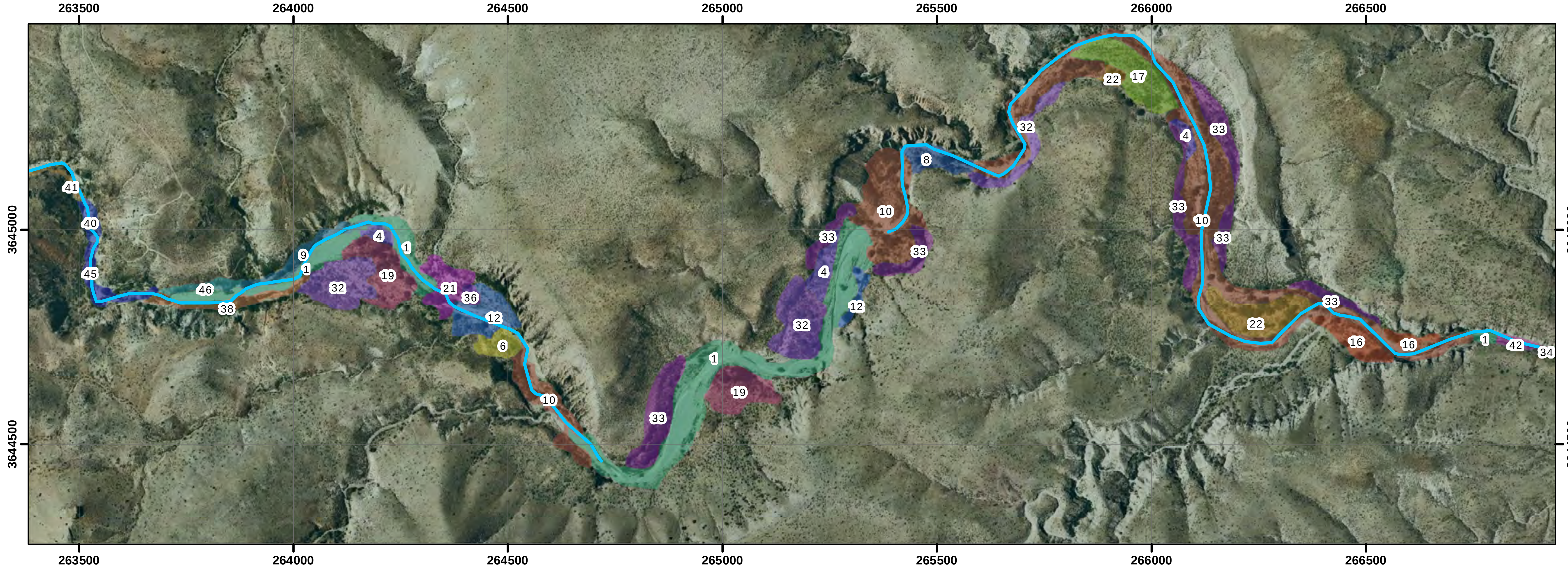
Map created by Chad McKenna, Parametrix, Inc. November 11, 2011.

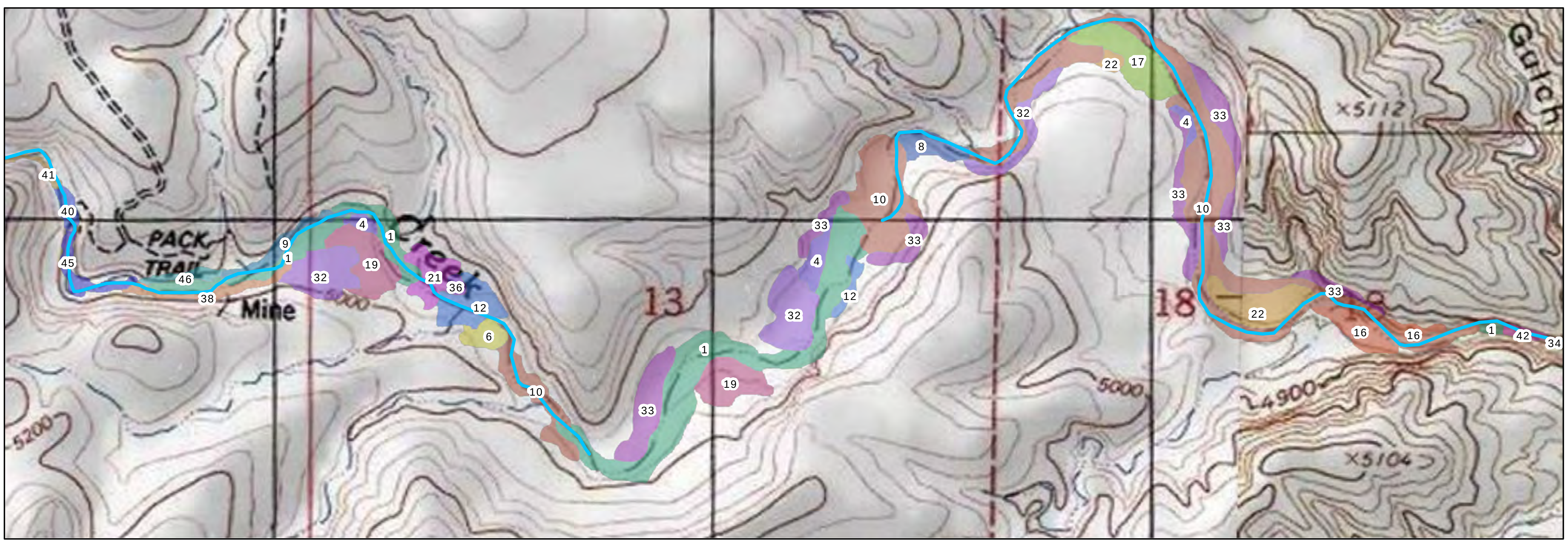
0 500 1,000 2,000 Feet

Map scale = 1 : 10,000

N

Detailed Riparian Vegetation Mapping: Percha Creek Map 2 of 6



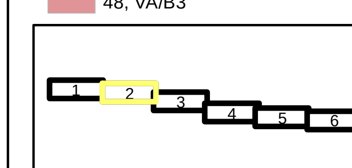


Legend

Stream Flow Observed

H&O Riparian Type

- 1, B5
- 2, BB-B5
- 3, BB-DW5
- 4, BB5
- 5, C-NLH/DW-HM3
- 6, C-NLH/HM-BB3
- 7, C-SE/CW3S
- 8, C-TW/B-BB3
- 9, C-TW/B2
- 10, C-TW/B3
- 11, C-VA/B3S
- 12, C/B3
- 13, C/BB4
- 14, C/CW3S
- 15, C/LW-B4
- 16, C/NLH-BB2
- 17, C/NLH-HM2
- 18, C/NLH-LW-B2
- 19, C/NLH1
- 20, C/SE-VA3
- 21, C/TW-NLH1
- 22, C2
- 23, C4
- 24, CW5
- 25, DW/BB3S
- 26, HM-BB5
- 27, NLH-LW/TH3S
- 28, NLH-LW4
- 29, NLH-VA/BB3
- 30, NLH-VA/CW-B3
- 31, NLH-VA4
- 32, NLH/BB3
- 33, NLH4
- 34, NO VEG
- 35, PP-Ce/NLH4
- 36, SE-C/TW3
- 37, SE/TH3
- 38, TW-C/B1
- 39, TW-C/CW-B3
- 40, TW-C/TW-B-CW3S
- 41, TW-C/TW-B3
- 42, TW-NLH/B3
- 43, TW-NLH4
- 44, TW/CW3
- 45, TW/TW-B3
- 46, TW/TW-CW-B3
- 47, VA-DW-LW/B3S
- 48, VA/B3



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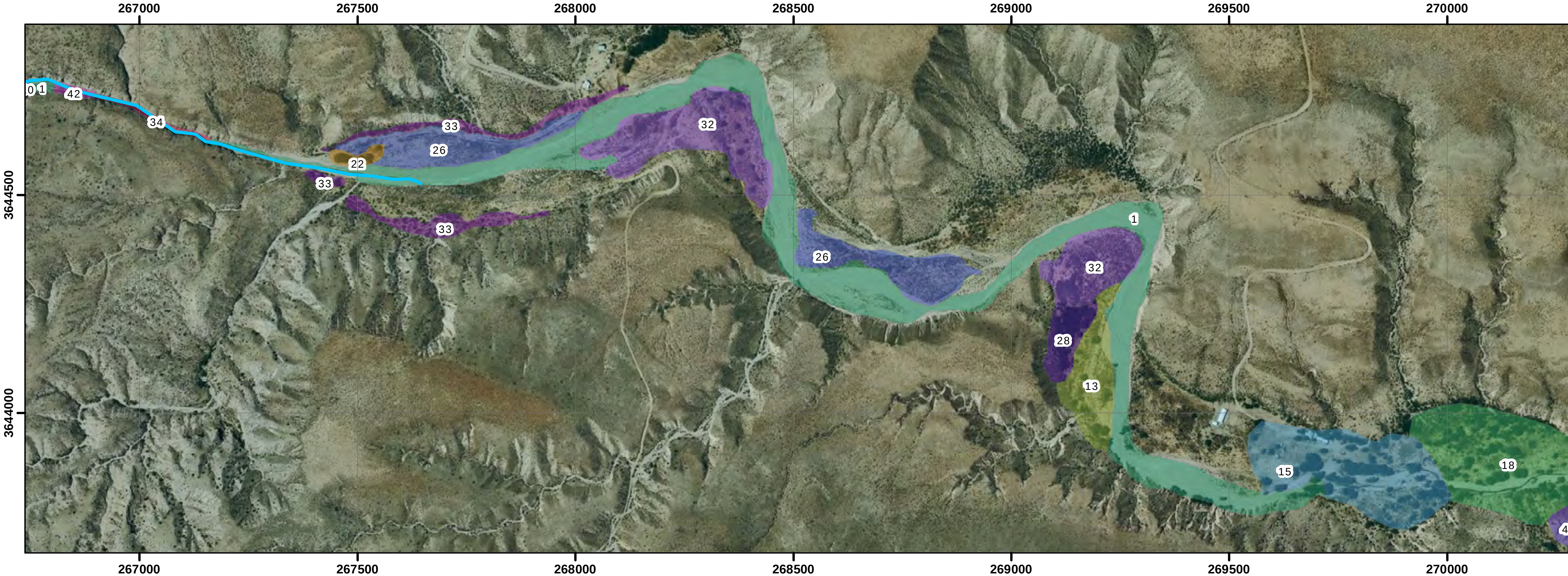
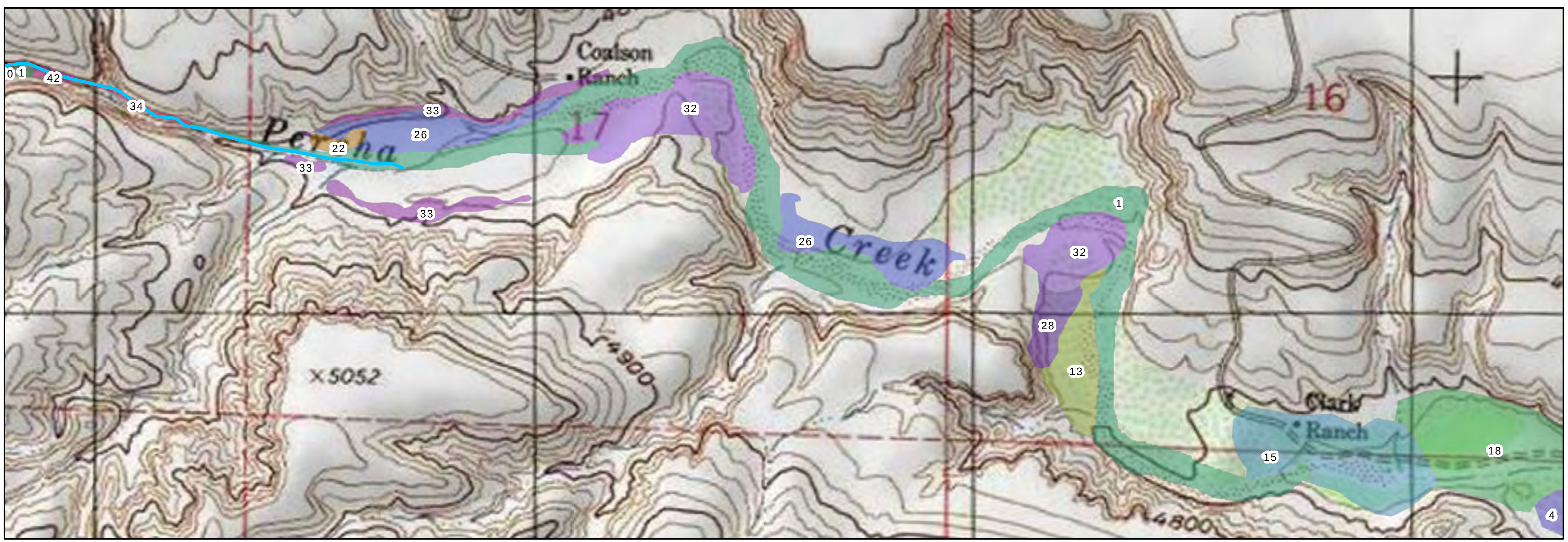
Parametrix

Map created by Chad McKenna, Parametrix, Inc. November 11, 2011.





Detailed Riparian Vegetation Mapping: Percha Creek
Map 3 of 6

Legend

Stream Flow Observed

H&O Riparian Type

- 1, B5
- 2, BB-B5
- 3, BB-DW5
- 4, BB5
- 5, C-NLH/DW-HM3
- 6, C-NLH/HM-BB3
- 7, C-SE/CW3S
- 8, C-TW/B-BB3
- 9, C-TW/B2
- 10, C-TW/B3
- 11, C-VA/B3S
- 12, C/B3
- 13, C/BB4
- 14, C/CW3S
- 15, C/LW-B4
- 16, C/NLH-BB2
- 17, C/NLH-HM2
- 18, C/NLH-LW-B2
- 19, C/NLH1
- 20, C/SE-VA3
- 21, C/TW-NLH1
- 22, C2
- 23, C4
- 24, CW5
- 25, DW/BB3S
- 26, HM-BB5
- 27, NLH-LW/TH3S
- 28, NLH-LW4
- 29, NLH-VA/BB3
- 30, NLH-VA/CW-B3
- 31, NLH-VA4
- 32, NLH/BB3
- 33, NLH4
- 34, NO VEG
- 35, PP-Ce/NLH4
- 36, SE-C/TW3
- 37, SE/TH3
- 38, TW-C/B1
- 39, TW-C/CW-B3
- 40, TW-C/TW-B-CW3S
- 41, TW-C/TW-B3
- 42, TW-NLH/B3
- 43, TW-NLH4
- 44, TW/CW3
- 45, TW/TW-B3
- 46, TW/TW-CW-B3
- 47, VA-DW-LW/B3S
- 48, VA/B3

1 2 3 4 5 6

0 500 1,000 2,000 Feet

Map scale = 1 : 10,000

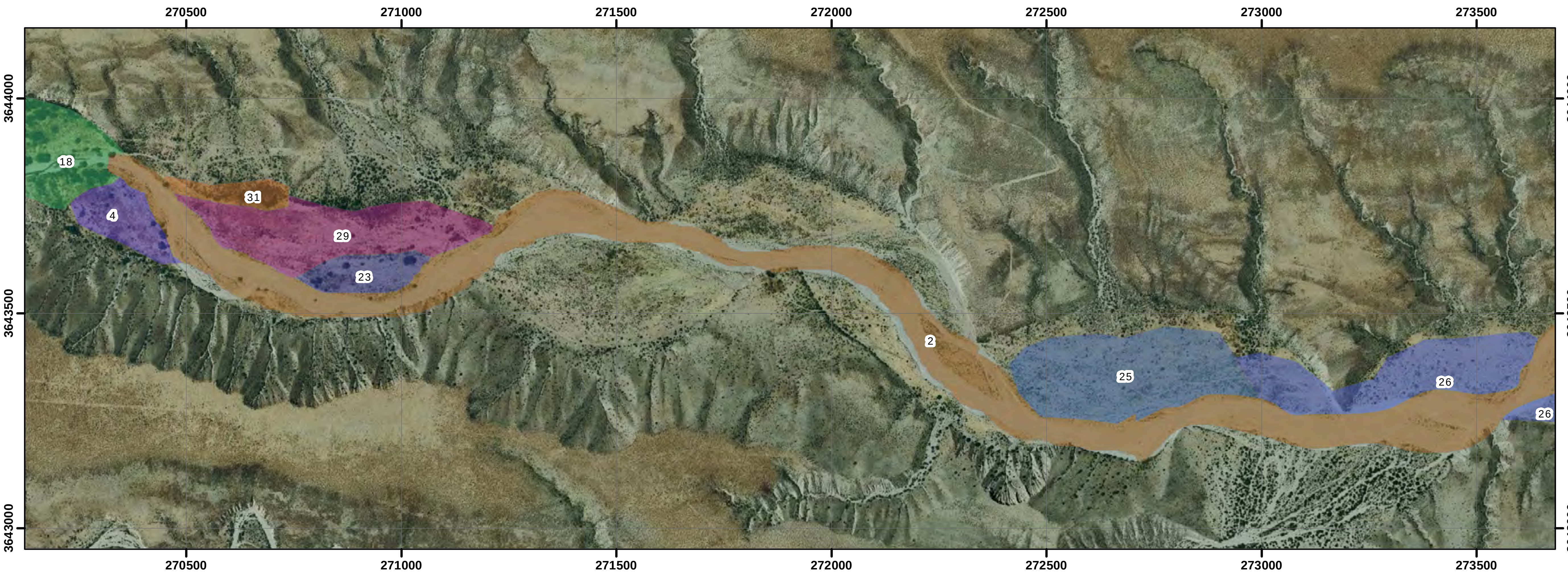
N

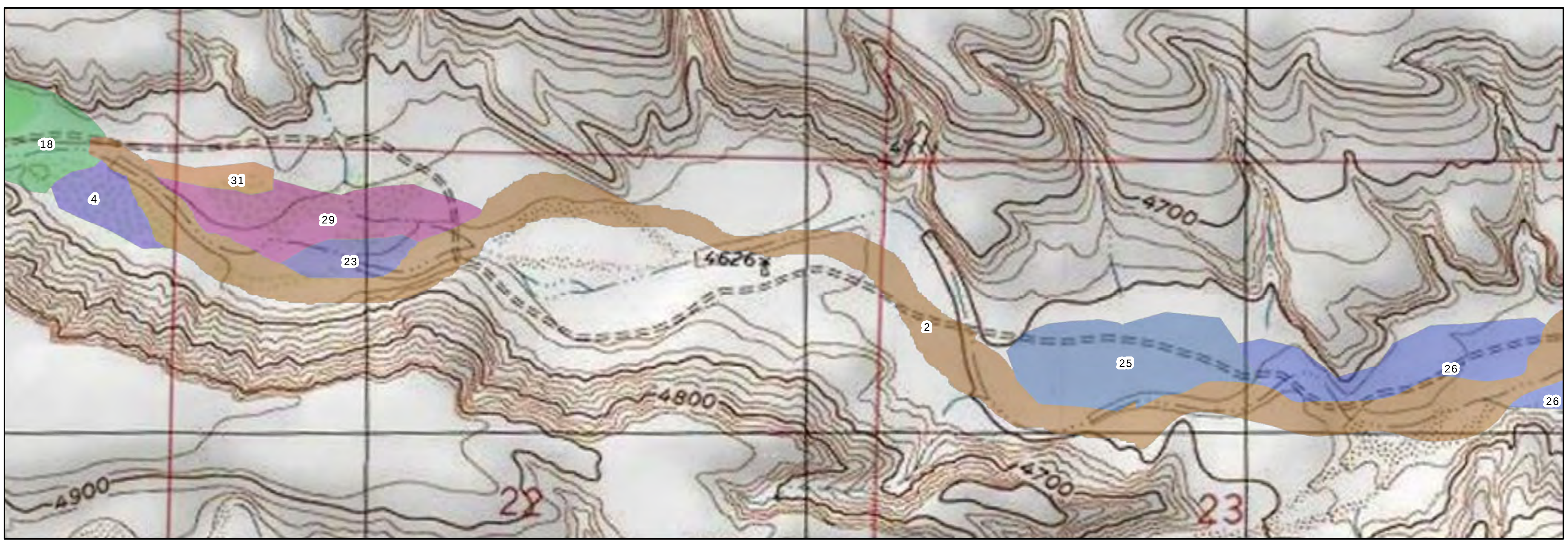
Parametrix

Map created by Chad McKenna, Parametrix, Inc. November 11, 2011.

Detailed Riparian Vegetation Mapping: Percha Creek

Map 4 of 6



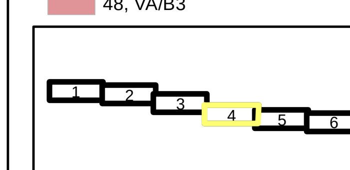


Legend

Stream Flow Observed

H&O Riparian Type

1, B5
2, BB-B5
3, BB-DW5
4, BB5
5, C-NLH/DW-HM3
6, C-NLH/HM-BB3
7, C-SE/CW3S
8, C-TW/B-BB3
9, C-TW/B2
10, C-TW/B3
11, C-VA/B3S
12, C/B3
13, C/BB4
14, C/CW3S
15, C/LW-B4
16, C/NLH-BB2
17, C/NLH-HM2
18, C/NLH-LW-B2
19, C/NLH1
20, C/SE-VA3
21, C/TW-NLH1
22, C2
23, C4
24, CW5
25, DW/BB3S
26, HM-BB5
27, NLH-LW/TH3S
28, NLH-LW4
29, NLH-VA/BB3
30, NLH-VA/CW-B3
31, NLH-VA4
32, NLH/BB3
33, NLH4
34, NO VEG
35, PP-Ce/NLH4
36, SE-C/TW3
37, SE/TH3
38, TW-C/B1
39, TW-C/CW-B3
40, TW-C/TW-B-CW3S
41, TW-C/TW-B3
42, TW-NLH/B3
43, TW-NLH4
44, TW/CW3
45, TW/TW-B3
46, TW/TW-CW-B3
47, VA-DW-LW/B3S
48, VA/B3



0 500 1,000 2,000 Feet

Map scale = 1 : 10,000

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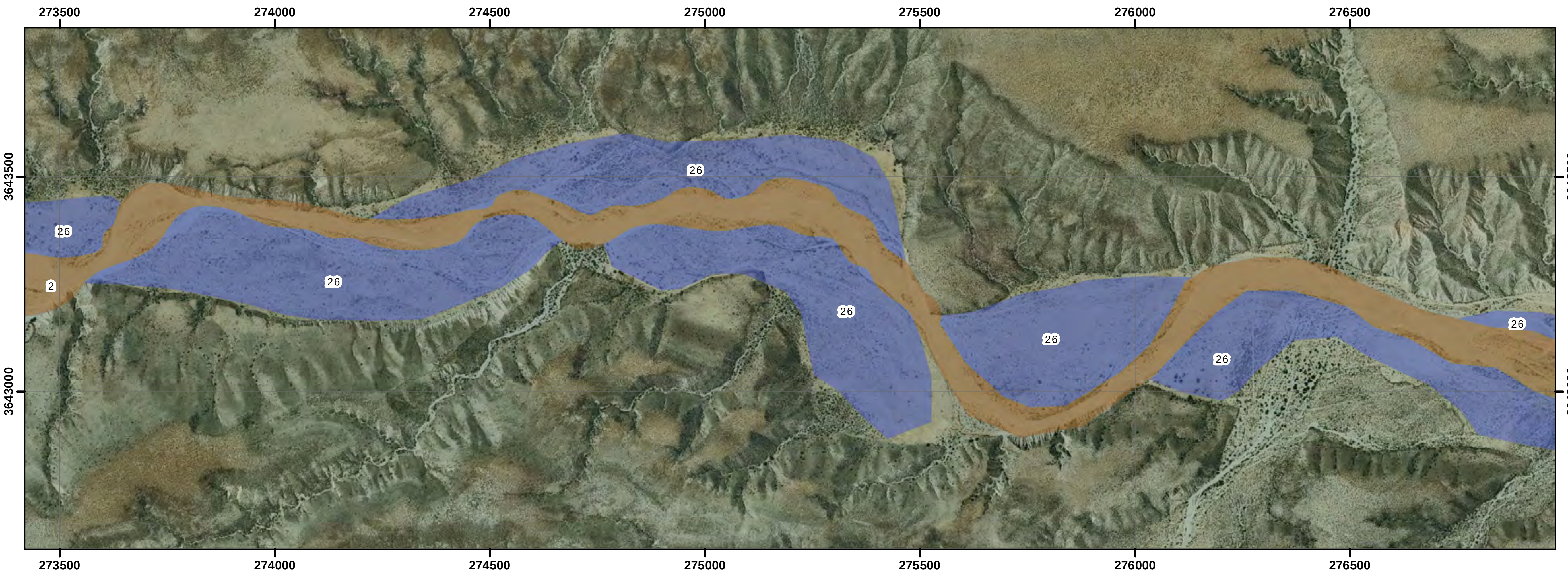
Parametrix

Map created by Chad McKenna, Parametrix, Inc. November 11, 2011.

Detailed Riparian Vegetation Mapping: Percha Creek Map 5 of 6



Legend

Stream Flow Observed

H&O Riparian Type

- 1, B5
- 2, BB-B5
- 3, BB-DW5
- 4, BB5
- 5, C-NLH/DW-HM3
- 6, C-NLH/HM-BB3
- 7, C-SE/CW3S
- 8, C-TW/B-BB3
- 9, C-TW/B2
- 10, C-TW/B3
- 11, C-VA/B3S
- 12, C/B3
- 13, C/BB4
- 14, C/CW3S
- 15, C/LW-B4
- 16, C/NLH-BB2
- 17, C/NLH-HM2
- 18, C/NLH-LW-B2
- 19, C/NLH1
- 20, C/SE-VA3
- 21, C/TW-NLH1
- 22, C2
- 23, C4
- 24, CW5
- 25, DW/BB3S
- 26, HM-BB5
- 27, NLH-LW/TH3S
- 28, NLH-LW4
- 29, NLH-VA/BB3
- 30, NLH-VA/CW-B3
- 31, NLH-VA4
- 32, NLH/BB3
- 33, NLH4
- 34, NO VEG
- 35, PP-Ce/NLH4
- 36, SE-C/TW3
- 37, SE/TH3
- 38, TW-C/B1
- 39, TW-C/CW-B3
- 40, TW-C/TW-B-CW3S
- 41, TW-C/TW-B3
- 42, TW-NLH/B3
- 43, TW-NLH4
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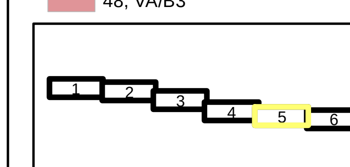
- 48, VA/B3



0 500 1,000 2,000 Feet

Map scale = 1 : 10,000

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Parametrix

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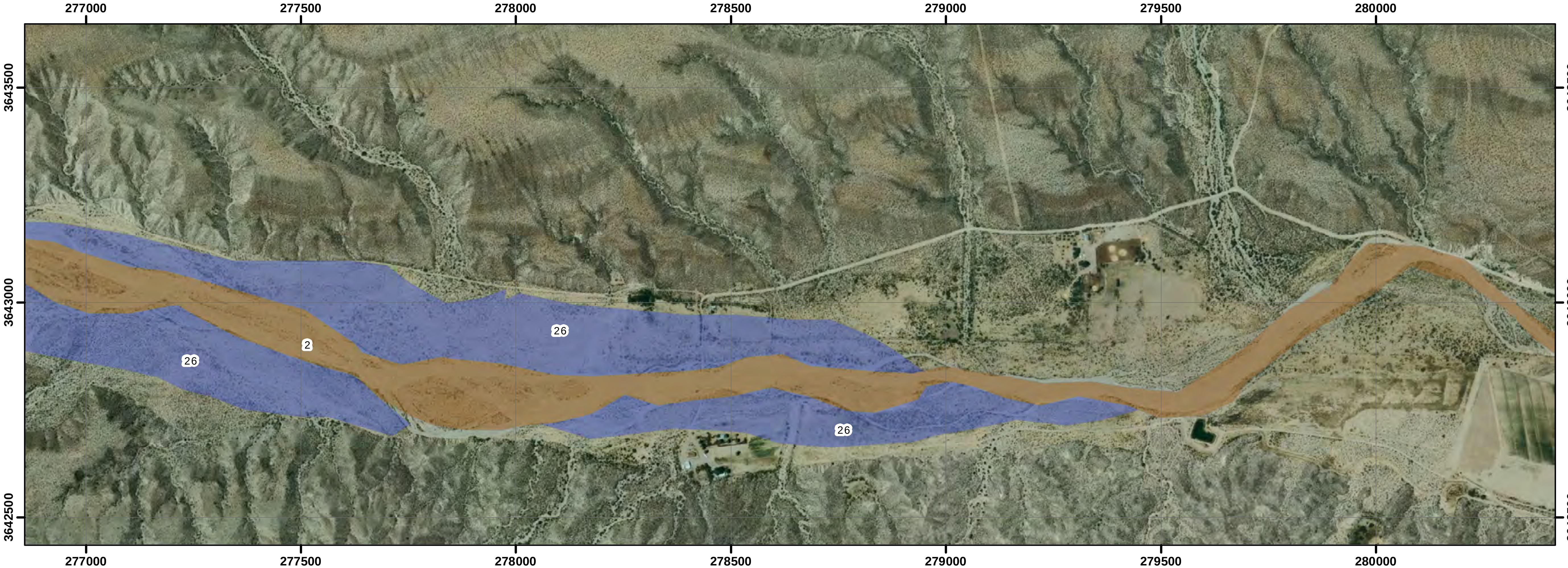

Detailed Riparian Vegetation Mapping: Percha Creek Map 6 of 6

Legend

Stream Flow Observed

H&O Riparian Type

1, B5
2, BB-B5
3, BB-DW5
4, BB5
5, C-NLH/DW-HM3
6, C-NLH/HM-BB3
7, C-SE/CW3S
8, C-TW/B-BB3
9, C-TW/B2
10, C-TW/B3
11, C-VA/B3S
12, C/B3
13, C/BB4
14, C/CW3S
15, C/LW-B4
16, C/NLH-BB2
17, C/NLH-HM2
18, C/NLH-LW-B2
19, C/NLH1
20, C/SE-VA3
21, C/TW-NLH1
22, C2
23, C4
24, CW5
25, DW/BB3S
26, HM-BB5
27, NLH-LW/TH3S
28, NLH-LW4
29, NLH-VA/BB3
30, NLH-VA/CW-B3
31, NLH-VA4
32, NLH/BB3
33, NLH4
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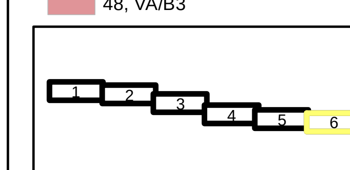
35, PP-Ce/NLH4
36, SE-C/TW3
37, SE/TH3
38, TW-C/B1
39, TW-C/CW-B3
40, TW-C/TW-B-CW3S
41, TW-C/TW-B3
42, TW-NLH/B3
43, TW-NLH4
44, TW/CW3
45, TW/TW-B3
46, TW/TW-CW-B3
47, VA-DW-LW/B3S
48, VA/B3



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Map created by Chad McKenna, Parametrix, Inc. November 11, 2011.

0 500 1,000 2,000 Feet

Map scale = 1 : 10,000

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Appendix 5-A

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

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

Prepared for

Bureau of Land Management
Las Cruces District Office
1800 Marquess St.
Las Cruces, NM 88005-3370

Prepared by

Parametrix
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Albuquerque, NM 87113-2439
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www.parametrix.com

August 2011 | 563-6671-001

CITATION

Parametrix. 2011. Biological Resources Survey Report, Copper Flat Pipeline and Well Sites, Sierra County, New Mexico. Prepared by Parametrix, Albuquerque, New Mexico.

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KEY TERMS

amsl	above mean sea level
BLM	Bureau of Land Management
CAW	Class A weeds
CBW	Class B weeds
CCW	Class C listed weeds
CWA	Clean Water Act
F	Fahrenheit
MBTA	Migratory Bird Treaty Act
NMCC	New Mexico Copper Corporation
NMDA	New Mexico Department of Agriculture
NMDGF	New Mexico Department of Game and Fish
NMRPTC	New Mexico Rare Plant Technical Council
NWI	National Wetland Inventory
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFS	United States Department of Agriculture-Forest Service
USFWS	United States Fish and Wildlife Service
USGS	U.S. Geological Survey

1. PROJECT DESCRIPTION AND LOCATION

New Mexico Copper Corporation (NMCC) is conducting regional water studies related to the possible development of the Copper Flat mine, located approximately 30 miles southwest of Truth or Consequences, New Mexico. The purpose of the project is to address infrastructure needs in order to conduct the regional water studies required. The proposed action being requested under this amendment to ROW 125293 is to permit the use of additional well sites for testing and monitoring purposes, to clear roads to access six of these wells, to redevelop and repair wells as needed, and to consider additional alternatives to discharge the water from the pipeline/well tests. The need for the project is to address the following infrastructure improvements:

- The wells that are being proposed for aquifer testing purposes include: PW-1, PW-2, PW-3, and PW-4. These four production wells may require redevelopment and repair. The aquifer testing via these four production wells will require the extraction and discharge of up to 159 acre feet of water.
- The proposed action includes the multiple alternative routes to discharge the water from the well test, with multiple route options to the pit lake and one option to the Greyback Arroyo.
- Wells that will be used for water quality and quantity monitoring purposes, but are classified as extraction wells, include: MW-2, MW-5, MW-6, MW-8, GWQ-1, and GWQ-8.
- The proposed action also includes the testing and rehabilitation of the pipeline that connects the mine site to the production well field. This pipeline will be tested on its own, and also used to support the production well aquifer test as part of the water discharge alternatives.
- Road access improvements are required for the following well sites: PW-1, PW-2, PW-3, PW-4, MW-5, MW-8, IW-3, GWQ-10, and NP-4.
- Well rehabilitation, including new well heads, are necessary on the following wells: GWQ-1 and GWQ-8.

Table 1. Proposed Action Summary

Proposed Action	Surveyed Area	Build Alternative	Build Alternative	Build Alternative
Pipeline	60-foot corridor with 50-foot buffer on each side.	Inspection/Maintenance/ Repair.	Sleeve pull through the existing line.	Temporary line connecting the existing line to the pit lake.
Access Roads	50-foot corridor with 50-foot buffer on each side.	Blade and clear.		
Collection Point	200-by-200-foot area.	Placement of a holding tank.		
Well sites	300-by-300-foot area.	Inspect/Maintain/Repair. Installation of pumps for aquifer testing.		
Aquifer Testing/ Discharge of Water	Identified on the figures.	Copper Flat Pit Lake: Pump water from aquifer. Then, carry water through pipeline and discharge to the Copper Flat Pit Lake.	Discharge to Greyback Arroyo following a corridor established from the area of PW-4.	

2. METHODS

In accordance with state and federal laws related to protection of natural resources, a field survey of the project area was conducted to evaluate potential impacts to threatened and endangered species, wetlands/waterways, migratory birds, noxious weeds, and other sensitive biological features. The proposed project area was surveyed and potential impacts to the natural environment were assessed by Parametrix 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.

The investigations also included a survey for noxious weeds as designated by the New Mexico Department of Agriculture (NMDA) and U.S. Department of Agriculture (USDA), and an evaluation of potential impacts to nesting birds protected under the Migratory Bird Treaty Act (MBTA) of 1918. In addition, the existing environment along the project corridor was evaluated for the presence of valuable wildlife and bird nesting habitat, sensitive areas, and wildlife corridors.

An assessment of waters of the U.S. that could be impacted by the proposed project was performed using U.S. Geological Survey (USGS) quadrangles, National Wetland Inventory (NWI) maps, aerial photography, and County soil survey maps in-house and then refined 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) and the Bureau of Land Management (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 project area, were removed from further consideration.

3. ENVIRONMENTAL SETTING

The project area is located in Sierra County, in the Chihuahuan Desert Grasslands sub-region of the Chihuahuan Deserts Ecoregion. The Chihuahuan Desert Grasslands are characterized by plateaus, high intermountain basins, alluvial fans, and bajadas. Most surface water is in the form of stream segments from an occasional spring source, or else an ephemeral stream that only flows after storm events. Annual precipitation ranges from 10 to 15 inches, and late summer thunderstorms are the source of most of the moisture. Average temperatures range from 24˚ Fahrenheit (F) to 53˚ F in the winter and 62˚ F to 92˚ F in the summer (Griffith et al. 2006).

The geology of the area consists of Quaternary colluvium with valley-fill alluvium, alluvium and piedmont alluvium, and discontinuous eolian deposits; Permian sandstone, siltstone, gypsum, dolomite, and limestone; Tertiary igneous and volcaniclastic rocks, and some Tertiary sandstones and conglomerates (Griffith et al. 2006).

Soils in the Chihuahuan Desert Grasslands ecoregion include thermic Aridisols, Entisols, and Mollisols with an Aridic or Ustic Aridic moisture regime (Griffith et al. 2006). The specific soil series mapped in the proposed project area is Luzena-Rock outcrop association. This soil type is well drained, has a depth to the water table of more than 80 inches, and is not classified as prime farmland by the Natural Resources Conservation Service Web Soil Survey (NRCS 2010).

The general elevation of the project area is approximately 5,000 feet above mean sea level (amsl). The majority of the project area has been previously disturbed by installation of a water pipeline, wells, and access roads. Vegetation in the project area is typical of Chihuahuan Desert Grasslands, with honey mesquite (*Prosopis glandulosa*), featherplume (*Dalea formosa*), black grama (*Bouteloua eriopoda*), and tobosagrass (*Pleuraphis mutica*) as dominant species.

4. RESULTS

4.1 VEGETATION

During the 2010 and 2011 field surveys, 67 species of plants were observed within the proposed project area (Table 2). The dominant plant species observed within the proposed project area consisted of low woollygrass (*Dasyochloa pulchella*), weeping lovegrass (*Eragrostis curvula*), spreading buckwheat (*Eriogonum effusum*), tarbush (*Flourensia cernua*), broom snakeweed (*Gutierrezia sarothrae*), creosote (*Larrea tridentata*), tobosagrass (*Pleuraphis mutica*), and honey mesquite (*Prosopis glandulosa*). These species were observed fairly uniformly throughout the proposed project area.

Table 2. Plants Observed During the 2010 and 2011 Field Surveys

Common Name	Scientific Name
Dwarf desertpeony	*Acourtia nana*
Powell's amaranth	*Amaranthus powellii*
Flatspine bur ragweed	*Ambrosia acanthicarpa*
Weakleaf bur ragweed	*Ambrosia confertiflora*
Great ragweed	*Ambrosia trifida*
Sand bluestem	*Andropogon hallii*
Sixweeks threeawn	*Aristida adscensionis*
Purple threeawn	*Aristida purpurea*
Spidergrass	*Aristida ternipes*
Groundplum milkvetch	*Astragalus crassicarpus*
Fourwing saltbush	*Atriplex canescens*
Yerba de pasmo	*Baccharis pteronioides*
Desert marigold	*Baileya multiradiata*
Silver beardgrass	*Bothriochloa laguroides*
Sixweeks grama	*Bouteloua barbata*
Side-oats grama	*Bouteloua curtipendula*
Black grama	*Bouteloua eriopoda*
Blue grama	*Bouteloua gracilis*
California brickellbush	*Brickellia californica*
Netleaf hackberry	*Celtis laevigata*
Whitemargin sandmat	*Chamaesyce albomarginata*
New Mexico thistle	*Cirsium neomexicanum*
Yellowspine thistle	*Cirsium ochrocentrum*
American bugseed	*Corispermum americanum*

(Table Continues)

Table 2. Plants Observed During the 2010 and 2011 Field Surveys (Continued)

Common Name	Scientific Name
Dodder	*Cuscuta* sp.
Tree cholla	*Cylindropuntia imbricata*
Christmas cactus	*Cylindropuntia leptocaulis*
Featherplume	*Dalea formosa*
Low woollygrass	*Dasyochloa pulchella*
Sacred thorn-apple	*Datura wrightii*
Fetid marigold	*Dyssodia papposa*
Scarlet hedgehog cactus	*Echinocereus coccineus*
Big jointfir	*Ephedra trifurca*
Weeping lovegrass	*Eragrostis curvula*
Spreading buckwheat	*Eriogonum effusum*
Shaggy dwarf morning-glory	*Evolvulus nuttallianus*
Apache plume	*Fallugia paradoxa*
Tarbush	*Flourensia cernua*
Broom snakeweed	*Gutierrezia sarothrae*
Indian rushpea	*Hoffmannseggia glauca*
Crown of thorns	*Koeberlinia spinosa*
Flatspine stickseed	*Lappula occidentalis*
Creosote	*Larrea tridentata*
Green sprangletop	*Leptochloa dubia*
Pale wolfberry	*Lycium pallidum*
Torrey wolfberry	*Lycium torreyi*
Slender goldenweed	*Machaeranthera gracilis*
Rough menodora	*Menodora scabra*
Bush muhly	*Muhlenbergia porteri*
Cactus apple	*Opuntia engelmannii*
Purple pricklypear	*Opuntia macrocentra*
Vine mesquite	*Panicum obtusum*
Mariola	*Parthenium incanum*
Lemonscent	*Pectis angustifolia*
Tobosagrass	*Pleuraphis mutica*
Honey mesquite	*Prosopis glandulosa*
Littleleaf sumac	*Rhus microphylla*
Burrograss	*Scleropogon brevifolius*
Silverleaf nightshade	*Solanum elaeagnifolium*
Spear globemallow	*Sphaeralcea hastulata*
Brownplume wirelettuce	*Stephanomeria pauciflora*
Greenthread	*Thelesperma megapotamicum*
Spiny dogweed	*Thymophylla acerosa*
Woolly tidestromia	*Tidestromia lanuginosa*
Banana yucca	*Yucca baccata*
Soaptree yucca	*Yucca elata*
Graythorn	*Ziziphus obtusifolia*

4.1.1 Potential Impacts and Mitigation

Under the proposed action, direct and short-term impacts to vegetation resulting from project-related ground disturbance activities would be minimal. Much of the proposed project area consists of existing roads (paved and unpaved), associated rights-of-way, and areas previously cleared around well sites. In addition, heavy cattle-grazing has affected vegetation over large portions of the proposed project corridor. Should water used for pipeline testing be discharged into Greyback Arroyo, a surface pipeline would be temporarily installed from PW-4 to Greyback Arroyo. Vegetation between PW-4 and the arroyo consists predominantly of mesquite (*Prosopis* sp.) and littleleaf sumac (*Rhus microphylla*). The temporary pipeline would minimally affect vegetation along the route.

The overall impact widths for the proposed project will be as follows: 30 feet in roadway corridors for blading/clearing of vegetation; 60 feet in the pipeline corridor for repair of the existing pipeline, sleeve installation, and temporary line installation; and 100 feet by 100 feet around well sites for monitoring activities. New project-related disturbance will be minimal when considered with the extent of previous disturbance on the proposed project site.

Subsequent to project activities, disturbed areas along roadways (esp. State Route 152) will be re-seeded with a local seed mix according to standard BLM post-construction protocols.

4.2 NOXIOUS WE EDS

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.

4.2.1 Potential Impacts and Mitigation

No state-listed noxious weeds were observed within the project area during the 2010 and 2011 biological surveys; therefore, the project is not expected to have an impact on the spread of noxious weeds. However, care should be used to prevent introduction of noxious weeds to the project site. Any fill material (soil) brought in from an outside source should be free of weed and invasive species. All heavy equipment should be cleaned to remove mud and dirt prior to entering and exiting public lands to remove potentially-occurring noxious weed seeds.

4.3 WILDLIFE

New Mexico provides extensive habitat for a wide variety of wildlife. Habitat within the proposed project area consists of desert grassland and creosote flat. During the 2010 and 2011 field surveys, 30 wildlife species or their sign were observed within the proposed project area (Table 3).

Table 3. Wildlife Observed During the 2010 and 2011 Field Surveys

Common Name	Scientific Name
Pocket gopher	*Thomomys sp*
White-throated woodrat	*Neotoma albigula*
Pocket mouse	*Perognathus sp*
Merriam's kangaroo rat	*Dipodomys merriami*
Eastern fence lizard	*Sceloporus undulatus*
Whiptail lizard	*Cnemidophorus sp*
American badger	*Taxidea taxus*
Black-tailed jackrabbit	*Lepus californicus*
Red-shouldered hawk	*Buteo lineatus*
Black-throated sparrow	*Amphispiza bilineata*
Barn swallow	*Hirundo rustica*
Red-tailed hawk	*Buteo jamaicensis*
Cactus wren	*Campylorhynchus brunneicapillus*
House finch	*Carpodacus mexicanus*
Canyon wren	*Catherpes mexicanus*
Common raven	*Corvus corax*
Chipping sparrow	*Spizella passerina*
Western kingbird	*Tyrannus verticalis*
White-winged dove	*Zenaida asiatica*
Gambel's quail	*Callipepla gambelii*
Curve-billed thrasher	*Toxostoma curvirostre*
Coyote	*Canis latrans*
Bobcat	*Lynx rufus*
Mule deer	*Odocoileus hemionus*
Desert cottontail	*Silvilagus auduboni*
Rock squirrel	*Spermophilus variegatus*
Turkey vulture	*Cathartes aura*
Funnel-web spider	*Family Agelenidae*
Honey bee	*Family Apidae*
Tarantula hawk wasp	*Pepsis formosa*

In addition to the observation of the above species or their sign, seven cactus wren (*Campylorhynchus brunneicapillus*) bird nests were identified within the project area and an active raptor nest was found in the windmill at well site MW-2. These findings are discussed in more detail in Section 4.4.

4.3.1 Potential Impacts and Mitigation

Potential impacts to wildlife from the proposed project are expected to be minimal because of the pre-existing disturbed nature of the project area. Project activities may cause minor disruption to foraging or localized migratory movement of certain species. Most animals currently utilizing the project area are expected to migrate to undisturbed areas adjacent to the project area, and no direct losses of large mammals or birds are expected as a result of this project.

4.4 MIGRATORY BIRDS

The MBTA protects over 1500 migratory bird species (see 50 CFR 10.133, List of Migratory Birds) in the United States and its territories. This act and Executive Order 13186 provide protection to migratory bird species, which includes protection of their nests and eggs.

Seven cactus wren bird nests were identified within the project area during the 2010 and 2011 biological surveys. During an August 2011 survey, an active raptor nest was observed in the windmill at well-site MW-2, and there are additional structures on the project site that provide habitat for nesting birds.

Migratory habitat for the southwestern willow flycatcher (*Empidonax trailii extimus*) occurs along the Rio Grande, although critical habitat for the species has not been designated as far south as Caballo Reservoir, which is the closest reach of the Rio Grande to the project area.

4.4.1 Potential Impacts and Mitigation

None of the wren nests were located within the area proposed for vegetation clearing on existing access roads. The raptor nest at well-site MW-2 will not be removed or disturbed, and none of the proposed actions are expected to affect the nest.

Due to the presence of bird nests in the proposed project corridor, clearing of vegetation should take place outside of the bird breeding season (roughly March through August). If this is not possible due to scheduling concerns, a pre-construction nest survey conducted by a qualified biologist is recommended. If active bird nests are to be affected by construction, then coordination with the USFWS is required and a permit must be obtained in order to move or disturb active nests.

Designated critical habitat for the southwestern willow flycatcher occurs many miles northeast of the project corridor; the species will not be affected by project activities.

4.5 THREATENED, ENDANGERED AND SENSITIVE SPECIES

Numerous fish, wildlife, and plant species are federally- , state- , and/or locally-listed in New Mexico. Many of these species have specific habitat requirements and, therefore, only occur in specific regions or habitat configurations. Over thirty wildlife species are listed by the New Mexico Department of Game and Fish (NMDGF) and United States Fish and Wildlife Service (USFWS) as threatened, endangered or candidate species (see Table 4). Other federal agencies (e.g., the United States Department of Agriculture-Forest Service [USFS] and the BLM) also list species as sensitive or as species of concern, and the State of New Mexico lists wildlife species as endangered, threatened, or sensitive (BISON-M 2009). Twenty one plant species are identified by the New Mexico Rare Plant Technical Council (NMRPTC) as noted for conservation. Species of concern, sensitive species, and rare plants do not have the rigorous legal protection of listed species, but information about them is included for planning purposes, and the relevant management agencies do have an obligation to consider impacts to these species.

Lists generated by the USFWS, NMDGF and NMRPTC were accessed online on June 10, 2011, and are attached to this document. No listed or special status species were observed within the proposed project area during the 2010 and 2011 biological surveys.

Table 4. Threatened, Endangered, Candidate and Sensitive Species

Scientific Name	Common Name	Status	Species Present	Habitat Present	Rationale for No Effect Determination
Ammodramus bairdii	Baird's sparrow	New Mexico – Threatened BLM - Sensitive	No	Yes	The grassland habitat could potentially support Baird's sparrow, but the species was not observed and is not expected to be impacted by project activities.
Accipiter gentilis atricapillus	Northern goshawk	BLM - Sensitive	No	No	Mature, closed-canopy coniferous forests are not present in or adjacent to the project corridor.
Agosia chrysogaster	Longfin dace	BLM - Sensitive	No	No	The stream habitat required by this species is not present in or adjacent to the project corridor.
Anthus spragueii	Sprague's pipit	USFWS - Candidate	No	Yes	The grassland habitat could potentially support Sprague's pipit, but the species was not observed and is not expected to be impacted by project activities.
Athene cunicularia hypugaea	Burrowing owl	BLM - Sensitive	No	Yes	The grassland habitat could potentially support Burrowing owls, but the species was not observed and is not expected to be impacted by project activities.
Bufo microscaphus microscaphus	Arizona toad	BLM - Sensitive	No	No	There are no streams or rivers in or adjacent to the project corridor.
Buteo regalis	Ferruginous hawk	BLM - Sensitive	No	Yes	The grassland habitat in the project corridor could potentially support the Ferruginous hawk, but the species was not observed and is not expected to be impacted by project activities.
Buteogallus anthracinus anthracinus	Common black-hawk	New Mexico - Threatened	No	No	There is no woodland stream habitat in or adjacent to the project corridor.
Calothorax lucifer	Lucifer hummingbird	New Mexico - Threatened	No	No	The arid montane habitat preferred by this species does not occur in or adjacent to the project corridor.

(Table Continues)

Table 4. Threatened, Endangered, Candidate and Sensitive Species (Continued)

Scientific Name	Common Name	Status	Species Present	Habitat Present	Rationale for No Effect Determination
Calypte costae	Costa's hummingbird	New Mexico – Threatened	No	No	There is no shrubland habitat in or adjacent to the project corridor.
Canis lupus baileyi	Mexican gray wolf	USFWS – Endangered New Mexico – Endangered	No	No	The range of this re-introduced species does not extend to the project corridor.
Charadrius montanus	Mountain plover	USFWS – Threatened	No	No	The shortgrass prairie required by this species does not exist within the project area.
Chlidonias niger surinamensis	Black tern	BLM – Sensitive	No	No	The riparian habitat required by this species does not occur in or adjacent to the project corridor.
Coccyzus americanus occidentalis	Yellow-billed cuckoo	USFWS – Candidate	No	No	The desert grassland habitat in the project area would not support the Yellow-billed cuckoo.
Columbina passerina pallescens	Common ground-dove	New Mexico – Endangered	No	No	There are no agricultural lands or riparian woodlands in the project corridor.
Corynorhinus townsendii pallescens	Pale Townsend's big-eared bat	BLM – Sensitive	Yes	Yes	The species' vocalization was detected at the mine tailings pond.
Cynanthus latirostris magicus	Broad-billed hummingbird	New Mexico – Threatened	No	No	There are no riparian woodlands within or adjacent to the project corridor.
Cynomys gunnisoni gunnisoni	Gunnison's prairie dog (montane)	USFWS – Candidate	No	No	The extensive shortgrass prairie required by this species does not occur within or adjacent to the project corridor.
Cyprinodon tularosa	White Sands pupfish	New Mexico – Threatened	No	No	There are no free-flowing streams or pools in the project corridor.
Empidonax trailii extimus	Southwestern willow flycatcher	USFWS – Critical habitat designated, Endangered New Mexico – Endangered	No	No	There is no suitable riparian habitat within or adjacent to the project corridor.
Falco femoralis septentrionalis	Aplomado falcon	USFWS – Endangered New Mexico – Endangered	No	Yes	The desert grassland habitat in the project area could potentially support the Aplomado falcon, but the species was not observed and is not expected to be impacted by project activities.

(Table Continues)

Table 4. Threatened, Endangered, Candidate and Sensitive Species (Continued)

Scientific Name	Common Name	Status	Species Present	Habitat Present	Rationale for No Effect Determination
Falco peregrinus anatum	Peregrine falcon	New Mexico – Threatened	No	Yes	Peregrine falcons could potentially forage in the project area, but the lack of roosting or nesting habitat makes it unlikely that this species would stay in the area for long periods of time.
Falco peregrinus tundrius	Arctic peregrine falcon	New Mexico – Threatened	No	No	The elevation of the project area is not high enough to support the preferred forest types of this species.
Gila nigra	Headwater chub	USFWS – Candidate New Mexico – Endangered	No	No	There are no streams in or adjacent to the project corridor.
Haliaeetus leucocephalus alascanus	Bald eagle	New Mexico – Threatened	No	No	There are no large bodies of water near the proposed project corridor.
Hedeoma todsenii	Todsen's pennyroyal	USFWS – Critical habitat designated; Endangered	No	No	This species grows in limestone soils on north- or east-facing slopes in pinon-juniper woodland; this habitat configuration is not present in or adjacent to the project site.
Hybognathus amarus	Rio Grande silvery minnow	USFWS – Endangered	No	No	The minnow is extirpated in Sierra County.
Idionycteris phyllotis	Allen's big-eared bat	BLM – Sensitive	No	Yes	The forested areas preferred by this species are not present in or adjacent to the project corridor.
Lanius ludovicianus excubitorides	Loggerhead shrike	New Mexico – Sensitive BLM – Sensitive	No	Yes	The desert grassland habitat in the project area could potentially support the Loggerhead shrike, but the species was not observed and is not expected to be impacted by project activities.
Myotis ciliolabrum melanorhinus	Western small-footed myotis bat	BLM – Sensitive	Yes	Yes	The species' vocalization was detected at the mine tailings pond.
Myotis evotis evotis	Long-eared myotis bat	BLM – Sensitive	Yes	Yes	The species' vocalization was detected at the mine tailings pond.

(Table Continues)

Table 4. Threatened, Endangered, Candidate and Sensitive Species (Continued)

Scientific Name	Common Name	Status	Species Present	Habitat Present	Rationale for No Effect Determination
Myotis lucifugus occultus	Occult little brown myotis bat	BLM – Sensitive	Yes	Yes	The species' vocalization was detected at the mine tailings pond.
Myotis thysanodes thysanodes	Fringed myotis bat	BLM – Sensitive	Yes	Yes	The species' vocalization was detected at the mine tailings pond.
Myotis volans interior	Long-legged myotis bat	BLM – Sensitive	Yes	Yes	The species' vocalization was detected at the mine tailings pond.
Myotis yumanensis yumanensis	Yuma myotis bat	BLM – Sensitive	Yes	Yes	The species' vocalization was detected at the mine tailings pond.
Onchorhynchus clarki virginalis	Rio Grande cutthroat trout	USFWS – Candidate	No	No	There are no streams or rivers in or adjacent to the project corridor.
Onchorhynchus gilae	Gila trout	USFWS – Threatened New Mexico – Threatened	No	No	There are no streams or rivers in or adjacent to the project corridor.
Ondatra zibethicus ripensis	Pecos river muskrat	BLM – Sensitive	No	No	There are no marshes or drainages in or adjacent to the project corridor.
Oreohelix pilsbryi	Mineral creek mountainsnail	New Mexico – Threatened	No	No	The montane habitat with limestone outcroppings required by this species does not occur in the project corridor.
Ovis canadensis mexicana	Desert bighorn sheep	New Mexico – Threatened	No	No	The slopes preferred by this species do not occur within or adjacent to the project corridor.
Passerina versicolor versicolor	Varied bunting	New Mexico – Threatened	No	No	The dense stands of mesquite preferred by this species are not present in or adjacent to the project corridor.
Pelecanus occidentalis carolinensis	Brown pelican	New Mexico – Endangered	No	No	There are no large rivers or lakes within or adjacent to the project corridor.
Phalacrocorax brasilianus	Neotropic cormorant	New Mexico – Threatened	No	No	There are no large bodies of water in or adjacent to the proposed project corridor.
Phrynosoma cornutum	Texas horned lizard	BLM – Sensitive	No	Yes	The project area contains the bunchgrass, cactus, and mesquite habitat preferred by this species.

(Table Continues)

Table 4. Threatened, Endangered, Candidate and Sensitive Species (Continued)

Scientific Name	Common Name	Status	Species Present	Habitat Present	Rationale for No Effect Determination
Plegadis chihi	White-faced ibis	BLM – Sensitive	No	No	There are no riparian woodlands or marshes in or adjacent to the project corridor.
Rana chiricahuensis	Chiricahua leopard frog	USFWS – Threatened	No	No	No streams or suitable wetlands exist in the project area.
Sterna antillarum athalassos	Least tern	USFWS – Endangered New Mexico – Endangered	No	No	The aquatic habitat required by this species does not occur within or adjacent to the project corridor.
Strix occidentalis lucida	Mexican spotted owl	USFWS – Critical habitat designated, Threatened	No	No	There are no old growth, closed-canopy forests within or adjacent to the project corridor.
Trogon elegans canescens	Elegant trogon	New Mexico – Endangered	No	No	The montane canyon woodlands preferred by this species do not occur in or adjacent to the project corridor.
Tyrannus crassirostris	Thick-billed kingbird	New Mexico – Endangered	No	No	There is no riparian habitat that would support this species in the project corridor.
Vireo bellii arizonae	Bell's vireo	New Mexico – Threatened	No	No	The dense shrubland or streamside woodland preferred by this species does not occur in or adjacent to the project area.
Vireo vicinior	Gray vireo	New Mexico – Threatened	No	No	There are no open woodland/shrublands within or adjacent to the project corridor.

The pit lake on the mine site provides foraging habitat for a variety of bat species listed as sensitive by the BLM. Bat vocalizations were recorded and identified by Parametrix biologists in the spring and summer of 2011. If water from pipeline testing were to be discharged into the pit lake, the surface area of the lake would increase and water quality would be improved, thereby providing more habitat for insects and more foraging resources for bats. There would be no negative impacts on bats if water were not discharged into the lake, as the size of the lake would not be reduced.

4.5.1 Potential Impacts and Mitigation

Based on survey results, the lack of suitable habitat, and the pre-existing disturbance at the site, the project is not expected to affect state- or federally-listed, or sensitive plant or wildlife species.

4.6 DESIGNATED CRITICAL HABITAT

The USFWS recognizes the importance of certain habitats for threatened and endangered species and has created designated critical habitat for animals and plants with specific requirements. The proposed project does not cross designated critical habitat for any protected species.

4.6.1 Potential Impacts and Mitigation

Critical habitat for one endangered species, the Rio Grande silvery minnow (*Hybognathus amarus*), has been designated in the project vicinity. Habitat for the silvery minnow has been designated in certain stretches of the Rio Grande, which flows into Caballo Reservoir approximately 5 – 6 miles east of the project area. The designated critical habitat reaches from Cochiti Dam south to San Marcial, New Mexico, but does not extend as far as Caballo Reservoir. The proposed project will have no impact on designated critical habitat for this species.

4.7 WETLANDS AND JURISDICTIONAL WATERS

Waters of the U.S. 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 project area was assessed for the presence of waters of the U.S. using U.S. Geological Survey topography maps and county soil survey maps, followed by a site visit to refine and re-evaluate the assessment.

Jurisdictional wetlands, those protected from unauthorized dredge and fill activities under Section 404 of the CWA (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.

One intermittent arroyo, the Greyback Arroyo, is located within the proposed project area. In the project area, the Greyback Arroyo does not have a permanent base flow, is dry for most of the year, and only flows during or immediately after rain events. The Greyback Arroyo joins with the Greenhorn Arroyo before discharging into the Rio Grande at Caballo Reservoir.

A small goodding willow (*Salix gooddingii*) wetland is located at the eastern end of the mine site, and is not jurisdictional. None of the proposed pipeline routes will affect the wetland, as all proposed routes go around it on existing unpaved roads or disturbed areas outside of the wetland area.

Water used in pipeline testing may be discharged into the pit lake located at the western end of the project site. The current size of the lake is considerably smaller than its historic extent due primarily to evaporation. If all the water from pipeline testing is discharged into the lake, it will be returned to its historic extent. Water would re-inundate a patch of cattails occurring west of the pit lake within its historic extent, and wetland habitat could be expanded.

The Preferred Alternative/Proposed Action would not cross any waters that are classified by the USACE as navigable (USACE 2009).

No specific surface water quality issues in the project area have been identified by the BLM.

4.7.1 Potential Impacts and Mitigation

Based on National Wetland Inventory (NWI) data and field verification, wetlands are present within the proposed project area. However, due to the absence of impact, a jurisdictional determination has not been completed. No adverse impacts to wetlands are expected from the proposed project.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

Based on 2010 and 2011 field surveys and a review of the project description, the following conclusions have been made regarding potential impacts to biological resources present within the project area:

- Direct and short-term impacts to vegetation would occur during project activities, as brush would be cleared along existing access roads. Impacts during the proposed action would occur on previously disturbed land.
- No direct losses of mammals, birds, or wildlife in general are expected as a result of the project. Proposed project activities may cause minor disruptions to foraging and, migratory movement, or breeding behavior of some species. There is currently a vast amount of undeveloped land in nearby areas where wildlife can temporarily relocate for cover and foraging.
- Suitable habitat for state- or federally-listed threatened, endangered, or sensitive wildlife or plant species, or species of concern observed during the field surveys was marginal and no species listed as threatened or endangered were observed during the survey. Bats listed as sensitive by the BLM were identified at the pit lake by their vocalizations. If water from pipeline testing were to be discharged into the pit lake, the surface area of the lake would increase and lake water quality would be improved, thereby providing more habitat for insects and more foraging resources for bats. There would be no negative impacts on bats if water were not discharged into the lake, as the size of the lake would not be reduced.
- The proposed project would have no impacts on any wetlands or waterways. The Preferred Alternative/Proposed Action would not cross any waters that are classified by the USACE as navigable (USACE 2009).

5.2 RECOMMENDATIONS

This report makes the following recommendations:

- Care should be used to prevent introduction of noxious weeds to the project site. Any fill material (soil) brought in from an outside source should be free of weed and invasive species. All heavy equipment should be cleaned to remove mud and dirt prior to entering and exiting public lands to remove potentially-occurring noxious weed seeds.
- Subsequent to project activities, disturbed areas along roadways (esp. State Route 152) will be re-seeded with a local seed mix according to standard BLM post-construction protocols.

- Seven cactus wren nests were identified within the project area. None of the wren nests were located within the area proposed for vegetation clearing on existing access roads. An active raptor nest was also found on the windmill at well-site MW-2. The raptor nest will not be removed or disturbed by project activities around the well. If active bird nests are to be affected by project activities in the future, then coordination with the USFWS will be required, and a permit must be obtained in order to move or disturb an active nest.

If the recommendations outlined in this report are followed, the proposed project is not expected to have a significant impact on the natural environment.

6. REFERENCES

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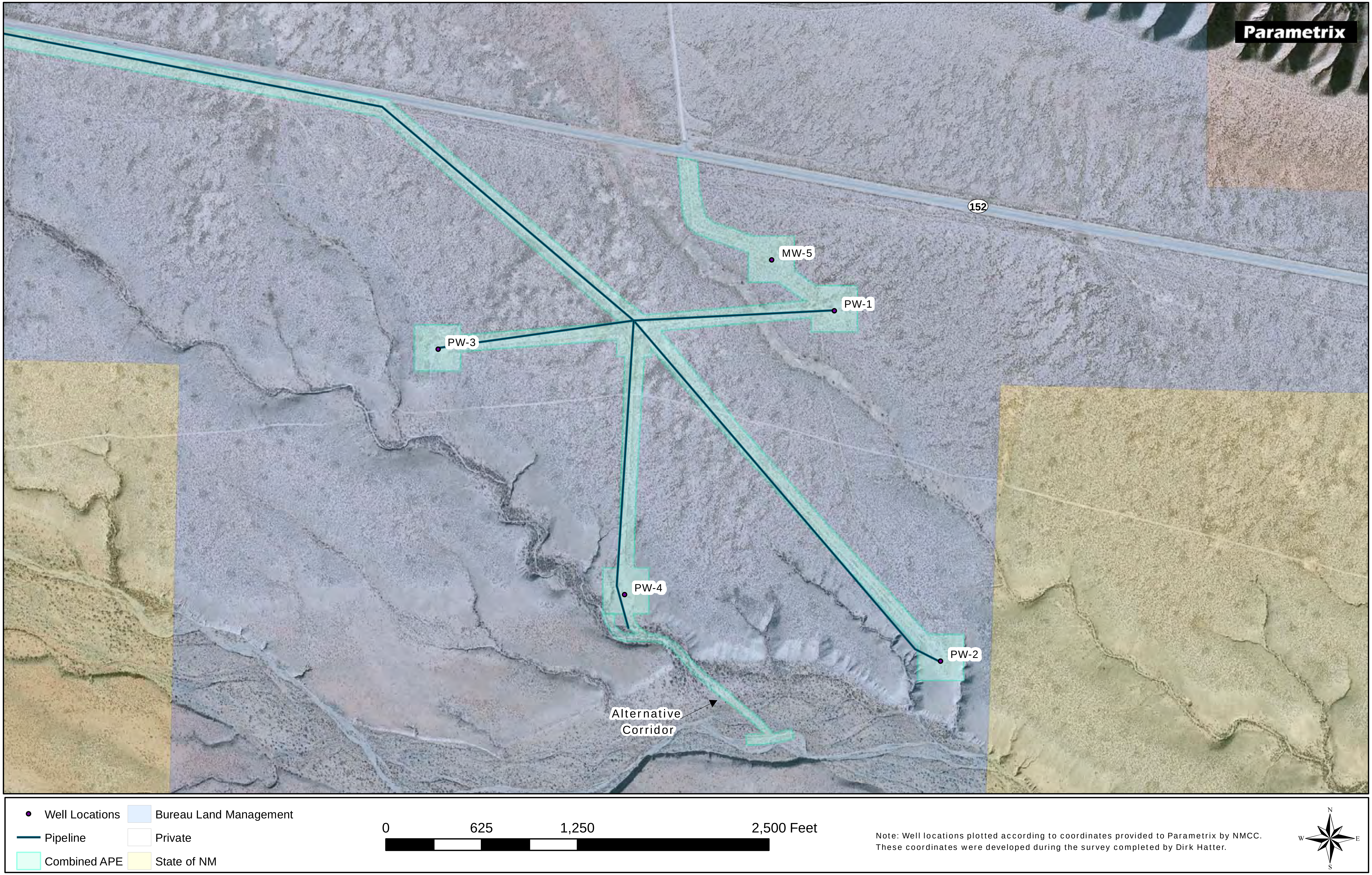
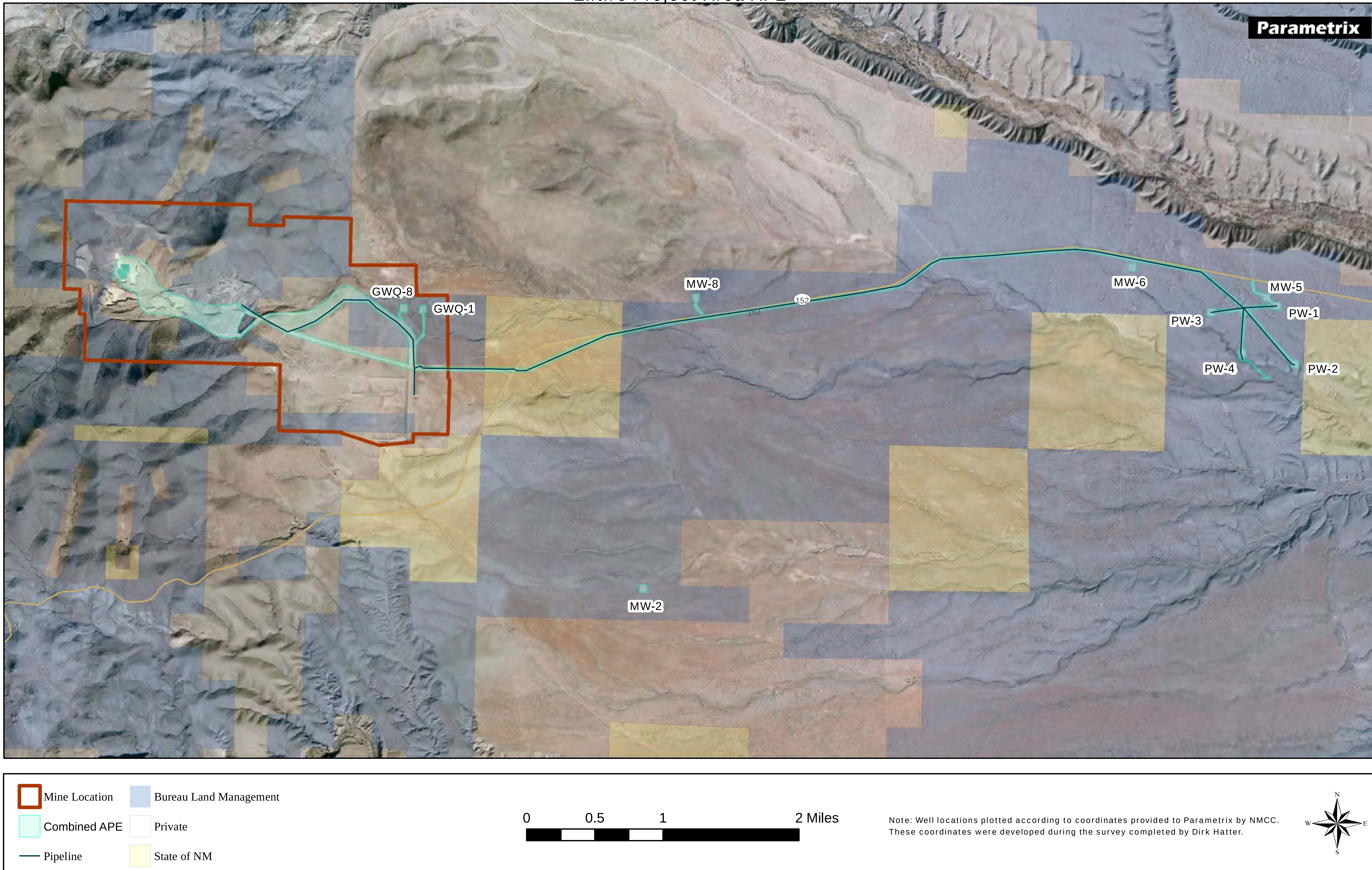
FIGURES



Note: Well locations plotted according to coordinates provided to Parametrix by NMCC. These coordinates were developed during the survey completed by Dirk Hatter.

Entire Project Area APE



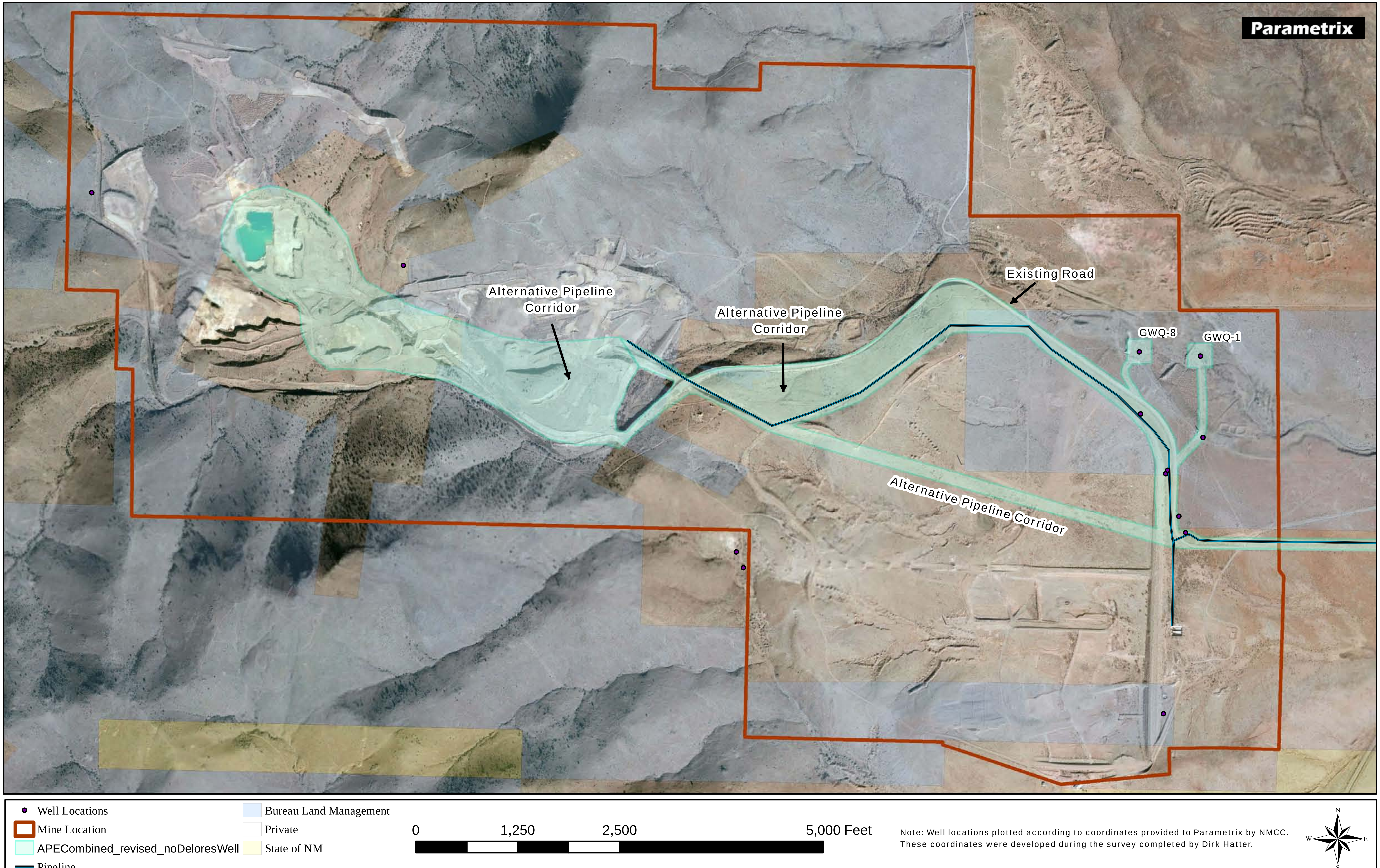
Well Locations
Pipeline
Combined APE
Bureau Land Management
Private
State of NM

0 1,250 2,500 5,000 Feet

Note: Well locations plotted according to coordinates provided to Parametrix by NMCC. These coordinates were developed during the survey completed by Dirk Hatter.

N E S W

APE in Mine Permit Area



Note: Well locations plotted according to coordinates provided to Parametrix by NMCC. These coordinates were developed during the survey completed by Dirk Hatter.

APPENDIX A

State and Federal Listed Species

Biota Information System Of New Mexico

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Report County TES Table for

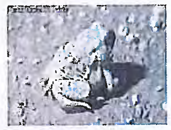
Sierra

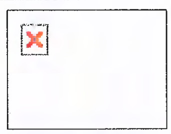
88 species returned.

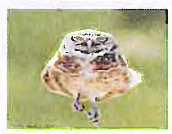
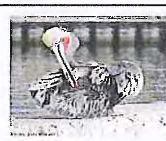
Taxonomic Group	# Species	Taxonomic Group	# Species
Fish	7	Mammals	23
Amphibians	4	Molluscs	7
Reptiles	4	Crustaceans	1
Birds	40	Lepidoptera; moths and butterflies	2

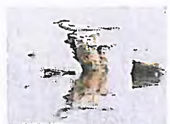
Export to Excel

Common Name	Scientific Name	Habitat Map	Species Photo (click photo to enlarge)	FWS-ESA	NM WCA	FS-R3	BLM-NM	NM-Sen	FWS-SOC
Chub, Rio Grande	Gila pandora		no photo	-	-	S	-	S	-
Chub, Headwater	Gila nigra		no photo	C	E	S	-	-	-
Dace, Longfin	Agosia chrysogaster	no map	no photo	-	-	S	S	-	-
Pupfish, White Sands	Cyprinodon tularosa		no photo	-	T	-	-	-	S
Sucker, Rio Grande	Catostomus plebeius		no photo	-	-	S	-	-	-
Trout, Cutthroat, Rio Grande	Oncorhynchus clarki virginalis (NM)	no map		C	-	S	-	S	-
Trout, Gila	Oncorhynchus gilae			T	T	S	-	-	-
Frog, Leopard, Chiricahua	Rana chiricahuensis	no map		T	-	S	-	S	-
Frog, Leopard, Northern	Rana pipiens	no map		-	-	S	-	-	-

Frog, Leopard, Plains	Rana blairi	no map		-	-	s	-	-	-
Toad, Arizona	Bufo microscaphus microscaphus (NM,AZ)	no map		-	-	s	s	s	-
Lizard, Horned, Texas	Phrynosoma cornutum	no map		-	-	s	s	-	-
Massasauga, Desert	Sistrurus catenatus edwardsii (NM,AZ)	no map		-	-	s	-	-	-
Slider, Big Bend	Trachemys gaigeae	no map		-	-	-	-	s	-
Kingsnake, Desert	Lampropeltis getula splendida (NM,AZ)	no map		-	-	s	-	-	-
Bittern, American	Botaurus lentiginosus	no map		-	-	s	-	-	-
Black-Hawk, Common	Buteogallus anthracinus anthracinus (NM)	no map		-	T	s	-	-	s
Bunting, Varied	Passerina versicolor versicolor (NM);dickeyae (NM)	no map		-	T	s	-	-	-
Cormorant, Neotropic	Phalacrocorax brasilianus	no map		-	T	s	-	-	-
Cuckoo, Yellow-billed	Coccyzus americanus occidentalis (western pop)	no map	no photo	C	-	s	-	s	-
Curlew, Long-billed	Numenius americanus americanus (NM)	no map		-	-	s	-	-	-
Eagle, Bald	Haliaeetus leucocephalus alascanus (NM)	no map		-	T	s	-	-	-

Egret, Great	Ardea alba egretta (NM)	no map		-	-	s	-	-	-
Egret, Snowy	Egretta thula brewsteri (NM)	no map		-	-	s	-	-	-
Falcon, Aplomado	Falco femoralis septentrionalis (NM)	no map		E	E	s	-	-	-
Falcon, Peregrine	Falco peregrinus anatum	no map		-	T	s	-	-	s
Falcon, Peregrine, Arctic	Falco peregrinus tundrius	no map	no photo	-	T	s	-	-	s
Flycatcher, Willow, SW.	Empidonax traillii extimus	no map		E	E	s	-	-	-
Goshawk, Northern	Accipiter gentilis atricapillus (NM,AZ);apache (NM,AZ)	no map	no photo	-	-	s	s	s	s
Ground-dove, Common	Columbina passerina pallescens (NM)	no map		-	E	s	-	-	-
Hawk, Ferruginous	Buteo regalis	no map		-	-	s	s	-	-
Hawk, Swainson's	Buteo swainsoni	no map		-	-	s	-	-	-
Hummingbird, Broad-billed	Cynanthus latirostris magicus (NM)	no map		-	T	s	-	-	-
Hummingbird, Costa's	Calypte costae	no map		-	T	s	-	-	-
Hummingbird, Lucifer	Calothorax lucifer		no photo	-	T	s	-	-	-
Ibis, White-faced	Plegadis chihi	no map		-	-	s	s	-	-

									
Kingbird, Thick-billed	Tyrannus crassirostris	no map		-	E	s	-	-	-
Kingfisher, Belted	Megaceryle alcyon	no map		-	-	s	-	-	-
Kite, Mississippi	Ictinia mississippiensis	no map		-	-	s	-	-	-
Osprey	Pandion haliaetus carolinensis (NM)	no map		-	-	s	-	-	-
Owl, Burrowing	Athene cunicularia hypugaea (NM,AZ)	no map		-	-	s	s	-	s
Owl, Elf	Micrathene whitneyi whitneyi (NM)	no map		-	-	s	-	-	-
Owl, Flammulated	Otus flammeolus	no map		-	-	s	-	-	-
Owl, Spotted, Mexican	Strix occidentalis lucida (NM,AZ)	no map		T	-	s	-	s	-
Pelican, Brown	Pelecanus occidentalis carolinensis (NM)	no map		-	E	s	-	-	-
Pipit, Sprague's	Anthus spragueii	no map	no photo	C	-	s	-	-	-
Plover, Mountain	Charadrius montanus		no photo	T	-	s	-	s	-
Plover, Snowy, Western	Charadrius alexandrinus nivosus (NM,AZ)	no map		-	-	s	-	-	-
Shrike, Loggerhead	Lanius ludovicianus excubitorides (NM);sonoriensis	no map		-	-	s	s	s	-

	(NM);gambeli (NM)								
Sparrow, Baird's	Ammodramus bairdii	no map		-	T	s	s	-	s
Tern, Black	Chlidonias niger surinamensis (NM)	no map		-	-	-	s	-	s
Tern, Least	Sterna antillarum athalassos (NM)	no map		E	E	s	-	-	-
Trogon, Elegant	Trogon elegans canescens (NM)	no map		-	E	s	-	-	-
Vireo, Bell's	Vireo bellii arizonae (NM,AZ);medius (NM)	no map		-	T	s	-	-	s
Vireo, Gray	Vireo vicinior			-	T	s	-	-	-
Bat, Big-eared, Allen's	Idionycteris phyllotis			-	-	s	s	s	s
Bat, Big-eared, Townsend's, Pale	Corynorhinus townsendii pallescens (NM,AZ)	no map	no photo	-	-	s	s	s	s
Bat, Myotis, Brn., Little, Occult	Myotis lucifugus occultus (NM,AZ)	no map	no photo	-	-	s	s	s	-
Bat, Myotis, Fringed	Myotis thysanodes thysanodes (NM,AZ)	no map	no photo	-	-	-	s	s	-
Bat, Myotis, Long-eared	Myotis evotis evotis (NM,AZ)	no map	no photo	-	-	-	s	s	-
Bat, Myotis, Long-legged	Myotis volans interior (NM,AZ)	no map	no photo	-	-	-	s	s	-
Bat, Myotis, Small-footed, W.	Myotis ciliolabrum melanorhinus (NM,AZ)	no map		-	-	-	s	s	-
Bat, Myotis, Yuma	Myotis yumanensis yumanensis (NM,AZ)	no map		-	-	-	s	s	-

									
Prairie Dog, Gunnison's, prairie populations	Cynomys gunnisoni gunnisoni (NM);zuniensis (NM)	no map		-	-	s	-	s	-
Prairie Dog, Gunnison's, montane populations	Cynomys gunnisoni gunnisoni (NM);zuniensis (NM)	no map	no photo	C	-	s	-	s	-
Gopher, Pocket, Botta's	Thomomys bottae albatus (AZ);alexandrae (AZ);alienus (NM);aureus (NM,AZ);catalinae (AZ);cervinus (AZ);cultellus (NM);desertorum (AZ);fulvus (NM,AZ);lachuguilla (NM);modicus (AZ);pectoralis (NM);peramplus (NM,AZ);perv	no map	no photo	-	-	s	-	-	-
Gopher, Pocket, Desert	Geomys arenarius brevirostris (NM)	no map	no photo	-	-	-	-	s	s
Gopher, Pocket, Yellow-faced	Cratogeomys castanops castanops (NM);hirtus (NM);parviceps (NM);perplanus (NM)	no map	no photo	-	-	s	-	-	-
Muskrat, Pecos River	Ondatra zibethicus ripensis (NM)	no map	no photo	-	-	-	s	s	s
Pronghorn, Chihuahuan	Antilocapra americana mexicana (NM,AZ)	no map	no photo	-	-	s	-	-	-
Rat, Wood, White Sands	Neotoma micropus leucophaea	no map	no photo	-	-	-	-	-	s
Ringtail	Bassariscus astutus arizonensis (NM,AZ);flavus (NM);yumanensis (AZ);nevadensis (AZ)	no map		-	-	s	-	s	-
Sheep, Bighorn, Desert	Ovis canadensis mexicana (listed pops)	no map		-	T	s	-	-	-
Shrew, Desert, Crawford's	Notiosorex crawfordi crawfordi (NM,AZ)	no map	no photo	-	-	s	-	-	-
Skunk, Hog-nosed, Common	Conepatus leuconotus mearnsi (NM);venaticus (NM,AZ)	no map	no photo	-	-	-	-	s	-
Skunk, Spotted, Western	Spilogale gracilis	no map	no photo	-	-	-	-	s	-
Vole, Long-	Microtus longicaudus longicaudus (NM);alticola	no	no photo	-	-	s	-	-	-

tailed	(AZ);baileyi (AZ);mordax (AZ)	map								
Wolf, Gray, Mexican	Canis lupus baileyi (NM,AZ)	no map		E	E	s	-	-	-
Mountainsnail, Mineral Creek	Oreohelix pilsbryi	no map	no photo	-	T	s	-	-	s
Mountainsnail, Subalpine	Oreohelix subrudis	no map	no photo	-	-	s	-	-	-
Mountainsnail, Morgan Creek	Oreohelix swopei	no map	no photo	-	-	s	-	-	-
Mountainsnail, Black Range	Oreohelix metcalfei acutidiscus (NM)	no map	no photo	-	-	s	-	-	-
Mountainsnail, Black Range	Oreohelix metcalfei metcalfei (NM)	no map	no photo	-	-	s	-	-	-
Woodlandsnail, Dry Creek	Ashmunella tetrodon animorum (NM)	no map	no photo	-	-	s	-	-	-
Woodlandsnail, Iron Creek	Ashmunella mendax	no map	no photo	-	-	s	-	-	-
Shrimp, Fairy, Moore's	Streptocephalus moorei	no map	no photo	-	-	s	-	s	-
Skipper, Skipperling, Four-potted	Piruna polingii	no map	no photo	-	-	s	-	-	-
Butterfly, Viceroy, Obsolete	Basilarchia archippus obsoleta (NM,AZ)	no map	no photo	-	-	s	-	-	s

Close Window

New Mexico Ecological Services Field Office

Listed and Sensitive Species in Sierra County

Total number of species: 33

Print

Common Name	Scientific Name	Group	Status
Sprague's pipit	*Anthus spragueii*	Bird	Candidate
Yellow-billed cuckoo	*Coccyzus americanus*	Bird	Candidate
Rio Grande cutthroat trout	*Oncorhynchus clarki virginalis*	Fish	Candidate
Northern aplomado falcon	*Falco femoralis septentrionalis*	Bird	Endangered
Southwestern willow flycatcher	*Empidonax traillii extimus*	Bird	Endangered
Rio Grande silvery minnow [3]	*Hybognathus amarus*	Fish	Endangered
Black-footed ferret [2]	*Mustela nigripes*	Mammal	Endangered
Todsen's pennyroyal Designated Critical Habitat	*Hedeoma todsenii*	Plant	Endangered
Whooping Crane	*Grus americana*	Bird	Experimental, Non-essential Population
Gray Wolf (Mexican Gray Wolf)	*Canis lupus baileyi*	Mammal	Experimental, Non-essential Population
Chiricahua leopard frog	*Rana chiricahuensis*	Amphibian	Threatened
Mexican spotted owl Designated Critical Habitat	*Strix occidentalis lucida*	Bird	Threatened
Gila trout	*Oncorhynchus gilae*	Fish	Threatened
White Sands pupfish	*Cyprinodon tularosa*	Fish	Under Review
Mineral Creek mountainsnail	*Oreohelix pilsbryi*	Mollusc - Invertebrate	Under Review

Species of Concern

Species of Concern are included for planning purposes only.

Common Name	Scientific Name	Group	Status
Desert viceroy butterfly	*Limenitis archippus obsoleta*	Arthropod - Invertebrate	Species of Concern

American peregrine falcon	*Falco peregrinus anatum*	Bird	Species of Concern
Arctic peregrine falcon	*Falco peregrinus tundrius*	Bird	Species of Concern
Baird's sparrow	*Ammodramus bairdii*	Bird	Species of Concern
Bell's vireo	*Vireo bellii*	Bird	Species of Concern
Black tern	*Chlidonias niger*	Bird	Species of Concern
Northern goshawk	*Accipiter gentilis*	Bird	Species of Concern
Western burrowing owl	*Athene cunicularia hypugaea*	Bird	Species of Concern
Desert sucker	*Catostomus clarki*	Fish	Species of Concern
Sonora sucker	*Catostomus insignis*	Fish	Species of Concern
Black-tailed prairie dog [1]	*Cynomys ludovicianus*	Mammal	Species of Concern
Organ Mountains Colorado chipmunk	*Eutamias quadrivittatus australis*	Mammal	Species of Concern
Southwestern otter	*Lutra canadensis sonorae*	Mammal	Species of Concern
Townsend's big-eared bat	*Corynorhinus townsendii*	Mammal	Species of Concern
White Sands woodrat	*Neotoma micropus leucophaea*	Mammal	Species of Concern
Duncan's pincushion cactus	*Coryphantha duncanii*	Plant	Species of Concern
Pinos Altos flame flower	*Talinum humile*	Plant	Species of Concern
Sandhill goosefoot	*Chenopodium cycloides*	Plant	Species of Concern

Endangered	Any species which is in danger of extinction throughout all or a significant portion of its range.	**Threatened**	Any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.
Candidate	Candidate Species (taxa for which the Service has sufficient information to propose that they be added to list of endangered and threatened species, but the listing action has been precluded by other higher priority listing activities).	**Proposed**	Any species of fish, wildlife or plant that is proposed in the Federal Register to be listed under section 4 of the Act. This could be either proposed for endangered or threatened status.
Experimental, Non-essential Population	A reintroduced population established outside the species' current range, but within its historical range. For purposes of section 7 consultation, this population is treated as a proposed species, except when it is located within a National Wildlife Refuge and National Park, when the population is considered threatened.		

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Results of County Search

SIERRA	
Scientific name	County-NM
Agastache cana	Doña Ana, Grant, Luna, Sierra
Astragalus castetteri	Doña Ana, Sierra
Cirsium wrightii	Chaves, Eddy, Guadalupe, Otero, Sierra, Socorro
Cuscuta warneri	Roosevelt, Sierra
Desmodium metcalfei	Grant, Sierra
Draba mogollonica	Catron, Grant, Sierra, Socorro
Draba standleyi	Doña Ana, Otero, Sierra, Socorro
Erigeron scopulinus	Catron, Sierra, Socorro
Escobaria duncanii	Sierra
Escobaria sandbergii	Doña Ana, Sierra
Grindelia arizonica var. neomexicana	Grant, Sierra
Hedeoma todsenii	Otero, Sierra
Hexalectris arizonica	Doña Ana, Hidalgo, Otero, Sierra
Hymenoxys vaseyi	Doña Ana, Sierra
Penstemon metcalfei	Sierra
Perityle staurophylla var. homoflora	Sierra, Socorro
Perityle staurophylla var. staurophylla	Doña Ana, Otero, Sierra
Physaria gooddingii	Catron, Sierra
Silene plankii	Bernalillo, Doña Ana, Sandoval, Sierra, Socorro, Torrance
Silene thurberi	Grant, Hidalgo, Sierra
Silene wrightii	Catron, Grant, Luna, Sierra, Socorro

Photo credits in header *Peniocereus greggii var. greggii* © T. Todsen, *Lepidospartum burgessii* © M. Howard, *Argemone pleiacantha ssp. pinnatisecta* © R. Sivinski

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Appendix 5-B

Winter Bird Survey Report

Parametrix
ENGINEERING . PLANNING . ENVIRONMENTAL SCIENCES

8801 JEFFERSON NE, BLDG B
ALBUQUERQUE, NM 87113-2718
T. 505.821.4700 F. 505.821.7131
www.parametrix.com

TECHNICAL MEMORANDUM

Date:	January 4, 2012
To:	New Mexico Copper Corporation
From:	Steve Albert, Senior Scientist, Parametrix
Subject:	Winter Bird Surveys at Copper Flat
cc:	
Project Number:	563-6671-002 (02/02)
Project Name:	Copper Flat Baseline Biological Surveys

INTRODUCTION

As part of baseline wildlife studies, Parametrix, Inc. conducted winter bird surveys at the Copper Flat Mine site and off-site reference areas in December 2011. The results were not completed in time to include within the original report, but are included herein.

Habitat use by many species of wildlife differs from season to season, when their life history, physiology, and – most importantly in temperate zones – the weather and habitat conditions change. This is especially true for birds, which are highly mobile and able to take advantage of transitory habitat conditions or to move into more favorable climates. While many species are year-round residents of a particular area, populations of other species may change greatly from season to season. As such, in addition to summer (breeding) population surveys, it's important to gather data about winter populations.

STUDY AREA AND METHODOLOGY

We sampled birds along the same walking transects described in Section 5 (Figure 5-5) using mostly the same methods. The only change was that, in contrast to starting surveys at or before sunrise and ending at approximately 9:00 a.m. in summer, when bird activity markedly decreases, we started slightly later and continued surveys until approximately 3:00 p.m. in winter. This was due to (1) the shorter daylight hours available for surveys; (2) colder times early in the morning when, although it was still light out, many birds were not yet active; and (3) due to colder temperatures throughout the day, birds in temperate climates in winter are much less likely to restrict foraging or other activities to early morning hours. This was borne out during surveys, as observers noticed that birds continued to be active during all daylight hours.

We sampled a total of 36 transects on the mine site in the Arroyo, Chihuahuan Desert Grassland (CDG), Chihuahuan Desert Shrubland (CDS), Pit Lake, and Disturbed Area/Waste Rock Pile (DA/WR) habitats; and 20 transects in off-site reference areas in the Arroyo, CDG, and CDS habitats. Two transects on the mine site were not sampled due to hazardous snow and ice conditions on the north side of Animas Peak in CDG habitat during the time of sampling. However, sampling of adjacent transects in similar habitat indicated that few birds were using this habitat at this time. We did not sample along Percha or Las Animas Creeks in winter.

RESULTS

Copper Flat Mine Permit Area

There were 46 species of birds identified on the mine site (Table 5-A-1). The number of bird species recorded by habitat on the mine site included 29 in the Arroyo habitat, 32 in the CDS, 23 in the CDG, 0 in the Pit Lake, and 19 in the DA/WR habitat. (Some birds were not seen or heard completely and only an identification of genus was possible.) In addition to having the most species, the Arroyo and CDG habitat were the most diverse. Overall bird numbers were similar in winter (1,146 birds) and summer (1,290 birds), as were total numbers of species (46 species in both seasons), though the mix of species was slightly different. Species detected in summer but not winter included ash throated flycatcher, barn swallow, black-chinned hummingbird, blue-gray gnatcatcher, blue grosbeak, broad-tailed hummingbird, brown-headed cowbird, Bullock's oriole, common nighthawk, curve-billed thrasher, great horned owl, Montezuma quail, northern mockingbird, Swainson's hawk, Townsend's warbler, turkey vulture, violet-green swallow, western kingbird, western wood pewee, white-winged dove, and Wilson's warbler. Species detected in winter but not summer included Brewer's sparrow, bushtit, Cassin's finch, chestnut-collared longspur, chipping sparrow, dark-eyed junco, golden eagle, grasshopper sparrow, green-tailed towhee, ladder backed woodpecker, mountain bluebird, northern harrier, red-naped sapsucker, ruby-crowned kinglet, sage sparrow, sage thrasher, song sparrow, Townsend's solitaire, verdin, vesper sparrow, and white-crowned sparrow. (Some of the birds recorded in one season but not the other may have been present in both seasons, but were not detected.) Though diversity of habitats (other than the Pit Lake) was similar, the highest diversity of species was recorded in the CDS, followed by the CDG, Arroyo, and DA/WR Areas.

Off-Site Reference Areas

There were 21 species of birds identified in the off-site reference areas (Table 5-A-1). The number of bird species recorded by habitat included a maximum of 13 in the Arroyo, 5 in the CDS, and 13 in the CDG (we did not sample in areas similar to the Pit Lake or Disturbed Areas/Waste Rock Pile in reference areas for reasons discussed in Chapter 5). Birds detected in summer but not winter included ash-throated flycatcher, blue-gray gnatcatcher, blue grosbeak, brown-headed cowbird, common nighthawk, curve-billed thrasher, lesser goldfinch, mourning dove, northern flicker, northern mockingbird, Say's phoebe, western kingbird, western wood pewee, and white-winged dove. Species detected in winter but not summer included Bewick's wren, bushtit, chipping sparrow, dark-eyed junco, green-tailed towhee, ruby-crowned kinglet, sage sparrow, Townsend's solitaire, verdin, vesper, white-crowned sparrow. (As noted above, some species recorded in one season but not the other may have been present in both seasons, but were not detected). The Arroyo habitat in reference areas was the most diverse, followed by the CDS and the CDG.

Table 5-A-1. Bird Species Detected in Different Habitats During Winter 2011 Surveys

	Copper Flat					Reference		
Species	**Arroyo**	**CDS**	**CDG**	**Pit**	**DA/WR**	**Arroyo**	**CDS**	**CDG**
American Kestrel		•	•					
American Robin	•		•					
Bewick's Wren	•	•				•		
Black-Throated Sparrow	•	•	•		•	•		•
Brewer's Sparrow	•	•						
Bushtit						•		
Cactus Wren						•		•
Canyon Towhee	•	•	•		•	•		•
Canyon Wren	•	•						
Cassin's Finch		•						
Chestnut-Collared Longspur	•							
Chihuahua Raven	•	•	•		•	•	•	•
Chipping Sparrow	•	•	•		•			•
Common Raven		•	•				•	•
Crissal Thrasher	•	•						
Dark-Eyed Junco	•	•			•	•		•
Gambel's Quail	•	•						•
Golden Eagle		•						
Grasshopper Sparrow			•					
Greater Roadrunner	•							
Green-Tailed Towhee	•		•					•
Horned Lark	•	•	•		•	•	•	
House Finch	•	•	•		•			
Ladder-Backed Woodpecker	•				•			
Lesser Goldfinch	•							
Loggerhead Shrike		•			•			
Meadowlark sp.		•	•					
Mountain Bluebird	•	•	•					
Mourning Dove		•			•			
Northern Flicker	•	•	•		•			
Northern Harrier			•					
Red-Naped Sapsucker		•						
Red-Tailed Hawk			•		•			
Rock Wren	•	•	•		•	•		•
Ruby-Crowned Kinglet	•		•		•	•		

Table Continues

Table 5-A-1. Bird Species Detected in Different Habitats During Winter 2011 Surveys (Continued)

	Copper Flat					Reference		
Species	Arroyo	CDS	CDG	Pit	DA/WR	Arroyo	CDS	CDG
Rufous-Crowned Sparrow	•	•	•		•			•
Sage Sparrow	•	•				•	•	
Sage Thrasher	•	•						
Say’s Phoebe		•			•			
Scaled Quail					•			
Song Sparrow		•						
Sparrow sp.			•					•
Spotted Towhee	•							
Townsend’s Solitaire		•						•
Verdin		•	•			•		
Vesper Sparrow	•	•	•					
Vireo sp.						•		
Western Meadowlark	•				•			
White-crowned Sparrow	•	•	•		•	•		
Total Species Encountered:	**29**	**32**	**23**	**0**	**19**	**14**	**5**	**13**
Shannon-Weaver Diversity Score:	**10.7**	**13.9**	**11.1**	**0.0**	**7.8**	**9.1**	**1.6**	**6.7**

Appendix 6-A

Copper Flat Mine
Order 1 Soil Survey of Permit Area

Copper Flat Mine

Order 1 Soil Survey of Permit Area

Prepared For:

THEMAC Resources Group, Ltd.

September 14, 2011

STETSON ENGINEERS INC.

WATER RESOURCE PROFESSIONALS
SERVING CLIENTS SINCE 1957

◈ COVINA, SAN RAFAEL, AND BAKERSFIELD, CALIFORNIA ◈ RENO, NEVADA ◈
◈ ALBUQUERQUE, NEW MEXICO ◈ MESA, ARIZONA ◈ CENTENNIAL, COLORADO ◈

Executive Summary

Stetson Engineers Inc. was retained by New Mexico Copper Corporation to conduct a soil survey of the Copper Flat copper mine near Hillsboro, NM 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 2000-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 feet. These map units will yield approximately 3,391,000 cubic yards, or 2,100 acre-feet of suitable topdressing materials.

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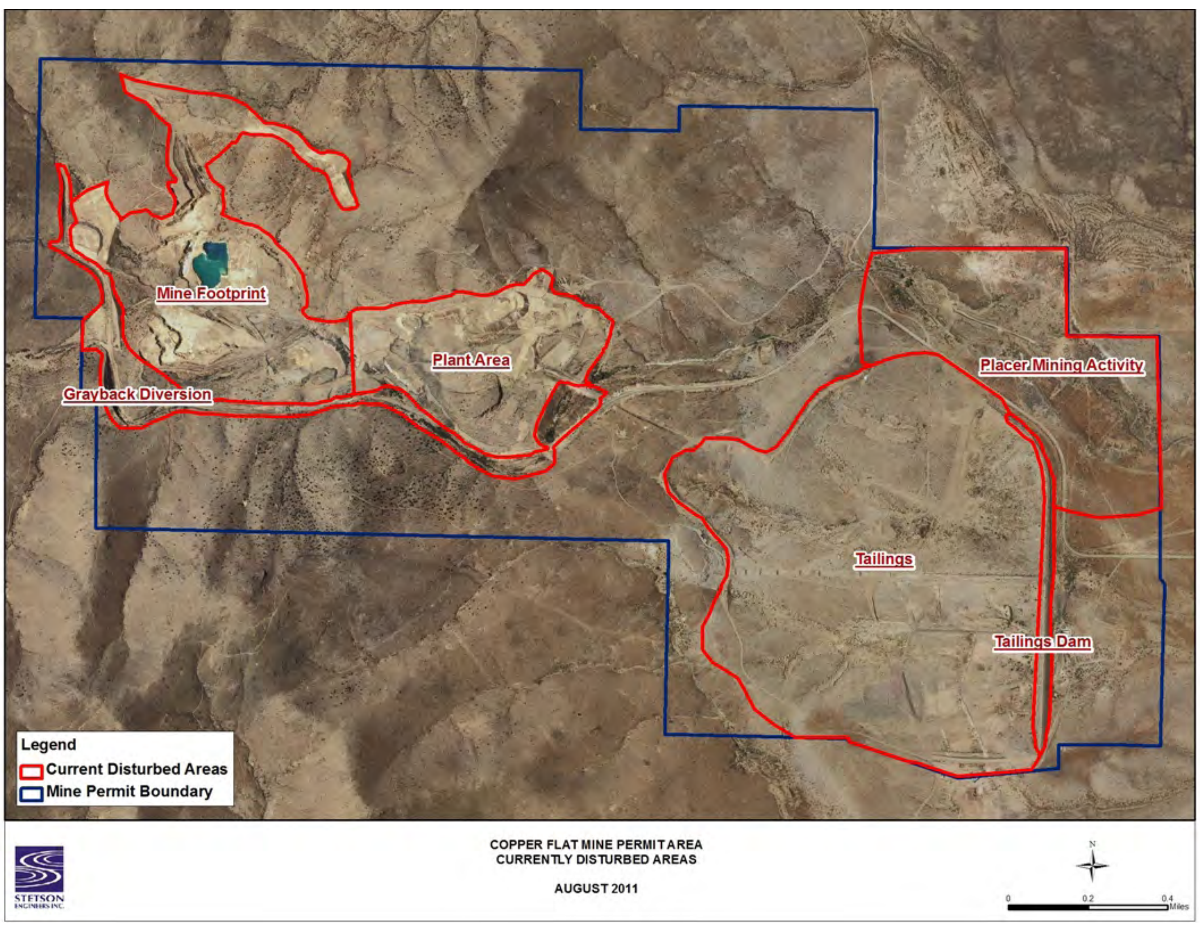
1.0 Introduction

Quintana Minerals Corporation developed and briefly operated a porphyry copper mine in the early 1980s. THEMAC Resources Group, Ltd. is evaluating resuming mining and milling operations, and is developing the materials required to obtain the permit to resume operations. The permit area includes about 2000 acres (Figure 1). The existing tailings storage facility occupies about 500 acres on the east end of the permit area. The mine, plant and Grayback Arroyo diversion occupies about 350 acres on the west end of the permit area, consisting of the pit and several levels of constructed benches containing no source of topdressing materials.

Grayback Arroyo has been diverted south of the mine, rejoining the original course east of the mine proper. Several placer gold claims have been active on Grayback Arroyo, and much of the flood plain and lower terraces have been disturbed and spoils piles are found throughout the Wash in the permit area. Some claims were also active within the current tailings storage facility area, and spoils piles are common along small arroyos and ephemeral drainage features. The tailings storage facility was reclaimed with topdressing materials.

Figure 1 Copper Flat Mine Permit Area
with Previously-Disturbed Areas Identified



The Sierra County Area, New Mexico Soil Survey (Soil Survey Staff, 1983) is in MLRA 42, Southern Desertic Basins, Plains, and Mountains. An Order 3 survey, mapped at a scale of 1:48,000 (1.3 miles/inch) exists for the portion of the county where the permit area is located (Appendix A). This level of detail maps primarily at the association or consociation level. The smallest unit that can be shown on a map at this scale is about 25 acres. Soil consociations are named after the dominant soil, and may include up to 25 percent of unnamed soils that do not significantly affect management, or 15 percent of unnamed soils that would alter management practices. Associations contain two or more soils occurring in repeatable patterns that could be mapped at the given scale, and that differ in morphology or management. Associations may include up to 25 percent of unnamed soils that do not affect the management, or 15 percent of unnamed soils that would alter management practices. Four map units occur within the permit area.

The soils on the east end near Grayback and Greenhorn Arroyos generally formed in mixed gravelly alluvium, on gently sloping talf (flat plain) and treads (terraces) of fan piedmonts. All soils are deep and well-drained. Most of the soils have calcic horizons at some depth with varying calcium carbonate contents. Some of the soils have argillic horizons (and higher clay contents), and hold more plant available water. Most of the soils are nonsaline and nonsodic. Most soils have greater coarse fragment (cobbles and/or gravel) content in the lower horizons than in the A horizon. The soils in Grayback and Greenhorn Arroyos formed in mixed alluvium on nearly level to gently sloping floodplains and stream terraces. These landscape positions are younger and less stable so the soils tend to show less morphological development than those on the fan piedmont talf and treads. The soils in the west portion of the permit area formed on limestone or igneous residuum and colluvium, and tend to be steeper and shallow over bedrock, with rock outcrops.

These materials were 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. The purpose of this survey was to identify areas that are potential topdressing sources, so areas without such potential were excluded from further evaluation. The Order 2 Soil Survey identified 12 map units, of which several were identified for closer examination in the Order 1 Soil 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. Transects extended beyond the boundaries of the Order 2 map units to identify their extent. There were 183 log sites chosen along these transects. The majority of the log sites were in the east end of the permit area where the landscape has lesser slopes, where there was a greater likelihood that suitable topdressing materials existed. Approximately 80 log sites were described outside the tailings storage facility, 70 inside it, and 30 on the west end around the mine. No protocol was necessary for identifying materials below free water or a water table, as neither was present on surveyed areas during sampling in June and July, 2011.

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 (Soil Survey Staff, 1996). Backhoe pits were dug at 19 sites, and 2 pits were dug by hand (on BLM land) for pedon description and sample collection.

Descriptions of soil profiles (pedons) followed standard NRCS Soil Survey Staff protocols (Soil Survey Staff, 1996). External attributes were recorded: Location, physiography, relief, slope, aspect, parent material, indications of salt or alkali, moisture, stoniness, presence of shallow groundwater, erosion, and vegetation. These characteristics were recorded for each horizon: Depth, boundaries, dry and moist colors, texture by feel, structure, consistence, visual estimate of gravel and cobbles, effervescence, presence of roots, and presence of redoximorphic features, illuvial clays, carbonate accumulations, gypsum accumulations, and/or other features, when present. 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.

The standard (Tier 1) lab tests included: USDA soil texture (sand, silt and clay percentages, Schoenberger et al., 2002) using the 6-hr hydrometer method (Gee and Orr, 2002), pH (Thomas, 1996), electrical conductivity on an extract of a saturated paste (ECe, Rhoades, 1996), calcium, magnesium, sodium (SPAC, 1999), and sodium adsorption ratio (Sumner and Miller, 1996). Additional tests conducted on specified samples included soil organic matter by loss on ignition (Nelson and Sommers, 1996), nitrate-nitrogen (USEPA, 1978a), phosphorus (USEPA, 1978b), calcium carbonate equivalent (Loeppert and Suarez, 1996), and sand size fraction (Gee and Orr, 2002). Samples inside the tailings facility or mine were screened (Tier 2) for arsenic (As), boron (B), cadmium (Cd), calcium (Ca), copper (Cu), iron (Fe), magnesium (Mg), manganese (Mn), molybdenum (Mo), potassium (K), nickel (Ni), sodium (Na), sulfur (S), and zinc (Zn) using an acid extraction (USEPA, 1996) and ICP detection (USEPA, 2007a), and chloride (Cl) (APHA, 2005), mercury (Hg) (USEPA, 2007b), selenium (Se) (Huang and Fujii, 1996), and acid-base potential which includes total sulfur (Tabatabai, 1996) and neutralization potential (Lawrence and Wang, 1997). Plant available fractions were determined with AB-DTPA extraction and ICP detection (SPAC , 1999).

Characterization of these profiles resulted in the selection of a representative profiles for each of the twelve taxonomic units, described in detail in Section 3.2.1 of this report. Those twelve taxonomic units were further subdivided into map units based upon the thickness of suitable topdressing material. The thickness of suitable material is indicated in each depth phase was represented as an addendum to the map unit symbol as follows:

-1 0 to 2 feet;
-2 2 to 4 feet;
-3 4 to 8 feet;
-4 8 to 12 feet;
-5 12 to 16 feet.

Map units are described in Section 3.2.2.

2.0 Determination of Suitability for Topdressing Material

2.1 Factors affecting Topdressing Suitability

Several factors may affect the suitability of soil materials for use as topdressing during reclamation. Steep slopes limit harvesting topdressing materials due to increased erosion potential and the difficulty in establishing vegetation to restabilize the slope. Soil texture, the relative amount of sand, silt, and clay, affects water available to plants (available water holding capacity, AWHC), rate of water movement into and through the soil, and seed-soil contact during germination. Cobbles and gravel decrease the total porosity, thereby decreasing the available water holding capacity. Cobbles and stones affect agricultural management equipment, though that is not an issue for this project. Stones decrease the available water holding capacity and increase the difficulty in harvesting and spreading the topdressing materials. Calcium carbonate accumulations are common in semiarid and arid regions as caliche, which limits nutrient availability, affects hydraulic properties, and may limit root growth at high concentrations. The available water holding capacity determines how much water a soil can hold against gravity and release to a plant. Soil pH affects nutrient availability, especially for micronutrients. Salinity competes with plant roots for water in the soil, decreasing the effective plant available water. Sodium has little impact on plants, but as a dispersing cation degrades soil structure and alters water movement into and through the soil. Selenium toxicity in range plants is rare, but there are accounts of selenium toxicity to livestock. Boron at high concentrations may be toxic to some plants. Acid/base accounting is a common practice for the reclamation of mine spoils.

New Mexico Mining and Minerals Division required additional soil tests that are not addressed in the suitability criteria, but that will be discussed with the presentation of the soil test results.

2.2 Criteria for Topdressing Suitability

Three suitability categories were identified: Good, fair, and unsuitable. Each pedon included in this report received a good or fair rating, though materials below the suitable materials may be unsuitable. Areas identified in the Order 2 and Order 1 surveys that had no suitable materials are not included in this report.

The suitability criteria standards for these soil and landscape features (Table 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 Mine permit area.

Table 1 Soil and Site Evaluation as Source for Topdressing[1], Copper Flat Mine[2], New Mexico

Soil/Landscape Property	Limits			Restrictive Feature
	Good	Fair	Unsuitable	
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

1. Topdressing: Soil material suitable for use as cover material and plant establishment. It may or may not be near the soil surface.
2. These guidelines apply only to the Copper Flat Mine project area, so soil parameters that do not exist within this project site are not incorporated into this table.

2.2.1 Explanation of Limits of Acceptability (Table 1)

Slope affects the ability to harvest the topdressing materials, and the ability to reclaim the harvested area. Steep slopes at Copper Flat Mine typically have shallow soils over bedrock and sparse vegetation. Removing the topsoil and vegetation would increase the potential to erode the remaining materials, and make stabilizing the remaining surface difficult because of difficulties in establishment of replacement vegetation. Areas with slopes less than 15 percent are classified as good, while slopes greater than 25 percent are unsuitable.

Soil texture has two extremes. Soils with too much sand are coarse, hold little plant available water, and do not provide a good media for seed germination. Coarse-textured soils are too sandy, and are unsuitable. Clay soils have such small pores that water movement through them is very slow, creating problems with infiltration, permeability and drainage, which may limit oxygen to the plant root zone. When dry, clay soils are hard, limiting root extension. Fine-textured soils are too clayey, and are unsuitable. Moderately-coarse and moderately-fine textured soils have fair suitability Medium-textured soils have good suitability.

Cobble (3- to 10-in diameter) and gravel (2-mm to 3-in diameter) content, or coarse fragments, primarily affect available water holding capacity at Copper Flat Mine. The Soil Taxonomy (Soil Survey Staff, 2010) and USDA limits (Schoenberger et al., 2002) for texture modifiers are used. Very gravelly or cobbly soils are skeletal (>35% rock fragments) and have fair suitability, while soils with greater than 60 percent coarse fragments are unsuitable. The upper limit is somewhat conservative, as soils with 70 percent gravel/cobble content and texture of loam or finer remain suitable for available water holding capacity. Several healthy vegetative communities currently exist on soils with high gravel content at Copper Flat Mine (Figure 2).

Figure 2 Vegetative Community with Gravel Content (2a) >55% and (2b) 70%.

2a.

2b.

Stones (10- to 25-in diameter) increase the difficulty in harvesting the materials, uniformly spreading the materials during reclamation, and in reseeding and revegetation. Soils with greater than 15 percent stones, the USDA modifier limit (Schoenberger et al., 2002) for stony textures, are unsuitable.

Calcium carbonate buffers the soil pH to slightly to moderately alkaline and limits availability of micronutrient metals to plants. These carbonates have very fine particle size, and at high concentrations may plug soil pores, limiting water movement through the soil. Many semiarid and most arid region soils have calcium carbonate accumulations. Calcic horizons (Soil Survey Staff, 2010) are classified when the secondary calcium carbonate accumulation in a horizon reaches 15 percent. At 40 percent, plugging of the pores in calcic horizons occurs. At this stage, root growth into the horizon becomes limited, and roots may be observed growing horizontally along the upper horizon boundary. Many thriving plant communities exist on soils with calcic horizons of less than 40 percent calcium carbonate (Figure 3). Using topdressing materials with high calcium carbonate concentrations would limit seedling germination and plant growth, so anything with greater than 40 percent calcium carbonate equivalent is unsuitable.

Figure 3 Vegetative Community with (3a) Calcic/Petrocalcic Horizon and (3b) >40% Gravel Content Over Strong Calcic Horizon.

3a. 3b.

Available water holding capacity (AWHC) in a native soil is primarily a function of soil organic matter, structure, texture, and depth, and is secondarily affected by coarse fragment content and salinity. The impact of soil structure is difficult to assess in the field, so field estimates of AWHC use the texture, depth, and gravel/cobble content of each horizon. This may be adjusted for salinity if lab results reveal it necessary. Since these materials will be harvested and used for topdressing materials, the total profile AWHC (inches) is not important, so the weighted average AWHC (in/in) for the suitable materials is used. Soils with less than 0.05 in/in are prone to drought and have difficulty sustaining healthy plant communities.

The primary impact of soil pH is on plant nutrient availability. Nutrient availability is extremely limited in strongly alkaline soils (pH ≥8.5), so such soils are unsuitable.

Salts compete with plants for water, so salinity limits plant growth, and especially affects seed germination and seedling growth. The conductivity of the soil saturated-paste extract (ECe) is a measure of the salinity. Many arid region plants are tolerant to slightly saline soils (4 ≤ ECe < 8 dS/m), but growth of most plants is affected at higher salinity levels. Unsuitable soils have salinity in of 8 dS/m or greater.

Sodium is not an issue for plants, but for soil. High concentrations of sodium ions disperse soil particles, resulting in plugging of pores and reductions in movement of water into and through the soil. Calcium and magnesium are flocculating ions and will partially mitigate the impact of sodium ions. The sodium adsorption ratio (SAR) considers the concentration of sodium relative to calcium and magnesium. Sodic soils have an SAR > 13. Soluble salts in the soil solution mitigate the sodium impact. Therefore, the effect of sodium on the soil must be considered in the context of the salinity level. Unsuitable soils have an SAR greater than five times the salinity (ECe).

Selenium and boron may be toxic to plants, but research regarding soil test levels associated with toxicity thresholds is limited. Selenium may accumulate in livestock grazing on plants growing on seleniferous soils, which average 4 to 5 ppm Se (Barker and Pilbeam, 2007). The available boron levels in most soils ranges from 0.5 to 5 ppm, which are not considered toxic (Barker and Pilbeam, 2007). The laboratory detection limit for boron in these samples was 6 ppm.

The acid/base potential considered the acid-forming potential of the total sulfur versus the acid neutralization potential of the calcium carbonate. Soils with high acid-forming potential are unsuitable, as they would require excessive amounts of lime during reclamation.

3.0 Description of the Soils

3.1 Explanation of Format

This section presents a detailed description of each type of soil mapped in the Order 1 Soil Survey (Table 2). The first section (Section 3.1.1, Soil Profile Descriptions of Taxonomic Units) is a technical profile description taken at a representative location of each named soil. This includes a discussion of the entire range of properties that occur within all areas mapped as that named soil. These descriptions are in conformance with the format and standards used in the National Cooperative Soil Survey Program (Soil Survey Staff, 1996).
The next section (Section 3.1.2, Soil Map Unit Descriptions) is a relatively brief discussion of the properties of each map unit. The soil taxonomic units were subdivided (according to depth) into map units which represent specific depth ranges of suitable material as it occurs in the project area. For example, the Typic Haplocambid soil ranges in depth from a few feet of suitable material up to several feet. In order to accurately quantify the volume of suitable topdressing material, it is necessary to map this soil in discreet units according to the thickness that material. Consequently, this soil was mapped as four distinct map units. Five depth phases were used in this report:

Depth phase	Depth range
-1	0 to 2 feet;
-2	2 to 4 feet;
-3	4 to 8 feet;
-4	8 to 12 feet;
-5	12 to 16 feet.

3.1.1. Soil Profile Descriptions of Taxonomic Units

All taxonomic units listed in Table 2 have suitable topdressing materials. Table 3 summarizes the suitability and limiting factors for each of the taxonomic units for which the descriptions follow.

Table 2 Copper Flat Mine Soil Survey, Order 1 Soil Taxonomic Units, Representative Sites and Classification

Taxonomic Unit	Site	Map Units	Soil Classification
Argic Petrocalcid	BH13	104-1	fine, smectitic, thermic Argic Petrocalcids
Calcidic Argiustoll	BH21	105-1	fine, smectitic, thermic Calcidic Argiustolls
Haplic Torriarent, loamy-skeletal	BH20	112-3	loamy-skeletal, mixed, superactive, calcareous, thermic Haplic Torriarents
Haplic Torriarent, tailings substrata	BH14	103-1	fine-loamy, mixed, superactive, calcareous, thermic Haplic Torriarents
Pachic Argiustoll	BH17	107-3	fine-loamy, mixed, superactive, thermic Pachic Argiustolls
Typic Calciargid, fine	BH18	110-1	fine, smectitic, thermic Typic Calciargids
Typic Calciargid, fine-loamy	BH11	111-1	fine-loamy, mixed, superactive, thermic Typic Calciargids
Typic Haplargid, clayey-skeletal	BH12	106-1	clayey-skeletal, smectitic, thermic Typic Haplargids
Typic Haplargid, fine	BH22	102-1 102-2	fine, smectitic, thermic Typic Haplargids
Typic Haplocambid	BH08	101-2 101-3 101-4 101-5	fine-loamy, mixed, superactive, thermic Typic Haplocambids
Typic Torriorthent, calcareous	79P	109-3 109-4	loamy-skeletal, mixed, superactive, calcareous, thermic Typic Torriorthents
Typic Torriorthent, nonacid	BH04	108-4	loamy-skeletal, mixed, superactive, nonacid, thermic Typic Torriorthents

Table 3 Copper Flat Mine Topdressing Suitability by Taxonomic Unit after Mixing Horizons that Meet Suitability Criteria

Taxonomic Unit	Taxon	Suitability	Limiting Factors
Argic Petrocalcid	104	Fair	Too clayey, Cobble+gravel
Calcidic Argiustoll	105	Fair	Too clayey, Cobble+gravel, Excess lime
Haplic Torriarent, loamy-skeletal	112	Fair	Too clayey, Cobble+gravel, Excess lime
Haplic Torriarent, tailings substrata	103	Fair	Too clayey, Cobble+gravel
Pachic Argiustoll	107	Fair	Too clayey, salinity
Typic Calciargid, fine	110	Fair	Too clayey
Typic Calciargid, fine-loamy	111	Fair	Too clayey, Cobble+gravel, Excess lime
Typic Haplargid, clayey-skeletal	106	Fair	Too clayey, Cobble+gravel
Typic Haplargid, fine	102	Fair	Too clayey
Typic Haplocambid	101	Good	
Typic Torriorthent, calcareous	109	Fair	Too clayey, Cobble+gravel
Typic Torriorthent, nonacid	108	Fair	Cobble+gravel

Taxonomic Unit: **Argic Petrocalcid**
Soil Classification: **fine, smectitic, thermic Argic Petrocalcid**
Map Unit: **104-1**

Argic Petrocalcid soils are moderately deep, alluvial soils that occur on eroded fan terrace remnants in the east part of the permit area (below the dike). These soils typically have loam to loamy sand surface layers underlain by clay loam and/or clay with gravel and cobble content ranging up to 30 percent by volume.

Typical pedon: A representative pedon of Argic Petrocalcid soils is located between Grayback and Greenhorn Arroyos, in the eastern part of the permit area (Site BH-13, UTM NAD83 Zone 13S 266753E 3649720N). The soil was examined in a freshly-excavated backhoe pit. The profile and landscape are shown in Figure 4.

A - 0 to 3 inches; brown (7.5YR 4/4) loamy sand, dark brown (7.5YR 3/4) moist; single grain; loose, loose, non-sticky and non-plastic; common medium and fine roots; estimated 10% gravel by volume; noneffervescent; moderately alkaline (pH 7.9); clear smooth boundary.

Bt1 - 3 to 12 inches; yellowish red (5YR 4/6) cobbly sandy clay loam, dark reddish brown (5YR 3/4) moist; weak medium subangular blocky; slightly hard, friable, moderately sticky and moderately plastic; few coarse and common medium roots; common faint clay films; estimated 10% gravel and 20% cobble by volume; slightly effervescent; moderately alkaline (pH 7.9); clear wavy boundary.

Bt2 - 12 to 21 inches; red (2.5YR 4/6) clay, dark red (2.5YR 3/6) moist; strong fine and medium prismatic parting to strong fine and medium angular blocky; hard, friable, very sticky and very plastic; few coarse and fine and common medium roots; many distinct thick clay films; estimated 5% gravel and 1% cobble by volume; strongly effervescent; few threads of carbonates below 18 inches; moderately alkaline (pH 7.9); clear wavy boundary.

Bkk - 21 to 32 inches; very pale brown (10YR 8/2) gravelly loam, very pale brown (10YR 8/3) moist; weak medium subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; few fine roots; common (15%) fine masses plugging pores, estimated 20% small hard gravel-size caliche fragments, 20% gravel and 5% cobble by volume; violently effervescent; nearly continuous carbonate coatings on rock fragments; moderately alkaline (pH 8.0); gradual wavy boundary.

Bkk/Bkkm - 32 to 54 inches; pinkish white (7.5YR 8/2), pink (7.5YR 7/4) moist; 70% cemented petrocalcic, 30% Bkk materials as above.

Range in characteristics:

The organic matter in the surface horizon is 3.4 percent.
The ochric horizon (A) ranges in thickness from 3 to 5 inches.
The argillic horizon (Bt1, Bt2) ranges in thickness from 15 to 20 inches.
These soils have a calcic horizon and a petrocalcic horizon (cemented caliche).

The rock fragment content ranges from 10 to 30 percent by volume and is dominantly gravel. These soils are commonly noneffervescent to slightly effervescent at the surface and violently effervescent in the lower strata.

Figure 4 Argic Petrocalcid Representative Pedon (Site BH-13) Profile (4a) and Landscape (4b).

4a

4b

Taxonomic Unit: **Calcidic Argiustoll**
Soil Classification: **fine, smectitic, thermic Calcidic Argiustoll**
Map Unit: **105-1**

Calcidic Argiustoll soils are deep, alluvial soils that occur on eroded fan terrace remnants in the east part of the permit area (below the dike). These soils typically have loam to clay loam surface layers underlain by loam, clay loam and/or clay with gravel and cobble content ranging from 15 to 35 percent by volume in the upper 3 feet.

Typical pedon: A representative pedon of Calcidic Argiustoll soils is located south of Greenhorn Arroyo, in the eastern part of the permit area (Site BH-21, UTM NAD83 Zone 13S 266935E 3649121N). The soil was examined in a freshly-excavated backhoe pit. The profile and landscape are shown in Figure 5.

Desert pavement -1 to 0 inches

A - 0 to 8 inches; dark yellowish brown (10YR 3/4) sandy clay loam, dark brown (10YR 3/3) moist; weak medium subangular blocky; soft, very friable, slightly sticky and slightly plastic; common very fine, fine and medium roots; estimated 5% gravel by volume; strongly effervescent; slightly alkaline (pH 7.8); clear wavy boundary.

Btk1 - 8 to 17 inches; dark brown (7.5YR 3/4) gravelly clay loam, dark brown (7.5YR 3/3) moist; weak course prismatic parting to moderate medium subangular blocky; slightly hard, friable, moderately sticky and moderately plastic; common very fine and fine roots; few faint patchy clay films; estimated 20% gravel and 5% cobble by volume; strongly effervescent; few threads of carbonates; moderately alkaline (pH 7.9); clear wavy boundary.

Btk2 - 17 to 24 inches; yellowish red (5YR 4/6) clay, reddish brown (5YR 4/4) moist; moderate fine prismatic parting to moderate medium subangular blocky; moderately hard, friable, very sticky and very plastic; common very fine and fine roots; many continuous thin clay films on ped faces; estimated 10% gravel by volume; strongly effervescent; few threads of carbonates; moderately alkaline (pH 7.9); abrupt wavy boundary.

Bkk - 24 to 38 inches; white (7.5YR 9.5/1) sandy clay loam, pinkish white (7.5YR 8.5/2) moist; weak medium subangular blocky; soft, friable, slightly sticky and slightly plastic; many fine masses of carbonate plugging pores; estimated 10% gravel by volume; violently effervescent; nearly continuous carbonate coatings on rock fragments; moderately alkaline (pH 7.9); clear wavy boundary.

Bk1 - 38 to 67 inches; pinkish white (7.5YR 8/2) extremely gravelly clay loam, brown (7.5YR 5/4) moist; weak medium subangular blocky; soft, friable, moderately sticky and moderately plastic; common (15%) fine masses of carbonates; estimated 80% gravel by volume; violently effervescent; nearly continuous carbonate coatings on rock fragments; moderately alkaline (pH 7.9); clear wavy boundary.

Bk2 - 67 to 79 inches; pink (7.5YR 7/3) extremely gravelly clay loam, yellowish red (5YR 5/6) moist; weak medium subangular blocky; soft, friable, moderately sticky and moderately plastic; estimated 60% gravel and 10% cobble by volume; strongly effervescent; common carbonate coatings on rock fragments; moderately alkaline (pH 7.9); clear wavy boundary.

Range in characteristics:

The organic matter in the surface horizon is 3.5 percent.
The mollic horizon (A and upper part of argillic) ranges in thickness from 8 to 20 inches.
The argillic horizon (Btk1, Btk2) ranges in thickness from 6 to 16 inches.

The calcic horizon likely ranges in thickness from 10 to 20 inches. The calcic horizon is underlain by a horizon with somewhat stratified fine gravels with discontinuous lenses of calcic materials up to 2 inches thick at various depths.

The rock fragment content ranges from 0 to 30 percent by volume and is dominantly gravel. These soils are commonly strongly effervescent at the surface and violently effervescent in the lower strata.

Figure 5 Calcidic Argiustoll Representative Pedon (Site BH-21) Profile (5a) and Landscape (5b).

5a

5b

Taxonomic Unit: **Haplic Torriarent, loamy-skeletal**
Soil Classification: **loamy-skeletal, mixed, superactive, calcareous, thermic Haplic Torriarent**
Map Unit: **112-3**

Haplic Torriarent, loamy-skeletal soils are constructed soils that occur in the southwest portion of the existing tailings facility. These soils typically have loam to clay loam surface layers underlain by clay loam with gravel and cobble content ranging from 10 to 40 percent by volume.

Typical pedon: A representative pedon of Haplic Torriarent soils is located west of the dike in the existing tailings facility (Site BH-20, UTM NAD83 Zone 13S 266082E 3649215N). The soil was examined in a freshly-excavated backhoe pit. The profile and landscape are shown in Figure 6.

A - 0 to 6 inches; yellowish brown (10YR 5/4) gravelly sandy clay loam, dark yellowish brown (10YR 4/4) moist; moderate, medium platy; soft, very friable, moderately sticky and moderately plastic; common very fine, fine and medium roots; estimated 25% gravel and 5% cobble by volume; violently effervescent; moderately alkaline (pH 7.9); clear smooth boundary.

C1 - 6 to 35 inches; yellowish brown (10YR 5/4) and light gray (10YR 7/2) very cobbly sandy clay loam, brown (7.5YR 4/4) and pale brown (10YR 6/3) moist; weak medium subangular blocky; slightly hard, friable, moderately sticky and moderately plastic; few fine and very fine roots; estimated 20% gravel and 20% cobble by volume; violently effervescent; moderately alkaline (pH 8.0); abrupt wavy boundary.

C2 - 35 to 52 inches; yellowish brown (10YR 5/4) very cobbly sandy clay loam, dark brown (7.5YR 3/3) moist; weak medium subangular blocky; very hard, very firm, moderately sticky and moderately plastic; few fine roots; estimated 20% gravel and 20% cobble by volume; violently effervescent; slightly alkaline (pH 7.8); clear smooth boundary.

C3- 52 to 84 inches; pink (7.5YR 7/3) and reddish brown (5YR 4/4) gravelly sandy clay loam, brown (7.5YR 5/3) and reddish brown (5YR 4/4) moist; weak medium subangular blocky; very hard, very firm, moderately sticky and moderately plastic; estimated 12% gravel and 5% cobble by volume; parts of matrix violently effervescent, others slightly effervescent; moderately alkaline (pH 7.9); clear smooth boundary.

C4 - 84 to 110 inches; brown (7.5YR 5/4) and reddish brown (5YR 4/4) clay loam, reddish brown (5YR 4/3) and dark reddish brown (5YR 3/3) moist; weak medium subangular blocky; soft, very friable, slightly sticky and slightly plastic; few medium roots; few soft carbonate masses; estimated 5% gravel and 5% cobble by volume; violently effervescent; slightly alkaline (pH 7.8).

Range in characteristics:

The organic matter in the surface horizon is 2.4 percent.
The ochric horizon (A) ranges in thickness from 2 to 10 inches.
There is little or no pedogenic development in these constructed soils. There are several thin to discontinuous calcic lenses below 6 inches created during construction. Much of the materials between 35 and 84 inches are highly compacted.

The rock fragment content ranges from 20 to 40 percent by volume and is dominantly gravel. These soils are commonly strongly to violently effervescent throughout.

Figure 6 Haplic Torriarent, Loamy-Skeletal Representative Pedon (Site BH-20) Profile (6a) and Landscape (6b).

6a

6b

Taxonomic Unit: **Haplic Torriarent, tailings substrata**
Soil Classification: **fine-loamy, mixed, superactive, calcareous, thermic Haplic Torriarent**
Map Unit: **103-1**

Haplic Torriarent soils are deep, constructed soils that occur in the existing tailings storage facility in the east part of the permit area (inside the dike). These soils were constructed circa 1986 during reclamation of the tailings facility. These soils typically have 10 to 40 inches of sandy loam to loam to clay loam surface layers underlain by tailings of very fine sandy loam to sandy loam to loam, with gravel and cobble content above the tailings ranging from 15 to 35 percent by volume. Tailings north of the east-west berm show evidence of being limed.

Typical pedon: A representative pedon of Haplic Torriarent, tailings substrata soils is located west of the dike in the eastern part of the permit area (Site BH-14, UTM NAD83 Zone 13S 266373E 3649855N). The soil was examined in a freshly-excavated backhoe pit. The profile and landscape are shown in Figure 7.

A - 0 to 12 inches; brown (7.5YR 5/3) sandy clay loam, brown (7.5YR 4/3) moist; weak medium subangular blocky; hard, friable, moderately sticky and moderately plastic; common very fine, fine and medium roots; estimated 20% gravel and 5% cobble by volume; strongly effervescent; slightly alkaline (pH 7.8); abrupt smooth boundary.

C1 – 12 to 20 inches; light gray (2.5Y 7/2) fine sandy loam, light olive brown (2.5Y 5/3) moist; massive; slightly hard, very friable, slightly sticky and slightly plastic; few very fine, common fine and coarse roots; slightly effervescent; moderately alkaline (pH 8.0); gradual smooth boundary.

C2 - 20 to 60 inches; pale brown (2.5Y 7/4) fine sandy loam, light olive brown (2.5Y 5/4) moist; massive; slightly hard, very friable, slightly sticky and slightly plastic; few very, common fine and coarse roots; noneffervescent; slightly alkaline (pH 7.8).

Range in characteristics:

The organic matter in the surface horizon is 1.9 percent.
The ochric (A) horizon ranges in thickness from 4 to 12 inches.

The rock fragment content ranges from 15 to 35 percent by volume and is dominantly gravel. These soils are commonly strongly effervescent at the surface and slightly effervescent to noneffervescent in the tailings, likely dependent upon amendments during reclamation.

Figure 7 Haplic Torriarent, Tailings Substrata Representative Pedon (Site BH-14) Profile (7a) and Landscape (7b,c).

7a

7b

7c

Taxonomic Unit: **Pachic Argiustoll**
Soil Classification: **fine-loamy, mixed, superactive, thermic Pachic Argiustoll**
Map Unit: **107-3**

Pachic Argiustoll soils are deep, alluvial soils that occur in valleys between fan terrace remnants in the east part of the permit area, and in a valley in the northwest part of the permit area, north of the mine. These soils typically have loam to gravelly sandy loam surface layers underlain by loam, clay loam and/or clay with gravel and cobble content ranging up to 15 percent by volume in the upper 4 feet. Some areas have an overburden of up to 6 inches of recent deposits.

Typical pedon: A representative pedon of Pachic Argiustoll soils is located about midway between Greenhorn and Grayback Arroyos, in the eastern part of the permit area (Site BH-17, UTM NAD83 Zone 13S 266625E 3649602N). The soil was examined in a freshly-excavated backhoe pit. The profile and landscape are shown in Figure 8.

A1 - 0 to 6 inches; brown (7.5YR 5/4) loam, brown (7.5YR 4/4) moist; weak medium subangular blocky; slightly hard, friable, slightly sticky and moderately plastic; many very fine and common medium roots; estimated <1% gravel by volume; strongly effervescent; slightly alkaline (pH 7.8); abrupt smooth boundary.

A2 - 6 to 14 inches; brown (10YR 4/3) clay loam, dark brown (10YR 3/3) moist; moderate medium subangular blocky parting to moderate medium granular; hard, friable, slightly sticky and moderately plastic; common fine and few medium and coarse roots; estimated <1% gravel by volume; noneffervescent; slightly alkaline (pH 7.8); clear smooth boundary.

Bt - 14 to 29 inches; brown (10YR 4/3) clay loam, dark brown (10YR 3/3) moist; weak medium prismatic parting to moderate medium angular blocky; hard, friable, moderately sticky and moderately plastic; common very fine and few fine and medium roots; common thick clay films on ped faces; estimated <1% gravel by volume; noneffervescent; slightly alkaline (pH 7.7); gradual smooth boundary.

Bk - 29 to 40 inches; brown (7.5YR 5/4) clay loam, brown (7.5YR 4/4) moist; weak medium angular blocky; hard, friable, moderately sticky and moderately plastic; few threads of carbonates on ped faces; estimated <1% gravel by volume; violently effervescent; slightly alkaline (pH 7.8); abrupt smooth boundary.

Btkb - 40 to 58 inches; brown (7.5YR 4/3) sandy clay loam, dark brown (7.5YR 3/4) moist; weak medium angular blocky; hard, friable, very sticky and moderately plastic; few thin clay films on ped faces; few threads of carbonates on ped faces; estimated <1% gravel by volume; strongly effervescent; moderately alkaline (pH 8.1); clear smooth boundary.

Bkkb - 58 to 80 inches; pinkish white (7.5YR 8/2) clay loam, light brown (7.5YR 6/4) moist; massive; extremely hard, friable, moderately sticky and moderately plastic; many fine masses of carbonate plugging pores; estimated <1% gravel by volume; violently effervescent; moderately alkaline (pH 8.0).

<u>Range in characteristics:</u>

The organic matter in the surface horizon is 3.9 percent.
The mollic horizon (A and upper part of argillic) ranges in thickness from 20 to 26 inches.
The argillic horizon (Bt) ranges in thickness from 15 to 37 inches.
The calcic horizon (Bkkb), when present, ranges in thickness from 10 to 22 inches.

The rock fragment content ranges from 0 to 15 percent by volume and is dominantly gravel. The gravel/cobble content below 4 feet ranges up to 45 percent. These soils commonly are noneffervescent in the surface or buried horizon, strongly effervescent in overburden material at surface, and violently effervescent in the lower strata. Some horizons in some areas are slightly saline and one horizon was sodic.

Figure 8 Pachic Argiustoll Representative Pedon (Site BH-17) Profile (8a) and Landscape (8b).

8a	8b
	

Taxonomic Unit: **Typic Calciargid, fine**
Soil Classification: **fine, smectitic, thermic Typic Calciargid**
Map Unit: **110-1**

Typic Calciargid soils are deep, mixed alluvial and colluvial soils that occur on fan terrace remnants in the southwest part of the tailings facility. These soils typically have gravelly loam to sandy clay loam surface layers underlain by clay loam to sandy clay loam with gravel and cobble content ranging up to 20 percent by volume in the upper 3 feet.

Typical pedon: A representative pedon of Typic Calciargid soils is located about in the southwest part of the tailings facility (Site BH-18, UTM NAD83 Zone 13S 265680E 3649473N). The soil was examined in a freshly-excavated backhoe pit. The profile and landscape are shown in Figure 9.

A - 0 to 7 inches; brown (10YR 5/3) sandy clay loam, dark brown (10YR 3/3) moist; moderate medium subangular blocky parting to moderate fine subangular blocky; slightly hard, friable, slightly sticky and moderately plastic; many very fine, fine and medium roots; estimated 5% gravel by volume; strongly effervescent; moderately alkaline (pH 8.0); clear smooth boundary.

Btk - 7 to 24 inches; brown (7.5YR 5/4) gravelly sandy clay loam, brown (7.5YR 4/4) moist; moderate fine angular blocky; hard, firm, moderately sticky and moderately plastic; many very fine and fine, and common medium roots; few thin clay films on ped faces; common soft carbonate masses; estimated 15% gravel and 5% cobble by volume; violently effervescent; moderately alkaline (pH 7.9); clear smooth boundary.

Bkk - 24 to 64 inches; white (10YR 8/1) sandy clay loam, light gray (10YR 7/2) moist; massive; slightly hard, very friable, very sticky and moderately plastic; few very fine roots; estimated 5% gravel and 5% cobble by volume; violently effervescent; slightly alkaline (pH 7.8); abrupt smooth boundary.

R – 64 inches; carbonate encrusted andesite.

Range in characteristics:

The organic matter in the surface horizon is 2.9 percent.
The ochric horizon (A) ranges in thickness from 7 to 9 inches.
The argillic horizon (Btk) ranges in thickness from 15 to 37 inches.
The calcic horizon (Bkk) ranges in thickness from 20 to 40 inches.

The rock fragment content ranges up to 15 percent by volume and is dominantly gravel. These soils commonly are strongly to violently effervescent throughout the profile. Some areas slightly saline horizons below 9 inches.

Figure 9 Typic Calciargid, Fine Representative Pedon (Site BH-18) Profile (9a) and Landscape (9b,c).

9a

9b

9c

Taxonomic Unit: **Typic Calciargid, fine-loamy**
Soil Classification: **fine-loamy, mixed, superactive, thermic Typic Calciargid**
Map Unit: **111-1**

Typic Calciargid, fine-loamy soils are deep, colluvial soils that occur on fan terrace remnants in the northwest part of the tailings facility. These soils typically have gravelly loam to very gravelly sandy loam surface layers underlain by loam to clay loam with gravel and cobble content ranging from 15 to 35 percent by volume in the upper 5 feet.

Typical pedon: A representative pedon of Typic Calciargid soils is located about in the northwest part of the tailings facility (Site BH-11, UTM NAD83 Zone 13S 266006E 3649936N). The soil was examined in a freshly-excavated backhoe pit. The profile and landscape are shown in Figure 10.

A1 - 0 to 3 inches; dark yellowish brown (10YR 4/4) gravelly loam, dark brown (10YR 3/3) moist; weak medium subangular blocky parting to moderate fine granular; soft, very friable, slightly sticky and slightly plastic; many very fine and fine roots; estimated 15% gravel and 5 % cobble by volume; violently effervescent; moderately alkaline (pH 8.2); abrupt smooth boundary.

A2 – 3 to 10 inches; dark yellowish brown (10YR 4/4) sandy clay loam, dark brown (10YR 3/3) moist; moderate medium subangular blocky; slightly hard, friable, moderately sticky and moderately plastic; common very fine, fine and medium roots; estimated 5% gravel and 5 % cobble by volume; violently effervescent; moderately alkaline (pH 8.2); clear smooth boundary.

Btk1 - 10 to 17 inches; yellowish red (5YR 5/6) gravelly clay loam, yellowish red (5YR 4/6) moist; moderate fine angular blocky; moderately hard, friable, moderately sticky and moderately plastic; few very fine roots; common moderately thick clay films on ped faces; estimated 10% gravel and 5% cobble by volume; violently effervescent; slightly alkaline (pH 7.8); clear smooth boundary.

Btk2 - 17 to 26 inches; pink (7.5YR 7/3) gravelly sandy clay loam, brown (7.5YR 5/4) moist; moderate fine angular blocky; soft, very friable, moderately sticky and moderately plastic; few very fine and medium roots; few thin clay films on ped faces; estimated 10% gravel and 10% cobble by volume; violently effervescent; slightly alkaline (pH 7.8); clear irregular boundary.

Bkk - 26 to 57 inches; white (7.5YR 9.5/1) gravelly loam, pinkish white (7.5YR 8/2) moist; weak moderate angular blocky; slightly hard, friable, moderately sticky and moderately plastic; violently effervescent; moderately alkaline (pH 8.3).

Range in characteristics:

The organic matter in the surface horizon is 3.3 percent.
The ochric horizon (A) ranges in thickness from 2 to 10 inches.
The argillic horizon (Btk1, Btk2) ranges in thickness from 10 to 26 inches.
The calcic horizon (Bkk) ranges in thickness from 20 to 40 inches.

The rock fragment content ranges from 15 to 35 percent by volume and is dominantly gravel. These soils commonly are violently effervescent throughout the profile.

Figure 10 Typic Calciargid, Fine-Loamy Representative Pedon (Site BH-11) Profile (10a) and Landscape (10b,c).

10a

10b

10c

Taxonomic Unit: **Typic Haplargid, clayey-skeletal**
Soil Classification: **clayey-skeletal, smectitic, thermic Typic Haplargid**
Map Unit: **106-1**

Typic Haplargid, clayey-skeletal soils are deep, alluvial soils that occur on fan terrace remnants in the northeast part of the permit area, south of Grayback Arroyo, and in the west portion of the permit area, south of the Grayback Arroyo diversion. These soils typically have sandy loam to very gravelly loam surface layers underlain by clay loam and clay with gravel and cobble content ranging from 35 to 60 percent by volume in the upper 5 feet.

Typical pedon: A representative pedon of Typic Haplargid soils is located about in the northwest part of the tailings facility (Site BH-12, UTM NAD83 Zone 13S 266920E 3649973N). The soil was examined in a freshly-excavated hand-dug pit. The landscape is shown in Figure 11.

A1 - 0 to 5 inches; brown (7.5YR 4/4) sandy loam, dark brown (7.5YR 3/4) moist; weak medium and fine subangular blocky; soft, very friable, slightly sticky and slightly plastic; common very fine and fine roots; estimated 10% gravel and 1 % cobble by volume; noneffervescent; slightly alkaline (pH 7.7); clear wavy boundary.

Bt1 – 5 to 10 inches; yellowish red (5YR 4/6) very cobbly clay loam, dark reddish brown (5YR 3/4) moist; moderate medium prismatic parting to moderate fine subangular blocky; moderately hard, friable, moderately sticky and moderately plastic; many fine and common medium roots; many thin clay films on ped faces; estimated 20% gravel and 30 % cobble by volume; noneffervescent; slightly alkaline (pH 7.8); clear wavy boundary.

Bt2 - 10 to 24+ inches; red (2.5YR 4/6) very cobbly clay, dark red (2.5YR 3/6) moist; strong fine prismatic parting to strong fine and medium angular blocky; extremely hard, friable, moderately sticky and very plastic; few medium roots; many thick 2.5YR 3/4 clay films on ped faces; estimated 30% gravel and 30% cobble by volume; noneffervescent; slightly alkaline (pH 7.8).

Range in characteristics:

The organic carbon in the surface horizon is 3.4 percent.
The ochric horizon (A) ranges in thickness from 2 to 10 inches.
The argillic horizon (Btk1, Btk2) ranges in thickness from 18 to 32 inches.

The rock fragment content ranges from 35 to 60 percent by volume and is dominantly cobbles. These soils commonly are noneffervescent throughout the profile.

Figure 11 Typic Haplargid, Clayey-Skeletal Representative Landscape (11a,b).

11a

11b

Taxonomic Unit: **Typic Haplargid, fine**
Soil Classification: **fine, smectitic, thermic Typic Haplargid**
Map Unit: **102-1; 102-2**

Typic Haplargid, fine soils are deep, residual soils formed in weathering shale that occur on fan terrace remnants in the southeast part of the tailings facility and in the west part, south of the Grayback Arroyo diversion. These soils typically have loam to clay loam surface layers underlain by clay loam and clay with gravel and cobble content less than 1 percent by volume in the upper 4 feet.

Typical pedon: A representative pedon of Typic Haplargid soils is located about midway between Greenhorn and Greyback Arroyos, in the south part of the tailings facility, near the dike (Site BH-22, UTM NAD83 Zone 13S 266381E 3648924N). The soil was examined in a freshly-excavated backhoe pit. The profile and landscape are shown in Figure 12.

A1 - 0 to 13 inches; light brown (7.5YR 6/4) clay loam, brown (7.5YR 4/4) moist; moderate medium subangular blocky; slightly hard, friable, moderately sticky and moderately plastic; many very fine and common fine and medium roots; strongly effervescent; slightly alkaline (pH 7.8); clear smooth boundary.

Btk - 13 to 30 inches; light reddish brown (5YR 6/4) silty clay loam, reddish brown (2.5YR 4/4) moist; strong fine angular blocky; hard, friable, very sticky and moderately plastic; few fine and medium roots; common thin clay films on ped faces; few threads of carbonates on ped faces; violently effervescent; moderately alkaline (pH 8.1); clear smooth boundary.

Bt - 30 to 51 inches; reddish brown (2.5YR 5/4) clay, dark reddish brown (2.5YR 3/4) moist; strong medium angular blocky; very hard, firm, very sticky and very plastic; few very fine and fine roots; common thick clay films on ped faces; strongly effervescent; moderately alkaline (pH 8.0); gradual smooth boundary.

Cr - 51 to 90 inches; reddish brown (2.5YR 4/3) clay, dark reddish brown (2.5YR 3/4) moist; strong coarse angular blocky parting to strong fine angular blocky; extremely hard, firm, very sticky and very plastic; strongly effervescent; moderately alkaline (pH 7.9).

Range in characteristics:

The organic matter in the surface horizon is 3.1 percent.
The ochric horizon (A) ranges in thickness from 3 to 13 inches.
The argillic horizon (Bt) ranges in thickness from 36 to 48 inches.
The Cr is likely weathered shale with rock structure.

The rock fragment content is less than 10 percent by volume and is dominantly gravel. These soils commonly are strongly effervescent in the surface and violently effervescent in the lower strata.

Figure 12 Typic Haplargid, Fine Representative Pedon (Site BH-22) Profile (12a) and Landscape (12b).

12a	12b
	

Taxonomic Unit: **Typic Haplocambid**
Soil Classification: **fine-loamy, mixed, superactive, thermic Typic Haplocambid**
Map Units: **101-2; 101-3; 101-4; 101-5**

Typic Haplocambid soils are deep, alluvial soils that occur on terraces along drainageways in the northeast part of the permit area (below the dike) and in small isolated areas in the northwest part of the area. These soils typically have loam surface layers underlain by loam, sandy loam, silt loam, and/or sand, with gravel and cobble content ranging up to 35 percent by volume.

Typical Pedon: A representative pedon of Typic Haplocambid soils (Map unit 101-5) is located near Grayback Arroyo in the northeast part of the permit area (Site BH-8, UTM NAD83 Zone 13S 266516E 3650592N). The profile and landscape are shown in Figure 13.

A - 0 to 11 inches; yellowish brown (10YR 5/4) loam, dark yellowish brown (10YR 3/4) moist; weak thin play structure overlying weak medium and coarse subangular blocky; soft, very friable, slightly sticky and slightly plastic; many very fine and fine roots; slightly effervescent; moderately alkaline (pH 8.0); clear wavy boundary.

Bw1 – 11 to 18 inches; dark yellowish brown (10YR 4/4) gravelly sandy loam, dark yellowish brown (10YR 3/4) moist; weak coarse subangular blocky structure; soft, very friable, slightly sticky and slightly plastic; many very fine and fine roots; estimated 20% gravel and 5% cobble by volume; slightly effervescent; moderately alkaline (pH 8.0); clear wavy boundary.

Bw2 – 18 to 26 inches; brown (7.5YR 4/4) silt loam, dark brown (7.5YR 3/4) moist; weak medium prismatic parting to weak medium subangular blocky structure; slightly hard, friable, sticky and slightly plastic; common very fine and fine roots; slightly effervescent; moderately alkaline (pH 7.9); clear wavy boundary.

Bw3 – 26 to 34 inches; brown (7.5YR 4/4) sandy loam, dark brown (7.5YR 3/4) moist; weak coarse prismatic parting to weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common very fine and fine roots; slightly effervescent; moderately alkaline (pH 7.9); abrupt wavy boundary.

C1 – 34 to 46 inches; dark yellowish brown (10YR 4/4) very gravelly coarse sand, dark yellowish brown (10YR 3/4) moist; single grain; loose, loose, nonsticky and nonplastic; few medium and fine roots; estimated 40% gravel by volume; noneffervescent; slightly alkaline (pH 7.8); abrupt wavy boundary.

C2 – 46 to 63 inches; dark yellowish brown (10YR 3/6) sand, dark yellowish brown (10YR 3/4) moist; single grain; soft, very friable, nonsticky and nonplastic; few fine and medium roots; noneffervescent; slightly alkaline (pH 7.8); abrupt wavy boundary.

C3 – 63 to 87 inches; brown (10YR 5/3) coarse sand, brown (10YR 4/3) moist; single grain; loose, loose, nonsticky and nonplastic; few medium roots; noneffervescent; strongly alkaline (pH 8.5); abrupt wavy boundary.

C4 – 87 to 120+ inches; brown (7.5YR 5/4) gravelly coarse sand, brown (7.5YR 4/4) moist; single grain; loose, loose, nonsticky and nonplastic; estimated 30% gravel by volume; noneffervescent; strongly alkaline (pH 8.5).

Range in Characteristics:

The organic matter in the surface horizon is 2.1 percent.
The ochric horizon (A) ranges in thickness from 5 to 20 inches.
The cambic horizon (Bw) ranges in thickness from 20 to 40 inches.

The soil is quite variable within short distances in some areas due to alluvial deposition processes, as well as past mining activities. The rock fragment content ranges from 5 to 25 percent by volume and is dominantly gravel. These soils are commonly slightly effervescent to strongly effervescent in the upper part, and may be noneffervescent in some strata. The substrata of this soil range from sandy loam to light clay loam and may be as much as 16 feet thick.

Figure 13 Typic Haplocambid Representative Pedon (Site BH-8) Profile (13a) and Landscape (13b,c).

13a

13b

	13c 

Taxonomic Unit: **Typic Torriorthent, calcareous**
Soil Classification: **loamy-skeletal, mixed, superactive, calcareous, thermic Typic Torriorthent**
Map Units: **109-3; 109-4**

Typic Torriorthent, calcareous soils are deep, alluvial soils that occur on valley terraces and floors in the west part of the tailings facility and along Grayback Arroyo. These soils typically have sandy loam to loam to clay loam surface layers underlain by alluvial deposits with varying textures with gravel and cobble content ranging from 35 to 60 percent by volume.

Typical pedon: A representative pedon of Typic Torriorthent soils is located in a small valley in the central western part of the tailings facility (Site 79P, UTM NAD83 Zone 13S 265530E 3649854N). The soil was examined from an augered core. The landscape is shown in Figure 14.

A - 0 to 6 inches; brown (7.5YR 4/3) very gravelly loam, dark brown (7.5YR 3/3) moist; weak medium subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; common medium and coarse roots; estimated 40% gravel by volume; strongly effervescent; slightly alkaline (pH 7.8); clear smooth boundary.

C1 - 6 to 16 inches; reddish brown (5YR 5/4) gravelly clay loam, reddish brown (5YR 4/4) moist; massive; hard, friable, moderately sticky and moderately plastic; common medium and coarse roots; estimated 30% gravel by volume; strongly effervescent; slightly alkaline (pH 7.8); clear smooth boundary.

C2 -16 to 20+ inches; reddish brown (5YR 5/4) very gravelly clay loam, reddish brown (5YR 4/4) moist; massive; hard, friable, moderately sticky and moderately plastic; common medium and coarse roots; estimated 40% gravel by volume; strongly effervescent; moderately alkaline (pH 7.9).

Range in characteristics:

The organic matter in the surface horizon is about 3 percent.
The ochric horizon (A) ranges in thickness from 4 to 16 inches.

The soil is quite variable within short distances in some areas due to past disturbances and alluvial deposition processes. The rock fragment content ranges from 35 to 60 percent by volume and is dominantly gravel. These soils commonly are strongly effervescent in the surface and may be noneffervescent in the lower strata.

Figure 14 Typic Torriorthent, Calcareous Representative Pedon (Site 79P) Landscape (14a,b).

	14a 
	14b 

Taxonomic Unit: **Typic Torriorthent, nonacid**
Soil Classification: **loamy-skeletal, mixed, superactive, nonacid, thermic, Typic Torriorthent**
Map Unit: **108-4**

Typic Torriorthent, nonacid soils are deep, mixed alluvial soils that occur in upland valleys in the west part of the permit area. These soils typically have sandy loam to silt loam surface layers underlain by loam to clay loam with gravel and cobble content ranging up to 70 percent by volume.

Typical pedon: A representative pedon of Typic Torriorthent, nonacid soils is located near the west boundary of the permit area (Site BH-04, UTM NAD83 Zone 13S, 262726 E, 3650612 N). The soil was examined in a freshly excavated backhoe pit. The profile and landscape are shown in Figure 15.

A – 0 to 5 inches, yellowish brown (10YR 5/4) sandy loam, dark yellowish brown (10YR 4/4) moist; weak thin platy structure; slightly hard, friable, slightly sticky and slightly plastic; many very fine and common fine roots; estimated less than 5% gravel by volume; noneffervescent; slightly alkaline (pH 7.5); abrupt smooth boundary.

C1 – 5 to 15 inches, construction rubble; massive; hard, friable; few very fine, fine, and coarse roots; estimated 10% gravel and 60% cobble by volume; noneffervescent; slightly alkaline (pH 7.6); abrupt smooth boundary.

C2 – 15 to 49 inches, yellowish brown (10YR 5/4) extremely cobbly sandy loam, dark yellowish brown (10YR 3/4) moist; weak medium subangular blocky parting to moderate fine granular; hard, friable, slightly sticky and slightly plastic; many very fine roots; estimated 30% gravel and 30% cobble by volume; noneffervescent; slightly alkaline (pH 7.6); gradual smooth boundary.

C3 – 49 to 73 inches, brown (7.5YR 4/4) extremely cobbly sandy loam, dark brown (7.5YR 3/4) moist; massive; hard, friable, slightly sticky and slightly plastic; few very fine, fine and medium roots; estimated 35% gravel and 25% cobble by volume; noneffervescent; moderately alkaline (pH 7.9); gradual smooth boundary.

C4 – 73 to 110 inches, dark yellowish brown (10YR 4/4) extremely cobbly sandy loam, dark yellowish brown (10YR 3/4) moist; massive; hard, friable, slightly sticky and slightly plastic; few very fine, fine and medium roots; estimated 35% gravel and 25% cobble by volume; noneffervescent; slightly alkaline (pH 7.8).

Range in characteristics:

The organic matter in the C2 horizon is 2.8 percent.
The ochric horizon (A) ranges in thickness from 4 to 8 inches.

The rock fragment content ranges from 50 to 60 percent by volume and is dominantly gravel. These soils commonly are noneffervescent throughout the profile.

Figure 15 Typic Torriorthent, Nonacid Representative Pedon (Site BH-04) Profile (15a) and Landscape (15b).

15a	15b
	

3.2.2 Soil Map Unit Descriptions

Soil map unit descriptions are presented in numerical order. Note that the number of the map unit corresponds to the polygon labels presented on the soil map.

Table 4 Map Unit Legend

Taxon	Taxonomic Unit	Map Unit
101	Typic Haplocambid	101-2 101-3 101-4 101-5
102	Typic Haplargid, fine	102-1 102-2
103	Haplic Torriarent, tailings substrata	103-1
104	Argic Petrocalcid	104-1
105	Calcidic Argiustoll	105-1
106	Typic Haplargid, clayey-skeletal	106-1
107	Pachic Argiustoll	107-3
108	Typic Torriorthent, nonacid	108-4
109	Typic Torriorthent, calcareous	109-3 109-4
110	Typic Calciargid, fine	110-1
111	Typic Calciargid, fine-loamy	111-1
112	Haplic Torriarent, loamy-skeletal	112-3

Map Unit 101-2

This soil is identified as a Typic Haplocambid. The area mapped as this unit has 2 to 4 feet of suitable material. The median thickness of suitable topdressing is 3 feet.

This soil is medium-textured with relatively few rock fragments. The texture of the suitable material (after mixing) ranges from sandy loam to silt loam and light clay loam, with an average clay content of 18 to 35 percent.

It is underlain by strata that have high calcium carbonate contents (caliche) and that are unsuitable for topdressing.

Map Unit 101-3

This soil is identified as a Typic Haplocambid. The area mapped as this unit has 4 to 8 feet of suitable material. The median thickness of suitable topdressing is 6 feet.

This soil is medium-textured with relatively few rock fragments. The texture of the suitable material (after mixing) ranges from sandy loam to silt loam and light clay loam, with an average clay content of 18 to 35 percent.

It is underlain by unsuitable strata that have high calcium carbonate contents (caliche), high clay content and/or extremely high content of rock fragments.

Map Unit 101-4

This soil is identified as a Typic Haplocambid. The area mapped as this unit has 8 to 12 feet of suitable material. The median thickness of suitable topdressing is 10 feet.

This soil is medium-textured with relatively few rock fragments. The texture of the suitable material (after mixing) ranges from sandy loam to silt loam and light clay loam, with an average clay content of 18 to 35 percent.

It is likely underlain by bedrock and/or other unsuitable material that has an extremely high content of rock fragments.

Map Unit 101-5

This soil is identified as a Typic Haplocambid. The area mapped as this unit has 12 to 16 feet of suitable material. The median thickness of suitable topdressing is 14 feet.

This soil is medium-textured with relatively few rock fragments. The texture of the suitable material (after mixing) ranges from sandy loam to silt loam and light clay loam, with an average clay content of 18 to 35 percent.

The rock content is greater in the lower strata, but after mixing will average less than 25 percent gravel.

Map Unit 102-1

This soil is identified as a Typic Haplargid, fine. The area mapped as this unit has 6 inches to 2 feet of suitable material. The median thickness of suitable topdressing is 1 foot.

This soil is moderately fine-textured with rock fragments on the surface. The texture of the suitable material (after mixing) is clay loam, with an average clay content of 35 to 40 percent. After mixing, the rock fragment content will be less than 25 percent.

It is underlain by strata of unsuitable material with high clay content.

Map Unit 102-2

This soil is identified as a Typic Haplargid, fine. The area mapped as this unit has 2 to 4 feet of suitable material. The median thickness of suitable topdressing is 3 feet.

This soil is moderately fine-textured with almost no rock fragments. The texture of the suitable material (after mixing) is clay loam, with an average clay content of 35 to 40 percent.

It is underlain by strata of unsuitable material with high clay content.

Map Unit 103-1

This soil is identified as a Haplic Torriarent, tailings substrata. The area mapped as this unit has 10 to 40 inches of suitable material over tailings. The median thickness of suitable topdressing is 1 foot.

This soil is medium to moderately fine-textured with rock fragments in the surface foot. The texture of the suitable material (after mixing) ranges from loam to clay loam, with an average clay content of 25 to 35 percent. After mixing, the rock fragment content will be less than 25 percent.

It is underlain by tailings with unsuitable acid/base potential, and high plant available copper.

Map Unit 104-1

This soil is identified as an Argic Petrocalcid. The area mapped as this unit has 6 inches to 2 feet of suitable material. The median thickness of suitable topdressing is 1 foot.

This soil is moderately fine-textured with almost no rock fragments. The texture of the suitable material (after mixing) ranges from sandy clay loam to clay loam, with an average clay content of 30 to 35 percent.

It is underlain by partially to completely cemented strata of unsuitable material with high calcium carbonate content (caliche).

Map Unit 105-1

This soil is identified as a Calcidic Argiustoll. The area mapped as this unit has 6 inches to 3 feet of suitable material. The median thickness of suitable topdressing is 1 foot.

This soil is moderately fine-textured with some rock fragments. The texture of the suitable material (after mixing) ranges from loam to clay loam, with an average clay content of 25 to 35 percent. After mixing, the rock fragment content will be less than 25 percent.

It is underlain by unsuitable strata of material with high clay and/or calcium carbonate content.

Map Unit 106-1

This soil is identified as a Typic Haplargid, clayey-skeletal. The area mapped as this unit has 8 to 20 inches of suitable material. The median thickness of suitable topdressing is 1 foot.

This soil is medium to moderately fine-textured with up to 60 percent rock fragments. The texture of the suitable material (after mixing) is clay loam, with an average clay content of 28 to 40 percent. After mixing, the rock fragment content will be about 30 percent.

It is underlain by unsuitable strata with high clay content.

Map Unit 107-3

This soil is identified as a Pachic Argiustoll. The area mapped as this unit has 4 to 8 feet of suitable material. The median thickness of suitable topdressing is 6 feet.

This soil is medium-textured with relatively few rock fragments. The texture of the suitable material (after mixing) is loam to clay loam, with an average clay content of 25 to 35 percent. After mixing, the rock fragment content will be less than 15 percent.

It is underlain by unsuitable strata with high clay and calcium carbonate content.

Map Unit 108-4

This soil is identified as a Typic Torriorthent, nonacid. The area mapped as this unit has 8 to 12 feet of suitable material. The median thickness of suitable topdressing is 10 feet.

This soil is medium-textured with up to 70 percent rock fragments which are dominantly gravel. The texture of the suitable material (after mixing) is sandy loam to loam, with an average clay content of 15 to 25 percent. After mixing, the rock fragment content will range from 50 to 60 percent.

It may be underlain by bedrock.

Map Unit 109-3

This soil is identified as a Typic Torriorthent, calcareous. The area mapped as this unit has 4 to 8 feet of suitable material. The median thickness of suitable topdressing is 6 feet.

This soil is medium to moderately fine-textured with 35 to 60 percent rock fragments. The texture of the suitable material (after mixing) is loam to clay loam, with an average clay content of 25 to 35 percent. After mixing, the rock fragment content will range from 40 to 50 percent.

It is underlain by unsuitable strata with high clay content or limited available water holding capacity due to excessive gravel/cobble content.

Map Unit 109-4

This soil is identified as a Typic Torriorthent, calcareous. The area mapped as this unit has 8 to 12 feet of suitable material. The median thickness of suitable topdressing is 10 feet.

This soil is medium to moderately fine-textured with 35 to 60 percent rock fragments. The texture of the suitable material (after mixing) is loam to clay loam, with an average clay content of 25 to 35 percent. After mixing, the rock fragment content will range from 40 to 50 percent.

It is underlain by unsuitable strata with high clay content or limited available water holding capacity due to excessive gravel/cobble content.

Map Unit 110-1

This soil is identified as a Typic Calciargid, fine. The area mapped as this unit has 6 inches to 2 feet of suitable material. The median thickness of suitable topdressing is 1 foot.

This soil is moderately fine-textured with 5 to 20 percent rock fragments. The texture of the suitable material (after mixing) is clay loam, with an average clay content of 30 to 38 percent. After mixing, the rock fragment content will be less than 15 percent.

It is underlain by unsuitable strata with high calcium carbonate content.

Map Unit 111-1

This soil is identified as a Typic Calciargid, fine-loamy. The area mapped as this unit has 6 to 30 inches of suitable material. The median thickness of suitable topdressing is 1 foot.

This soil is medium to moderately fine-textured with 15 to 35 percent rock fragments. The texture of the suitable material (after mixing) is loam to clay loam, with an average clay content of 20 to 35 percent. After mixing, the rock fragment content will be about 25 percent.

It is underlain by unsuitable strata with high calcium carbonate content.

Map Unit 112-3

This soil is identified as a Haplic Torriarent, loamy-skeletal. The area mapped as this unit has 2 to 9 feet of suitable material. The median thickness of suitable topdressing is 6 feet.

This soil is medium to moderately fine-textured with 10 to 40 percent rock fragments. The texture of the suitable material (after mixing) is loam to clay loam, with an average clay content of 25 to 35 percent. After mixing, the rock fragment content will range from 20 to 30 percent.

It is underlain by unsuitable strata with high clay content.

3.3 Laboratory Testing and Test Results

Representative samples from each soil taxonomic unit were collected for laboratory analysis. These tests were conducted in two tiers. Tier 1 analysis was conducted on all samples: texture, pH, electrical conductivity (salinity), and SAR. Calcium carbonate equivalent was specified for selected calcic horizons. Organic matter, nitrate/nitrite-nitrogen and phosphorus (total and available) were evaluated on most surface samples. Sand size fractions were determined on tailings substrata. When field texture estimates and lab texture varied widely, a professional judgment was used in the profile descriptions. Tier 1 results for all soils are presented in Table 5.

The Haplic Torriarents, tailings substrata horizons were sieved for sand size fraction: 12-20 inches, 26% very fine sand and 29% fine sand; 22-60 inches, 22% very fine sand and 43% fine sand.

There were no serious concerns with the results of the Tier 1 results relative to topdressing suitability. The Pachic Argiustoll had a minor salinity issue in the lower horizons, but this could be an isolated event, as samples analyzed were collected only from the backhoe pit. Mixing of materials during collection would diminish the salinity impact. The bottom horizon of the fine Typic Calciargid had a high calcium carbonate equivalent, but that horizon was excluded from the suitable materials. Nitrogen and phosphorus levels were low, as would be expected in arid region range and disturbed soils. Available potassium levels were on the lower end of the range typically expected in semiarid and arid region soils.

A second tier of samples were conducted on those pedons within the tailings facility or possibly disturbed by mining activities. The acid/base potential and available elements results were presented in Table 6a. The data to calculate acid/base potential and total results were presented in Table 6b. Elements not detected during analysis were not included in the tables: Total and available arsenic, available boron, total and available cadmium, total and available mercury, available nickel.

The tailings substrata were unsuitable due to the acid/base potential, and will be discussed in more detail later in the report. 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). Further, though the lab procedures extracted some of the elements, the actual plant availability in the soil likely would be less due to the slightly to moderately alkaline pH that reduces availability of the metals, Cu, Fe, Mn, and Zn. The high total potassium levels did not result in high plant available levels.

Table 5 Tier 1 Soil Test Results for Representative Horizons of Typical Pedons by Taxonomic Unit

Taxonomic Unit	Taxon	Depth	Texture	pH	ECe	SAR	$CaCO_3$	Organic Matter	NO_3/ NO_2	Phosphorus Avail.	Phosphorus Total	Clay	Sand	Silt
		- in -			dS/m		--------- % ---------		---------- ppm ----------			--------- % ---------		
Argic Petrocalcid	104	0-12	SC	7.9	0.4	0.1		3.4	3	ND	50	38	58	5
Calcidic Argiustoll	105	0-8	SCL	7.8	0.5	0.2		3.5	1	3	105	27	60	13
		8-17	SC	7.9	0.3	0.9		4.0				37	53	10
		17-24	C	7.9	0.4	0.4	9					61	30	9
		24-38	SCL	7.9	0.6	1.9	18					24	58	18
Haplic Torriarent loamy-skeletal	112	0-6	SCL	7.9	0.5	0.2	19	2.4	2	5	130	23	64	13
		6-35	SCL	8.0	0.4	1.5	15					34	53	13
		35-52	SCL	7.8	1.8	1.3	8					27	60	13
		52-84	SCL	7.9	1.6	2.5	12					34	53	13
		84-110	SC	7.8	2.4	2.0	12					40	48	12
Haplic Torriarent. tailings substrata	103	0-12	SCL	7.8	0.4	0.3		1.9	1	ND	93	27	58	15
		12-20	FSL	8.0	1.2	0.2						15	55	30
		20-60	FSL	7.8	2.7	0.2						15	60	25
Pachic Argiustoll	107	6-14	CL	7.8	1.4	1.0		3.9	12	2	105	35	38	28
		14-29	C	7.7	6.7	4.9		4.1				43	39	19
		40-58	SCL	8.1	8.1	14.1						34	48	18
Typic Calciargid, fine	110	0-7	SCL	8.0	0.4	0.1		2.9	1	ND	117	30	57	13
		7-24	SCL/SC	7.9	0.5	0.4	11					35	55	10
		24-64	SCL	7.8	1.3	1.7	43					27	53	20
Typic Calciargid, fine-loamy	111	3-10	SCL	7.8	0.3	0.1		3.3	0	ND	95	33	58	10
		10-17	C/SC	7.9	0.3	0.3	13					45	45	10
		17-26	SCL	8.0	0.3	0.7	23					22	65	13

Table 5 Tier 1 Soil Test Results for Representative Horizons of Typical Pedons by Taxonomic Unit (continued)

Taxonomic Unit	Taxon	Depth	Texture	pH	ECe	SAR	CaCO3	Organic Matter	NO_3/ NO_2	Phosphorus Avail.	Phosphorus Total	Clay	Sand	Silt
									------------ ppm		-----------	------------ %		--------
		- in -			dS/m		-------- %	--------			-			----
Typic Haplargid, fine	102	0-13	SC	7.8	0.4	0.1		3.1	1	ND	54	40	50	10
		13-30	CL/C	8.1	0.3	1.9	22					40	35	25
		30-51	C	8.0	2.9	3.0						50	25	25
		51-90	C	7.9	2.4	2.9						50	25	25
Typic Haplocambid	101	0-18	SL	8.0	0.5	0.1		2.1	3	5	125	15	75	10
		18-34	SL	7.9	0.6	0.5		2.4				18	62	20
		34-63	SL	7.8	2.7	0.9						11	70	19
		63-110	S	8.5	0.3	1.6						8	92	0
Typic Torriorthent, nonacid	108	15-49	SL	7.6	0.8	0.5		2.8	12	ND	157	18	65	18
		49-73	SL	7.9	0.4	1.5		3.2				13	73	15
		73-110	SL	7.8	0.5	1.7		3.3				18	68	15

Table 6a Tier 2 Acid/Base Potential and Available Results for Representative Horizons of Typical Pedons for Selected Taxonomic Units

Taxonomic unit	Taxon	Depth	Acid/ Base Potential	Cl	Cu	Fe	Mn	Mo	K	Se	Ca	Mg	Na	Zn
		- in -	T $CaCO_3$ /1000 T	ppm										
Haplic Torriarent loamy-skeletal	112	0-6	185	20	3	5	4.6	ND	231	ND	73	4	7	ND
		6-35	146	ND	5	9	0.9	ND	95	0.007	36	3	36	ND
		35-52	75	67	5	9	1.4	ND	187	0.004	218	12	75	ND
		52-84	119	99	3	5	0.6	ND	127	0.002	153	17	123	ND
		84-110	124	412	3	5	0.9	ND	154	0.006	254	23	125	ND
Haplic Torriarent. tailings substrata	103	0-12	126	17	3	10	2.6	ND	166	ND	62	7	11	ND
		12-20	-6	ND	85	108	4.7	1.2	70	0.025	174	39	13	4.7
		20-60	-13	ND	74	64	1.8	1.7	73	0.046	514	75	17	3.6
Typic Calciargid, fine	110	0-7	21	ND	4	9	2.9	ND	425	0.005	63	4	3	ND
		7-24	113	ND	4	8	1.4	ND	160	0.002	73	3	13	ND
		24-64	428	36	1	6	0.6	ND	62	ND	179	6	85	ND
Typic Calciargid, fine-loamy	111	3-10	134	ND	8	5	1.4	ND	138	0.004	58	2	4	ND
		10-17	129	ND	8	6	1.0	ND	136	ND	48	2	7	ND
		17-26	234	ND	3	8	0.9	ND	66	0.002	37	2	15	ND
Typic Torriorthent, nonacid	108	15-49	16	ND	15	14	2.4	ND	94	ND	84	19	21	ND
		49-73	16	ND	12	9	1.1	ND	77	0.005	30	8	35	ND
		73-110	20	ND	8	8	0.8	ND	81	0.010	34	8	43	ND

Not detected: Arsenic, boron, cadmium, mercury, and nickel.

Table 6b Tier 2 Data to Calculate Acid/Base Potential and Total Results for Representative Horizons of Typical Pedons for Selected Taxonomic Units

Taxonomic unit	Taxon	Depth	$CaCO_3$	S	Acid Neutral-ization Potential	Acid Generating Potential	B	Cu	Fe	Mn	Mo	Ni	K	Zn
		- in -	----- % -----		-- T $CaCO_3$/1000 T --		---------------------------- ppm ----------------------------							
Haplic Torriarent	112	0-6	19	0.02	185.0	0.6	ND	62	26400	755	ND	10	1950	60
loamy-skeletal		6-35	15	0.09	149.0	2.8	ND	44	29100	494	ND	11	2060	57
		35-52	8	ND	75.2	0.2	ND	48	35500	631	ND	15	2820	63
		52-84	12	0.02	120.0	0.6	ND	32	28700	466	ND	16	2160	58
		84-110	12	ND	124.0	0.4	ND	37	31700	431	ND	16	2540	59
Haplic Torriarent.	103	0-12	13	ND	126.0	0.5	ND	40	29100	541	ND	12	2370	60
tailings substrata		12-20	2	0.9	21.7	28.1	ND	716	22400	356	9	7	2880	64
		20-60	2	1.02	18.6	31.8	ND	612	20000	270	15	5	2420	48
Typic Calciargid,	110	0-7	2	0.02	21.7	0.5	32	34	38400	636	ND	17	4230	69
fine		7-24	11	0.02	114.0	0.5	30	26	31800	517	ND	14	3230	62
		24-64	43	0.02	429.0	0.6	ND	23	15600	399	ND	8	977	44
Typic Calciargid,	111	3-10	13	ND	134.0	0.4	ND	62	34700	535	ND	14	2780	63
fine-loamy		10-17	13	0.02	130.0	0.6	ND	69	31100	452	ND	14	2760	63
		17-26	23	0.02	234.0	0.5	ND	58	23500	553	ND	9	1440	52
Typic Torriorthent,	108	15-49	2	ND	16.6	0.3	49	486	65000	1290	ND	16	5390	70
nonacid		49-73	2	ND	16.6	0.4	54	735	73900	1680	ND	24	6420	92
		73-110	2	ND	20.7	0.4	50	450	68600	1400	ND	19	5050	68

Not detected: Arsenic, cadmium, and mercury.

4.0 Summary

4.1 Location and Quantity of Suitable Material

There are about 425 acres that will yield approximately 3,391,000 cubic yards, or 2,100 acre-feet of suitable topdressing materials (Figures 16-17, Table 7 contains the map unit legend). Suitable topdressing materials were determined as the product of the area of each map unit and the median depth of the suitable material (after mixing) in that unit.

Figure 16 Location of Map Units with Suitable Topdressing Materials, East Portion of Permit Area

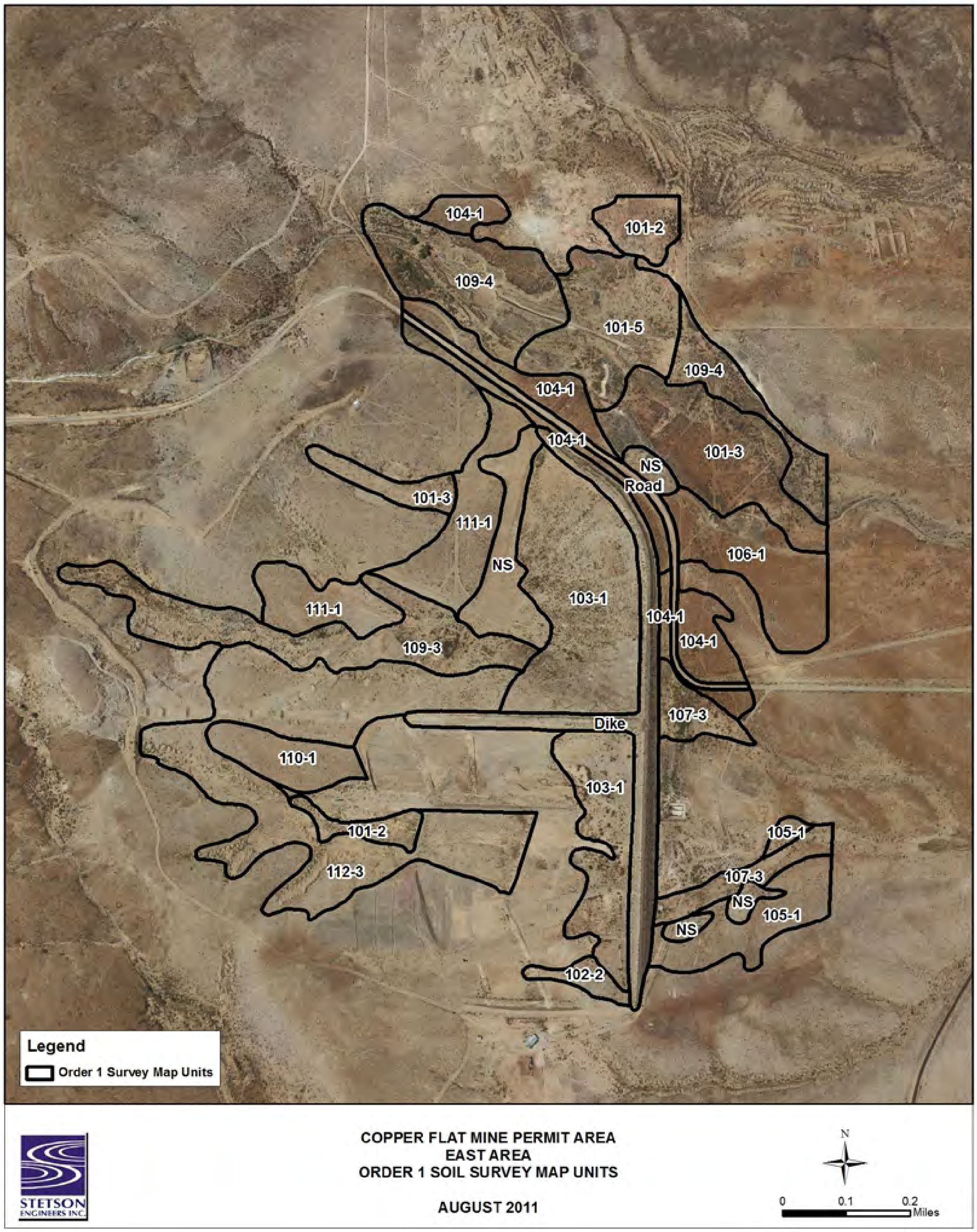


Figure 17 Location of Map Units with Suitable Topdressing Materials, West Portion of Permit Area.

Table 7 Estimate of Suitable Topdressing Materials (after mixing)

Taxonomic Unit	Map Unit	Median Depth	--------- Area ---------		Volume
		feet	acres	sq-ft	cubic yards
Typic Haplocambid	101-2	3	11.0	480,019	53,335
	101-3	6	40.5	1,762,671	391,705
	101-4	10	4.9	213,589	79,107
	101-5	14	37.0	1,611,406	835,544
Typic Haplargid, fine	102-1	1	8.9	388,346	14,383
	102-2	3	3.3	145,357	16,151
Haplic Torriarent, tailings substrata	103-1	1	61.7	2,687,769	99,547
Argic Petrocalcid	104-1	1	29.9	1,303,273	48,269
Calcidic Argiustoll	105-1	1	15.5	677,352	25,087
Typic Haplargid, clayey-skeletal	106-1	1	20.6	899,213	33,304
Pachic Argiustoll	107-3	6	15.8	690,114	153,359
Typic Torriorthent, nonacid	108-4	10	2.3	99,799	36,963
Typic Torriorthent, calcareous	109-3	6	30.3	1,321,143	293,587
	109-4	10	38.0	1,653,361	612,356
Typic Calciargid, fine	110-1	1	10.1	440,689	16,322
Typic Calciargid, fine-loamy	111-1	1	27.7	1,206,996	44,704
Haplic Torriarent, loamy-skeletal	112-3	6	65.8	2,867,270	637,171
Total			**423.5**		**3,390,894**

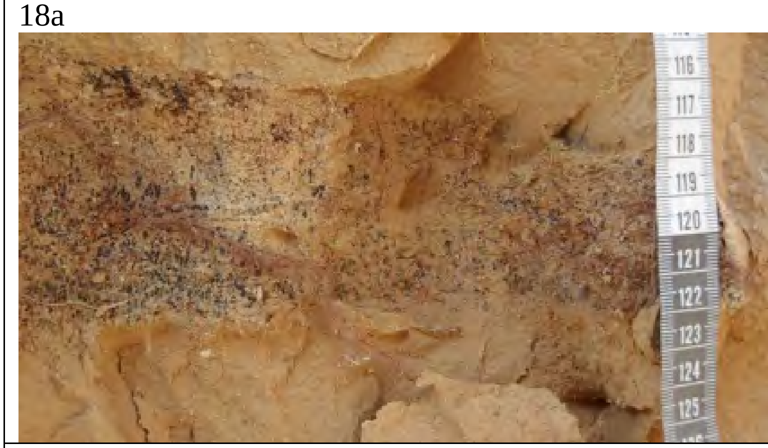
4.2 Tailings Discussion

Though available copper, iron, zinc, molybdenum and selenium were elevated to some degree, 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. Roots readily grow into the tailings substrata (Figure 18a), and the vegetative community is thriving (Figures 7 b,c, 18b).

The tailings were not considered suitable for topdressing materials due to the acid/base potential. However, one could argue that given the high calcium carbonate content of the lower horizons in four of the Order 1 map units, there would be more than adequate acid neutralizing potential were the tailings substrata mixed with material from calcic horizons. Mixing the materials would lower the available copper due to the pH increase and carbonate-metal chemistry decreasing solubility of copper and other metals.

Figure 18 Roots (18a) and Vegetative Community on Soils Overlying Tailings (18b)

18a

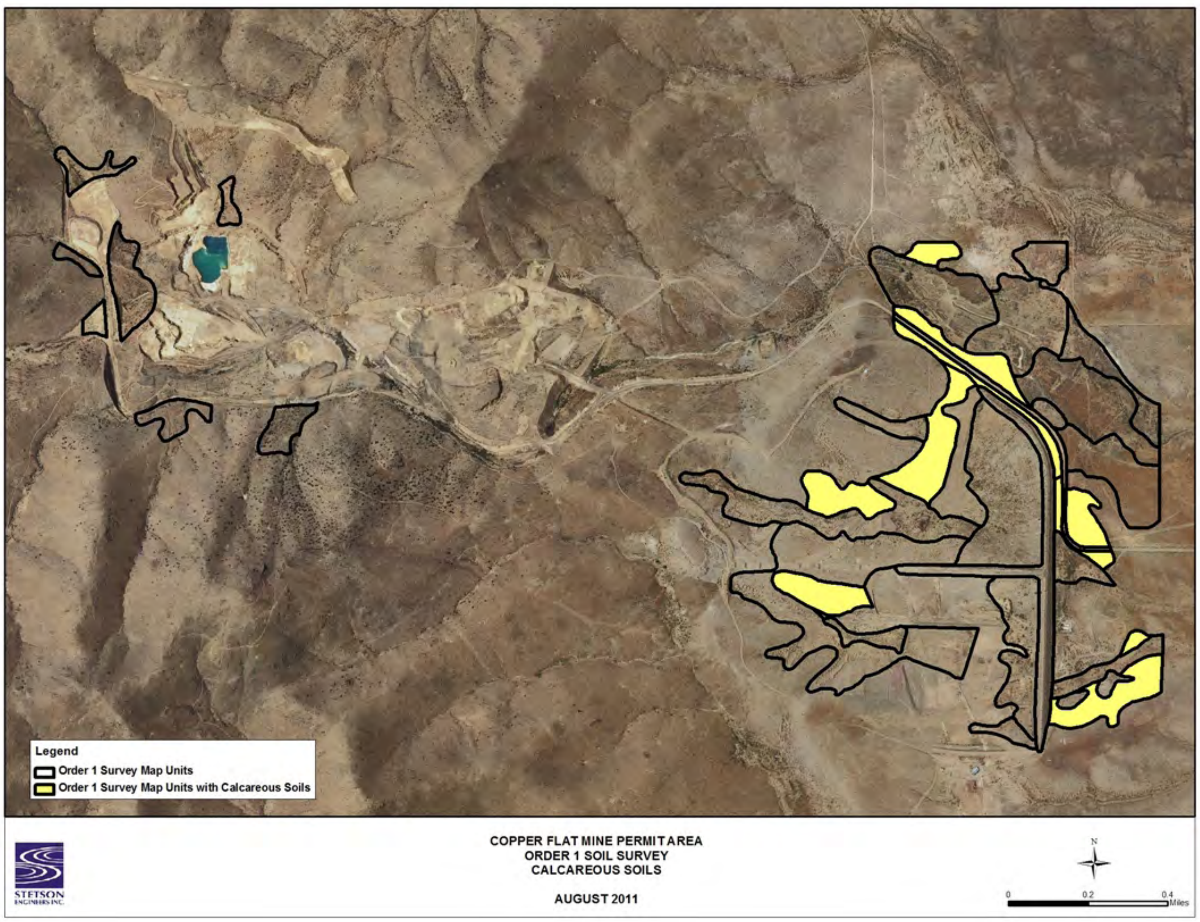


18b

4.3 Neutralization Potential

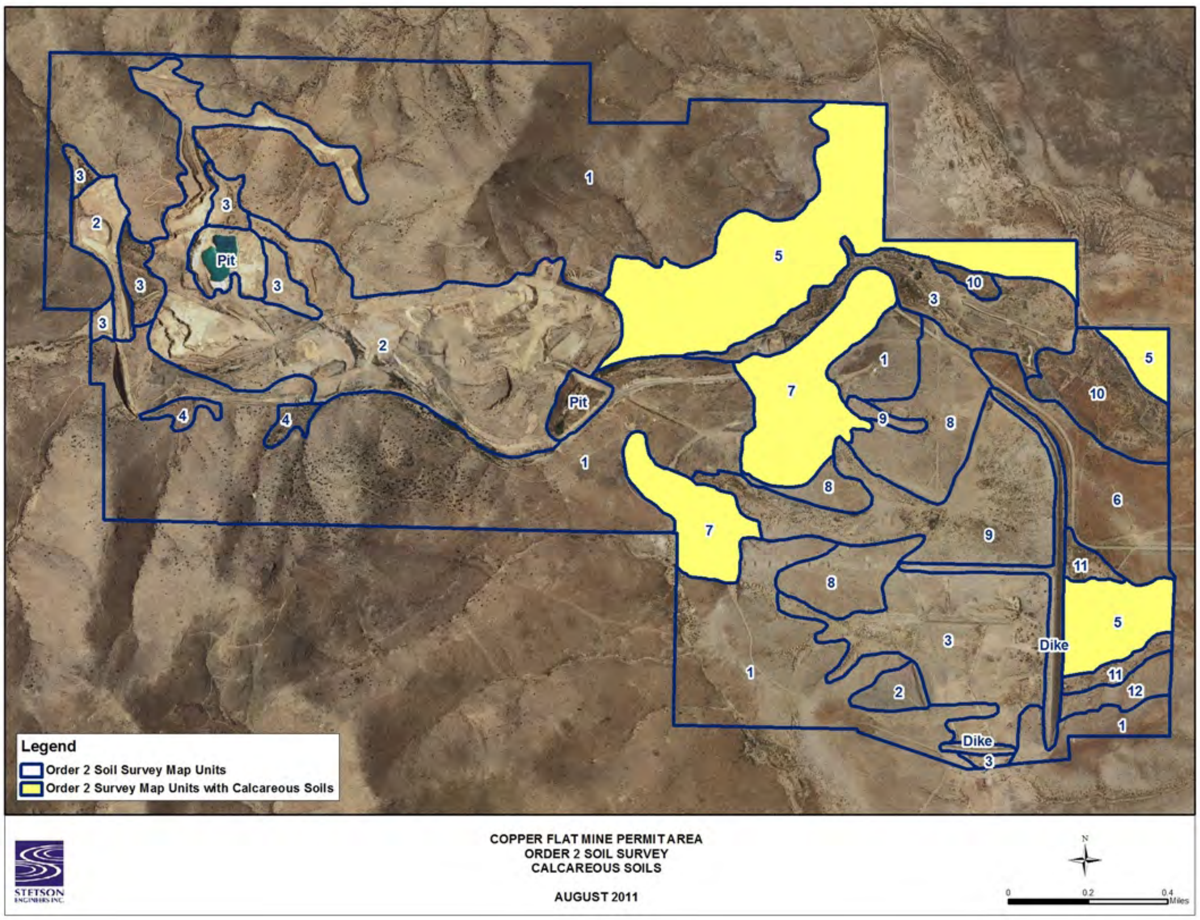
As mentioned in the tailings discussion, four of the Order 1 map units had calcic horizons with high calcium carbonate equivalents below the suitable topdressing materials (Figure 19). Tables 5 and 6 reported three horizons with greater than 20% calcium carbonate equivalent. The acid neutralizing potential was 10 times the calcium carbonate equivalent. Most of the calcic horizons in the Order 1 soil survey were not sampled for lab analysis, since the scope of this study was to map and characterize sources of suitable topdressing materials and these horizons were unsuitable. The total depth of the calcic materials was not characterized in three of the four map units (about 70 acres) with calcic horizons, as the deepest horizon described was calcic, and calcic materials usually continued below the last horizon described. Thus the volume of calcareous materials and total acid neutralization potential was not characterized in the Order 1 map units.

Figure 19 Order 1 Map Units with Calcic Horizons and High Acid Neutralization Potential



Two Order 2 map units had shallow topsoil overlying calcic horizons (Figure 20). These map units were not considered significant sources of suitable topdressing material, so they were not included in the Order 1 survey. However, the calcareous materials in these soils could be characterized and quantified for acid neutralization potential, as well. There were approximately 360 acres identified as calcareous soils in the Order 2 soil survey in which the material volume and acid neutralization potential could be characterized.

Figure 20 Order 2 Map Units with Calcic Horizons and High Acid Neutralization Potential



Thus the calcareous soils in the eastern end of the permit area could have substantial acid neutralization potential that has not yet been characterized.

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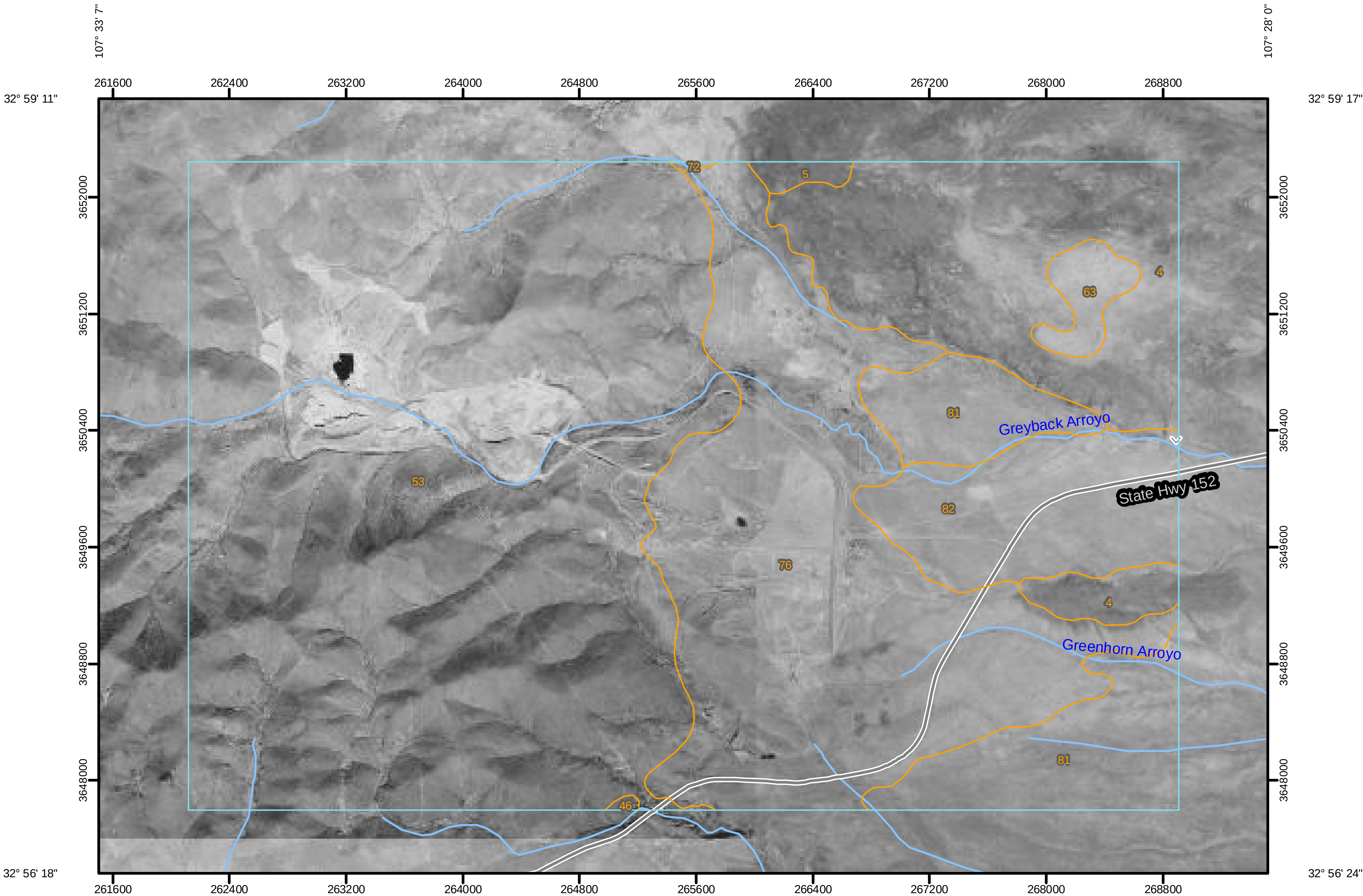
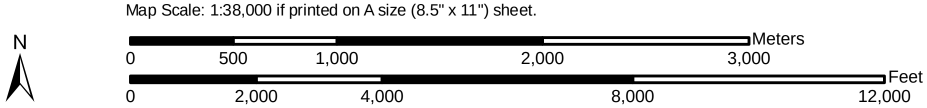
Appendix A
Copper Flat Mine Permit Area
NRCS Soil Map

Soil Map—Sierra County Area, New Mexico
(Copper Flat mine and tailings storage facility)



Map Scale: 1:38,000 if printed on A size (8.5" x 11") sheet.



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Units

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other

Special Line Features
- Gully
- Short Steep Slope
- Other

Political Features
- Cities

Water Features
- Oceans
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads

MAP INFORMATION

Map Scale: 1:38,000 if printed on A size (8.5" × 11") sheet.

The soil surveys that comprise your AOI were mapped at 1:48,000.

Please rely on the bar scale on each map sheet for accurate map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 13N NAD83

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Sierra County Area, New Mexico
Survey Area Data: Version 10, May 13, 2009

Date(s) aerial images were photographed: 10/2/1996; 10/8/1996

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Sierra County Area, New Mexico (NM660)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
4	Akela very gravelly loam, moderately rolling	907.8	12.2%
5	Akela-Rock outcrop association, very steep	27.0	0.4%
46	Ildefonso-Scholle association, hilly	4.2	0.1%
53	Luzena-Rock outcrop association, very steep	3,749.3	50.3%
63	Nickel-Chamberino association, gently sloping	78.7	1.1%
72	Rock outcrop-Deama association, extremely steep	3.3	0.0%
76	Scholle-Ildefonso association, moderately rolling	1,705.4	22.9%
81	Tres Hermanos gravelly fine sandy loam, gently sloping	534.1	7.2%
82	Tres Hermanos-Hap association, gently sloping	446.7	6.0%
Totals for Area of Interest		**7,456.4**	**100.0%**

Appendix B
Copper Flat Mine
Pipeline Report

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New Mexico Copper Corporation Interim Report
Water Supply Pipeline Corridor Evaluation

Prepared by Clay Robinson, PhD, CPSS, PG
July 15, 2011

Background:
Quintana Minerals Corporation operated a porphyry copper mine from 1981 to 1982. A pipeline was constructed from 1978 to 1980 to supply water for the mill. The pipeline used 20-inch steel pipe with welds at 40 feet, and was installed 2 to 4 feet deep to the top of the pipe. The pipe is encased in concrete to cross arroyos. Minimum installation dimensions were likely 4 feet wide by 4 to 6 feet deep.

The pipeline traverses Sec. 30-31, T 15S, R5W, Sec 25-27, 31-34, T15S, R6W in Sierra County, NM, beginning near Grayback Arroyo about 1 mile northwest of its junction with Greenhorn Arroyo. The pipeline runs northwest about 0.5 miles, turns west-southwest parallel to NM 152 (90 on older maps) for about 5 miles, then turns west about 1 mile to enter the east boundary of the permit area.

New Mexico Copper Corporation is evaluating resuming mining and milling operations, and is developing the materials required to obtain the permit to resume operations. New Mexico Mining and Minerals Division may require New Mexico Copper Corporation to remove the existing pipeline as a requirement of the permit to operate the mine.

Nature of this report:
This report is a review of readily available materials relative to soils and vegetation in Sierra County, NM. No field data were collected for this analysis. This report does not address the likely impact of pipeline removal on the soils or vegetation. Such an evaluation would require a field assessment of soils and vegetation to determine actual conditions.

This report will use information readily available from the NRCS Soil Survey of Sierra County, NM (Soil Survey Staff, 2011b), and soil series descriptions (Soil Survey Staff, 2011a) to address the likely conditions of undisturbed soils adjacent to the pipeline, and the likely condition of disturbed soils in the pipeline right-of-way. The pipeline right-of-way consists of two portions: The ditch in which the pipeline was laid, and the adjacent area outside the ditch.

Further, this report will use ecological site descriptions developed by NRCS range scientists (NRCS, 2011) to address the likely vegetative composition of those undisturbed and disturbed soils.

Soil characteristics:
The Sierra County Area, New Mexico Soil Survey (Soil Survey Staff, 1983) is in MLRA 42, Southern Desertic Basins, Plains, and Mountains. An Order 3 survey, mapped at a scale of 1:48,000 (1.3 inches/mile) exists for the portion of the county where the pipeline is. This level of detail maps primarily at the association or consociation level. The smallest unit that can be shown on a map at this scale is about 25 acres. Soil consociations are named after the dominant soil, and may include up to 25% of unnamed soils that do not significantly affect management, or 15% of unnamed soils that would alter management practices. Associations contain two or more soils occurring in repeatable patterns that could be mapped at the given scale, and that differ in morphology or management. Associations may include up to 25% of unnamed soils that do not affect the management, or 15% of unnamed soils that would alter management practices.
The pipeline traverses four soil map units:

62 Nickel very gravelly fine sandy loam, very steep (consociation)
 Nickel and similar soils, 80%
63 Nickel-Chamberino association, gently sloping
 Nickel and similar soils, 45%
 Chamberino and similar soils, 35%
81 Tres Hermanos gravelly fine sandy loam, gently sloping (consociation)
 Tres Hermanos and similar soils, 75%
82 Tres Hermanos-Hap association, gently sloping
 Tres Hermanos and similar soils, 45%
 Hap and similar soils, 40%

Information on the soils is taken from the Official Series Descriptions (Soil Survey Staff, 2011a), and WebSoilSurvey (Soil Survey Staff, 2011b).

All soils were formed in mixed gravelly alluvium, and occur on talf (flat plain) and treads (terraces) of fan piedmonts. All soils are deep, well-drained, and have calcic horizons. The Nickel and Chamberino soils are on slightly lower landscape positions and have greater gravel/cobble contents than the Tres Hermanos and Hap soils. The Nickel and Chamberino soils are in the same taxonomic family. The Tres Hermanos and Hap soils have argillic horizons (and higher clay contents), hold more plant available water, and are in the same taxonomic family. They also have higher calcium carbonate contents (40% maximum vs 25% maximum). The Hap soil is in the Gravelly Loam ecological site, while the others are in the Gravelly ecological site. The Tres Hermanos soil is nonsaline to slightly saline, while the others are nonsaline. The Hap soil may have a slightly sodic horizon, while the others are nonsodic. All soils have 150 to 500% greater coarse fragment (cobbles and/or gravel) in the lower horizons than in the A horizon.

In an undisturbed state, these soils have thin A horizons. The Chamberino, Nickel, and Tres Hermanos soils are calcareous to the surface, while the Hap is noncalcareous in the ochric horizon (A) and top of the argillic horizon (to about 18 inches). The Hap typically has no cobbles in the profile, and has more fine gravels than the other soils. It also has a slightly lower pH in the upper profile. These differences place the Hap in the Gravelly Loam ecological site, while the Chamberino, Nickel, and Tres Hermanos soils are in the Gravelly ecological site.

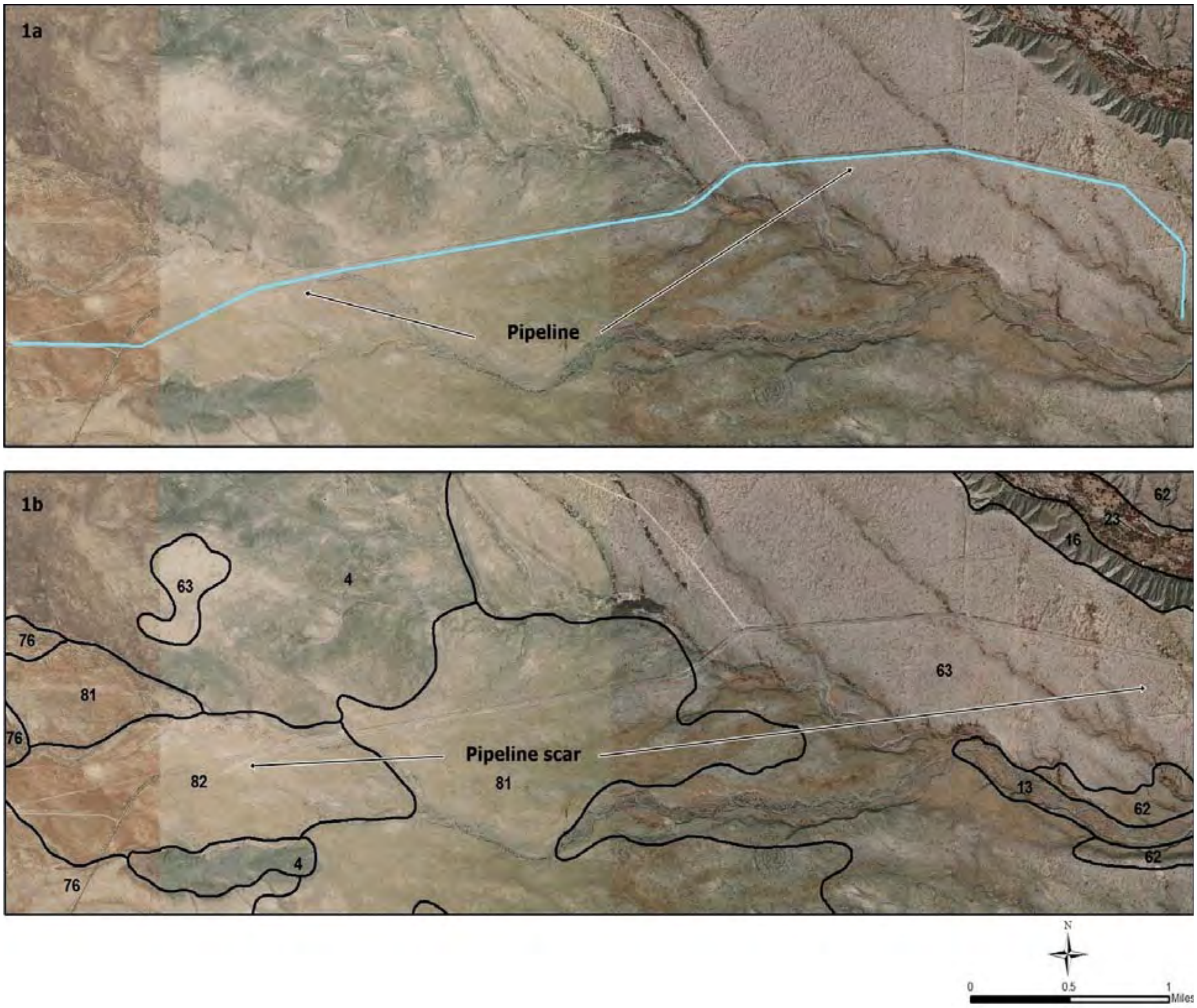
Vegetative characteristics:
Native climax vegetation in the Gravelly Loam ecological site (NRCS, 2011) was likely a diverse grassland community dominated by black grama, with lesser amounts of bush muhly, Arizona cottontop, and/or cane bluestem. Shrub densities are low in undisturbed sites. Disturbance and over-grazing decreases density of black grama and other favorable grasses, while increasing the density of tobosa, threeawns, burrograss, fluffgrass, snakeweed and shrubs. Climax vegetation in the Gravelly ecological site (NRCS, 2011) was likely a mixed black grama/bush muhly and shrubs/halfshrubs (mostly creosotebush and mariola) community. Disturbance and overgrazing decreases the density of grasses and increases the shrub density, possibly concomitant with invasion of tarbush, honey mesquite, and whitethorn acacia, especially if creosotebush density declines. In both ecological sites, transition to shrubland increases bare soil surface exposed, increasing erosion. Erosion removes nutrients and organic matter and makes grass reestablishment difficult, and grasses may take decades or more to recover.

Likely disturbed soil and vegetation characteristics:
Pipeline construction removed soil to a minimum depth of 4 to 6 feet, with a minimum width of 4 to 6 feet. The removed soil is placed on one side of the ditch. Once the pipeline is installed, the soil materials are placed back into the ditch to cover the pipe. At the time of construction, regulations did not require topsoil segregation, thus all soil horizons to the depth of the ditch were mixed together and placed on one side of the ditch. When the pipeline was covered, more mixing occurred, and some of the soil materials likely remained on the side of the ditch. Core samples in such disturbed soils commonly reveal fragments of horizons in no discernible order.

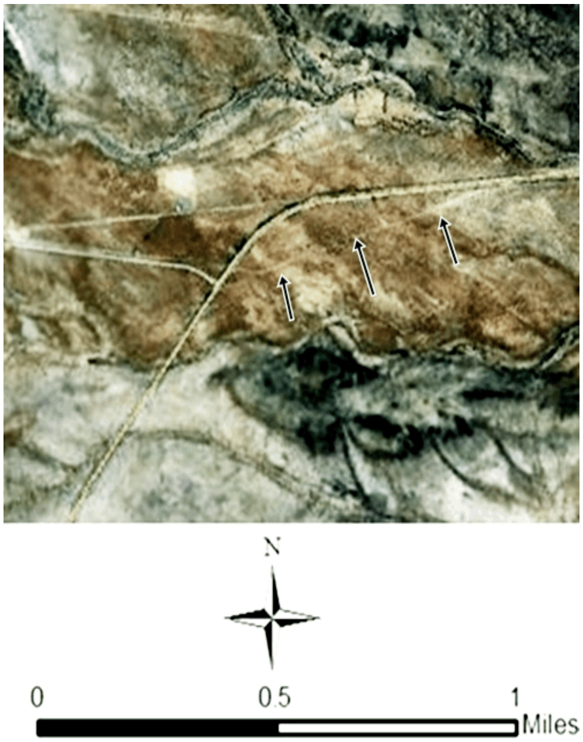
The results of mixing in all these soils likely will be a 4 to 6-fold increase in carbonates in the top 8 to 10 inches of the replaced soil. The disturbed Hap soil likely will become calcareous throughout the profile. The Tres Hermanos and Hap soils likely also will have a slight clay increase in the surface layer. All soils will have increased gravel and/or cobbles in the surface after construction. The Hap and Tres Hermanos soil likely will have up to 20% increase in gravel in the surface layer, leading to an estimated 35 to 50% gravel in the surface layer. The Nickel and Chamberino soils likely will have up to 15% increase in cobbles and 30% increase in gravel in the surface layer, leading to an estimated 20% cobbles and 50% gravel in the surface layer.

Construction of a pipeline removes the native vegetation and mixes the soil horizons so that the soil responds like a truncated profile. Vegetation establishment is slow. This is evidenced by the lack of vegetation over the pipeline constructed 30 years ago. Appendix B Figure 1a shows the location of the pipeline. Appendix B Figure 1b is the same image including the soil map units, but without the line, the photo was taken in 1996. The pipeline scar is visible on the east and west sides of the photo. In the center it parallels the road, and is difficult to discern. GoogleEarth imagery of the pipeline in Appendix B Figure 2 shows the scar from the pipeline is plainly visible in 2009, 29 years after construction (GoogleMaps, 2011).

Appendix B Figure 1. Quintana Minerals Corp. water supply pipeline route (1a, in blue) and visible scar along the pipeline route, with soil map units (1b)



Appendix B Figure 2. Enlarged portion of west edge of pipeline. Arrows point to scar in 2009.



Map unit symbol	Map unit name
4	Akela very gravelly loam, moderately rolling
13	Arizo and Canutio soils, gently sloping
16	Badland-Nickel complex, extremely steep
23	Brazito loamy fine sand, gently sloping
62	Nickel very gravelly fine sandy loam, very steep
63	Nickel-Chamberino association, gently sloping
76	Scholle-Ildefonso association, moderately rolling
81	Tres Hermanos gravelly fine sandy loam, gently sloping
82	Tres Hermanos-Hap association, gently sloping

Two factors contribute to the scars visible on aerial and satellite imagery. The vegetation over the construction zone is generally less dense than outside the zone, and different species representing a degraded ecological state are present. All soils affected by the pipeline have calcic horizons beginning 4 to 18 inches below the surface. The calcic horizons in the Tres Hermanos and Hap soils have very light colors (pink, pinkish gray, white). During pipeline construction, the soil horizons are mixed during trenching and refilling. As a result, calcic horizon fragments will be on the soil surface, increasing the reflectivity and visibility of the scar.

Recommended action:
If New Mexico Mining and Minerals Division requires New Mexico Copper Corporation to remove the pipeline as a condition of the permit of operation, we recommend a soil and vegetative cover survey be completed along the pipeline. Such a survey is necessary because the map scale in the soil survey is insufficient to address the potential impact of such a disturbance, and appropriate reclamation procedures.

If the pipeline is allowed to remain, we recommend no further action is warranted based upon the existing data and current use of the area.

Appendix B References:

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Appendix 7-A

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

Alta Gold Co.

Copper Flat Mine

Geochemical Review of Waste Rock, Pit Lake Water Quality and Tailings

PREPARED BY:

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November 1996
SRK Project No. 68609

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FIGURES

1 INTRODUCTION

A review of the pit lake chemistry and geochemical test work and observation data of the waste rock piles and tailings impoundment at the Copper Flat project, New Mexico, is presented herein. The review is based upon previous laboratory data collected by SRK (US), Inc., a geochemical model devised by SRK (US), Inc. and field data collected during a site visit in November 1996.

Mitigation options for water quality are also discussed and recommendations made for future areas of focus and long term monitoring.

2 PROJECT DESCRIPTION AND LOCAL GEOLOGY

The Copper Flat redevelopment project is located approximately 23 miles southwest of Truth or Consequences and 5 miles northeast of Hillsboro, Sierra County, New Mexico (Figure 2.1). Alta Gold proposes to rebuild the mine site, as it existed in 1986 when owned by Quintana Minerals. Mining in the area began in 1877 with primarily alluvial gold operations with the main period of copper extraction from 1911 to 1931 (Harley, 1934).

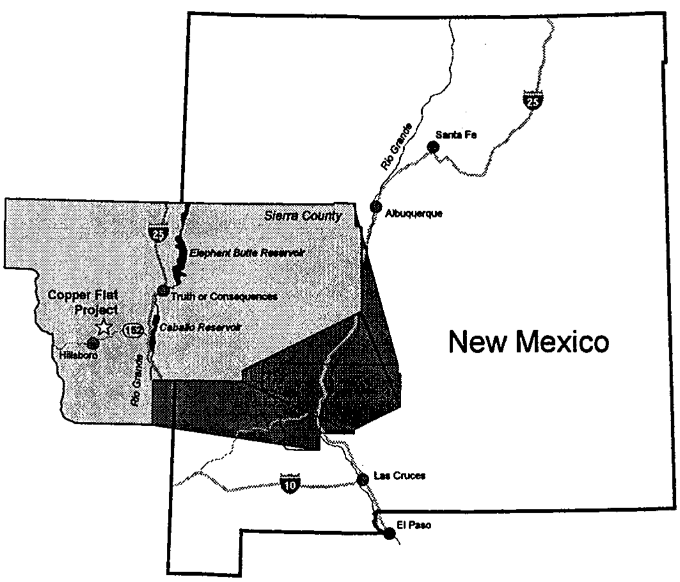


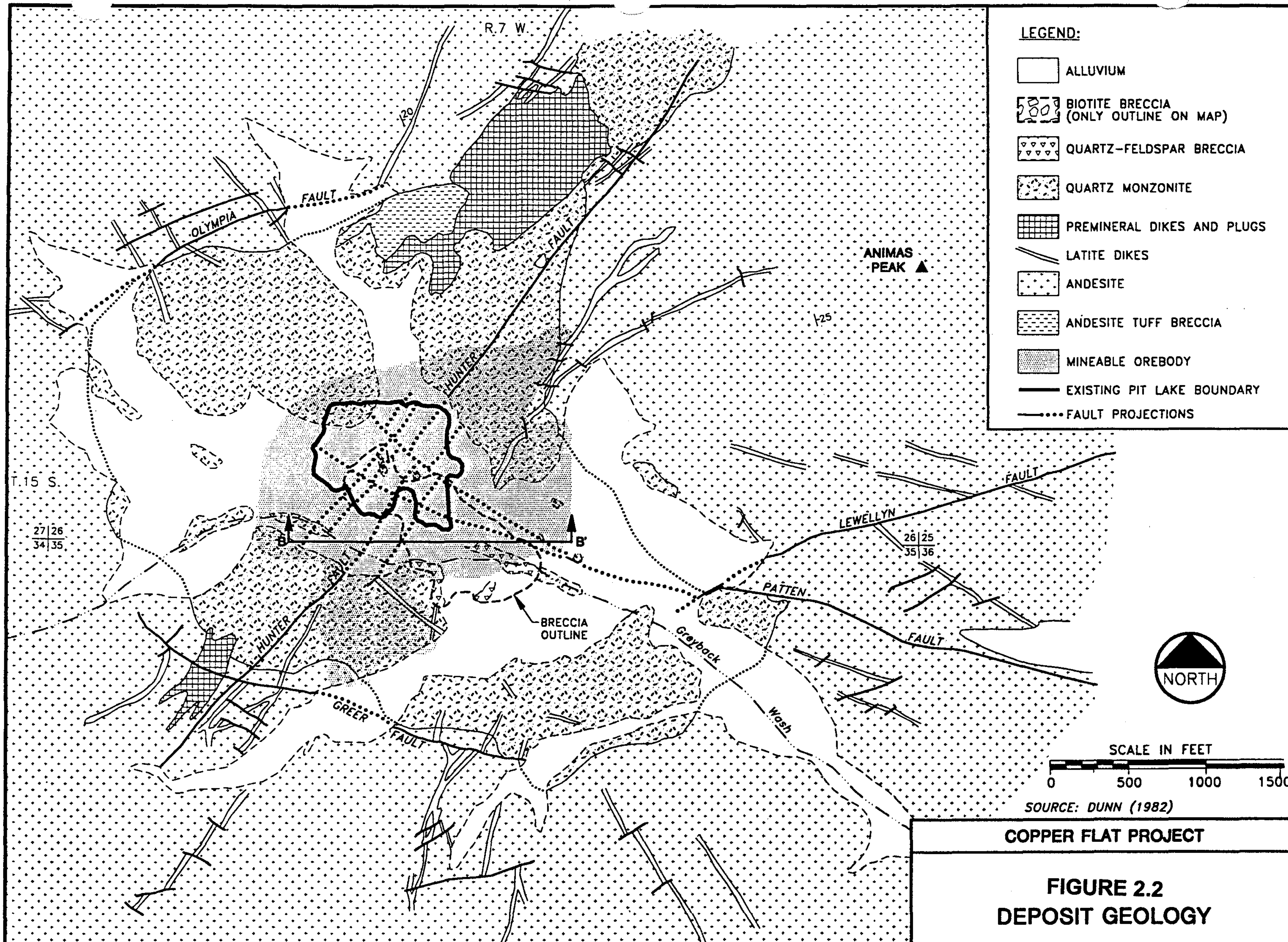
Figure 2.1 Project Location

During the 1950's and mid-1980's, attempts were made along the Sternberg lode to extract copper by *in-situ* acid leaching. The current plans propose to produce a sulfide concentrate by flotation with the operational life expectancy of approximately 10-12 years.

The Copper Flat deposit is located within a Cretaceous age caldera which intruded into the Paleozoic marine sediments and Precambrian basement rocks exposed in the upthrust Black Range and Animas Hills west of the project boundary (Figure 2.2). To the east the Rio Grande Rift forms a prominent geographical feature. The rift created a graben which has subsequently been infilled by a 700 m thick layered gravel alluvium of the Santa Fe Group.

The oldest sedimentary unit exposed in the immediate area is the Ordovician age Montoya Limestone Group which outcrops in the southeast of the concession area. Overlying the group is the Fusselman Dolomite, a massive 70 m thick dolomite-limestone unit of Silurian age. Unconformably resting on the dolomite sequence is the Percha shale unit which comprises 50-90 m thick unit of argillceous sedimentary rocks.

Magmatic activity in the Copper Flat area began with andesitic volcanic activity, and included the placement of quartz monzonite pluton stocks and latite dykes, and culminated in the hydrothermal activity which formed the copper deposit.



COPPER FLAT PROJECT

FIGURE 2.2
DEPOSIT GEOLOGY

DATE: OCT/19/1995 12-476\401\GEO-DEP2

The andesite is a fine grained porphyritic rock with phenocrysts of plagioclase (andesine) and Ca-Mg-Fe amphibole in a groundmass of plagioclase and orthoclase. The andesite is massive with occasional agglomerates and is coarse grained in the vicinity of the Copper Flat pit. Magnetite and apatite have been observed as common accessories in the andesite.

The mineralization at Copper Flat is similar to copper porphyry style deposits with the exceptions that zonation is relatively poor and no appreciable supergene enrichment zone is observed. Both features are common in copper porphyrys elsewhere in the world. Sulfide content in the disseminated mineralized lodes in the monzonite stock varies up to 5%, with the majority being pyrite. Radiating from the stock are mineralized veins with the highest Cu grades developed in brecciated monzonite. The leached oxide cap is relatively thin (5-15 m) and sulfides are relatively unaltered in the deposit. The major sulfides are pyrite and chalcopyrite with accessory molybdenite and bornite. Trace amounts of enargite, acanthite, tetrahedrite, sphalerite and galena also occur. Gangue mineralogy includes quartz, feldspar, muscovite, biotite, apatite, calcite and fluorite. The deposit also contains appreciable gold, presumably held as a trace element in primary sulfides.

Whilst being similar to classic Copper Porphyry (Dunn, 1992; Einaudi, 1982; Titley, 1982) the deposit at Copper Flat has no appreciable supergene enrichment and is poorly zoned, but has a well developed skarn halo. The lack of supergene enrichment suggests that sulfides in the deposit are not very reactive or that environmental conditions existing at the site since formation do not significantly effect sulfide stability. The low humidity in the area has probably slowed down any potential water-rock interactions, but it is the highly crystalline nature of the sulfides which is the dominant control over sulfide stability in the deposit. By contrast, in many copper porphyrys, such as Mamut in Malaysia or Butte in Montana, sulfide grain size is smaller, total sulfide concentrations are higher, and sulfide connection is better than at Copper Flat, so electrical conductivity is maintained through sulfide material over a greater distance, increasing the distance between cathode and anode causing more intense weathering (see Section 3).

The type of zoned alteration halo and degree to which they are developed in porphyry deposits is a reflection of host rock. Here, Ca-rich andesite and basalt are dominant as opposed to more silica-rich host rocks (such as dacite) observed at other porphyry locations. The skarn reflects the wide availability of Ca and Mg in the tertiary extrusives and the high volatile CO_2 content of the original deposit. This is beneficial as the skarn contains a high proportion of acid consuming minerals which assist in maintaining an alkaline pH.

3 SULFIDE OXIDATION, ACID GENERATION AND CONSUMPTION

3.1. *Primary source of acidity*

The mechanisms of sulfide oxidation involve the transfer of electrons. Because most sulfide minerals are electrical conductors in the semiconductor to metallic range (Table 3.1), they can be considered as electrochemical "corrosion" cells similar to galvanic corrosion of metal alloys (Bailey & Peters, 1976; Thornber, 1975, 1983, 1992; Sato, 1992). Sulfides may be thought of as "geo-batteries" with the emphasis on "self-corrosion" by sulfide ores.

Table 3.1: A comparison of the Resistivities of Various Minerals (data from Thornber 1992)

Mineral/Rock	Log_{10} resistivity in ohm/m	Conducting nature
Metals	-8 to -6	metallic
Graphite, C	-7.5 to -5	metallic
Arsenopyrite FeAsS	-6 to -3	semi-conductor
Chalcocite Cu_2S	-4.2 to -3.9	semi-conductor
Chalcopyrite $CuFeS_2$	-4.1 to -0.3	semi-conductor
Covellite CuS	-6.8 to -4.1	semi-conductor
Galena PbS	-5.8 to -0.2	semi-conductor
Hematite Fe_2O_3	>10	insulator
Manganite MnOOH	-0.9 to -0.1	semi-conductor
Pyrite FeS_2	-5.6 to 0.5	semi-conductor
Pyrolusite MnO_2	-3.1 to 1.2	semi-conductor
Sphalerite ZnS	-2.7 to 4.2	insulator
Realgar As_2S_3	-5 to -3.2	semi-conductor
Orpiment As_4S_4	-3 to 0.2	semi-conductor/insulator
Stibnite Sb_2S_3	-2 to 2.1	insulator
Sulfide-massive	-6.6 to -1.7	semi-conductor
Sulfide-massive, weathered	-3.1 to 0.4	semi-conductor/insulator
Sulfide-matrix supported	-4.4 to 0.8	semi-conductor/insulator
Sulfide-disseminated	-0.9 to 2.9	insulator

These electrochemical reactions are a combination of a reduction reaction at a cathode and an oxidation reaction at the anode. The cathodic reduction of dissolved oxygen can be generalized as:

$$O_2 + 2H_2O + 4e^- \rightarrow 4OH^- \quad (1)$$

combined with sulfide oxidation:

$$MS + 4H_2O \rightarrow M^{2+} + SO_4^{2-} + 8H^+ - 8e^- \quad (2)$$

where M is a divalent metal

to give the total reaction:

$$MS + 2O_2 \rightarrow M^{2+} + SO_4^{2-} \quad (3)$$

Galvanic "corrosion" has been confirmed in numerous experimental studies (Bailey & Peters, 1976; Thornber, 1975; 1983; Lowson, 1982; McKibben & Barnes, 1986)

Additionally hydrogen ions are released in the process of metal hydrolysis:

$$M^{2+} + H_2O \rightarrow M(OH)^+ + H^+ \quad (4)$$

and

$$M(OH)^+ + H_2O \rightarrow M(OH)_2 + H^+ \quad (5)$$

When iron is the cation, then production of acidic solutions is most pronounced (Table 3.2). However, it should be noted that not all sulfides generate acidity on oxidation(Thornber, 1992). Indeed sulfides of the type M_2S such as Arsenopyrite and Chalcocite actually consume H+ on oxidation:

$$2Cu_2S + 6H_2O + 5O_2 = 4Cu^{2+} + 2SO_4^{2-} + 2H^+ + 8OH^-$$

Dissolution or oxidation of pyrite initially produces Fe^{2+}, which is immediately oxidized to Fe^{3+} which is either precipitated as an oxyhydroxide or reduced by pyrite generating more Fe^{2+} and increased acidity. The rate at which these reactions occur are first order (McKibben & Barnes, 1986) and fairly rapid. For example at pH 1, 3m^2 of pyrite per litre of solution will reduce 50% of the initial ferric concentration in approximately 50 minutes.

Oxidation of ferrous iron by oxygen has been shown to be a function of pH and can be defined by the reaction rate:

$$-d[Fe^{2+}] = k' \, [Fe^{2+}] \, [O_2]$$

where $k=10^{-7}$ $atm^{-1}min^{-1}$ at 298 K.

The rate of sulfide oxidation can be controlled by the rate at which oxygen is supplied and reduced at the cathode-solution interface. The separation of the cathodic oxygen-consuming, alkali-producing reaction from the anodic, oxidizing, dissolution, acid-producing reaction will have a major control on the mineralogy of the resulting assemblage. The greater the distance between cathode and anode, the more extensive the conducting area and consequently the greater the potential for sulfide oxidation. Anodic reactions can occur deep within cracks, fissures and along grain boundaries where solutions can penetrate without the necessity for substantial dissolved oxygen (Lowson, 1982; Thornber, 1975; 1992).

The cathodic oxygen reduction reaction will be favoured on the more resistant sulfide grains, such as pyrite, chalcocite and covellite or on various gangue minerals. These resistant sulfide grains will become isolated with continued oxidation and form separate cells which will oxidize more slowly. Where the cathodic reaction dominates, water pH increases and released metals will react to form metal salts. A general sequence for pyrite oxidation, as an example of sulfide oxidation, is given in Table 3.2

Table 3.2: Oxidation Reactions of Iron Sulfide and Sulfate Minerals Generating Acidity (after Kleinnman and Pacelli, 1991; Thornber, 1992)

Reaction 1	
	a) $FeS_2 + 3\frac{1}{2}O_2 + H_2O = Fe^{2+} + 2SO_4^{2-} + 2H^+$ b) $2FeS_2 + 7O_2 + 2H_2O = 2Fe(SO_4) + 2H_2(SO_4)$
Reaction 2	
	a) $Fe^{2+} + 2\frac{1}{2} H_2O + \frac{1}{4}O_2 = Fe(OH)_3 + 2H^+$ b) $2Fe(SO_4) + H_2(SO_4) + \frac{1}{2}O_2 = Fe_2(SO_4)_3 + H_2O$
Reaction 3	
	$Fe^{2+} + \frac{1}{2}O_2 + H^+ = Fe^{3+} + \frac{1}{2}H_2O$
Reaction 4	
	$FeS_2 + 14Fe^{3+} + 8H_2O = 15Fe^{2+} + 2SO_4^{2-} + 16H^+$
Stage 1	
	Reaction 1: proceeds abiotically and by bacterial oxidation (reaction b more common with bacterial oxidation) Reaction 2: proceeds abiotically, slows as pH falls (reaction b more common with bacterial oxidation) pH approximately 4.5 or higher, high sulphate, low Fe, low pH
Stage 2	
	Reaction 1: proceeds abiotically and by bacterial oxidation (reaction b more common with bacterial oxidation) Reaction 2: proceeds at rate determined primarily by activity of bacteria such as *T.ferrooxidans* pH approximately 2.5-4.5, high sulphate, Fe and low pH. Low Fe^{3+}/Fe^{2+} ratio
Stage 3	
	Reaction 3: proceeds at rate determined by activity of *T.ferrooxidans* Reaction 4: proceeds at rate determined by rate of reaction 3 pH generally below 2.5, high sulphate, total Fe and low pH. High Fe^{3+}/Fe^{2+} ratio

Consequently, massive sulfide ores are generally good conductors; however, those which contain major amounts of sphalerite and/or significant pyrite are much poorer as both minerals have moderate resistivities (Thornber, 1992). With increased acidity most metals such as Fe, Cu or Al will become more soluble.

Where sulfides are more dispersed, such as in the Copper Flat ores, the distance between oxidizing sulfides is greater and conduction is reduced so the extent of oxidation is not as great. Each sulfide grain weathers as an isolated cell and the only influence that one sulfide grain can have on another is via aqueous solution. Access by dissolved oxygen will determine leaching, and sulfide composition will influence pH, water chemistry, reaction rate, and secondary mineralogy. Generally, leaching is greatest near the surface.

3.2. *Secondary source of acidity*

During weathering, sulfides produce a range of sulfates, hydroxides and oxides which are stable in oxidizing acidic pH, for example the formation of jarosite (Figure 3.1).

A good example is the formation of römerite from the oxidation of pyrite:

$$3FeS_2 + 11O_2 + 16H_2O = Fe^{2+}Fe^{3+}{}_2(SO_4)_4.14H_2O + 2SO_4^{2-} + 4H^+$$

For each mole of FeS_2 oxidized, only a third of the available sulfate and "one-eighth" of the available hydrogen is released. The rest is stored as unhydrolized, partly oxidized iron mineral. These sulfate minerals are termed **Acid Volatile Sulfates.** The most common of these salts are given in Table 3.3. Not all release hydrogen and sulfate on dissolution, but all release sulfate anions.

These minerals are highly soluble, therefore, they represent an instantaneous source of acidic sulfate-rich water upon dissolution and hydrolysis, for example the dissolution of römerite:

$$Fe^{2+}Fe^{3+}{}_2(SO_4)_4\cdot 14H_2O = 2FeO.OH + Fe^{2+} + 4SO_4^{2-} + 6H^+ + 9H_2O$$

Subsequent oxidation of ferrous iron and hydrolysis of ferric iron at pH > 2 provides an additional source of acidity (Table 3.2). Hence, iron-sulfate hydrate minerals are important as both sinks and sources of acidity, sulfate, and possibly metal ions on precipitation and rapid release on exposure to moisture (Cravotta, 1994).

Optical microscopy of field samples suggests that precipitates collected in November 1996 consist of chalcanthite, coqumibite, gypsum, aragonite, jarosite, alunite andbrochanthite. Langite and melanterite are present as pit wall precipitates close to the current pit lake level. Azurite, malachite, pseudomalachite, beaverite, legrandite, atacamite and turquoise are also present in the south wall of the pit and on the higher benches to the east. Within an andesite intrusive in the east wall vesicles associated with the contact margin of the dyke with the monzonite are infilled with azurite, malachite, scorodite, libethenite, atacamite, schlumbergite and cuprite along with zeolites, calcite and quartz. The results of X-Ray diffraction analysis are forthcoming to confirm the mineralogy.

3.3. *Acid Consumption or Neutralization*

Acid-neutralization reactions results from mineral buffering of H^+ in drainage. This buffering is frequently accompanied by the precipitation of metal-hydroxides, hydroxy-sulfates and oxyhydroxide minerals. These reactions can reduce the rate of acid generation by forming an inhibitory surface coating to the reactive sulfides. The major buffering minerals for ARD are shown in Table 3.4

The major mineral phase which consumes acidity is calcite by the reaction:

$$CaCO_3 + H_2SO_4 + H_2O = CaSO_4.\ 2H_2O + CO_2$$

Carbonate minerals possess varying degrees of acid neutralization. In the case of siderite and to a lesser extent ankerite, the reason for the limited neutralizing capacity is that ferrous iron in these minerals is an additional source of acidity due to the strong hydrolysis of ferrous iron in solution .

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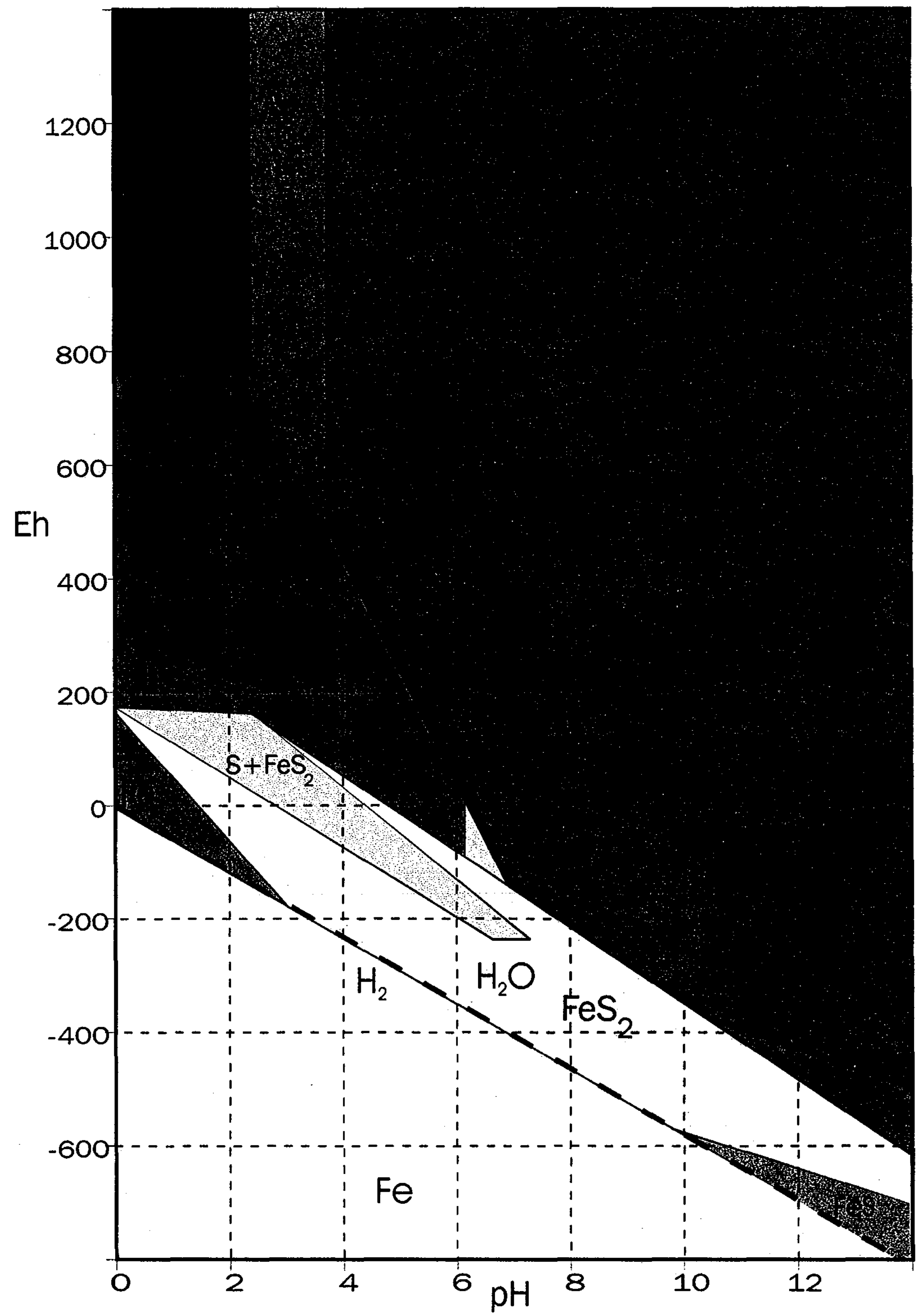

Eh-pH DIAGRAM FOR Fe- C -S - H O - O SYSTEM
(Fe,S =10^{-6}M and $P_{CO} = 10^{-2}$)

DATE: 02/12/96	PROJ. No. U857	COPPER FLATS	
SRK		**Eh-pH DIAGRAM FOR THE Fe-S-C-O-H AT 298 K**	Figure 3.1

Table 3.3: Acid Volatile Salts

Selected soluble sulfates		Selected less soluble sulfates	
	Iron minerals		
copiapite	$Fe^{2+}Fe_4^{3+}(SO_4)_6(OH)_2.20H_2O$	amerantite	$Fe^{3+}(SO_4)OH.3H_2O$
coquimbite	$Fe_2^{3+}(SO_4)_3.9H_2O$	fibroferrite	$Fe^{3+}(SO_4)OH.5H_2O$
ferricopiapite	$Fe_{2/3}^{2+}Fe_4^{3+}(SO_4)_6(OH)_2.20H_2O$		
melanterite	$Fe^{2+}SO_4.7H_2O$	schwertmannite	$Fe_8O_8(SO_4)(OH)_6$
ferrohexahydrite	$Fe^{2+}SO_4.5H_2O$		
paracoquimbite	$Fe_2^{3+}(SO_4)_3.9H_2O$		
rhomboclase	$HFe(SO_4)_2.4H_2O$		
rozenite	$Fe^{2+}SO_4.4H_2O$		
siderotil	$Fe^{2+}SO_4.6H_2O$		
szomolnokite	$Fe^{2+}SO_4.H_2O$		
	Other transition metals		
Alunogen	$Al_2(SO_4)_3.17H_2O$	Anglesite	$PbSO_4$
Bianchite	$ZnSO_4.6H_2O$	Antlerite	$Cu_3(SO_4)(OH)_4$
Chalcanthite	$CuSO_4.5H_2O$	Basalumite	$Al(SO_4)(OH)_{10}.H_2O$
Goslarite	$ZnSO_4.7H_2O$	Brochantite	$Cu_4(SO_4)(OH)_6$
Gunningite	$ZnSO_4.H_2O$	Jurbanite	$Al(SO_4)(OH).5H_2O$
Retgesite $.2H_2O$	$NiSO_4.6H_2O$	Langite	$Cu_4(SO_4)(OH)_6$

Alunite-Jarosite Group

Very common group of Acid Mine Drainage & Gossan minerals. Can incorporate many trace metals and oxyanions.

$A^{2+}Fe_4^{3+}(SO_4)_6(OH)_2.20H_2O$ *or* $B_{2/3}^{3+}Fe_4^{3+}(SO_4)_6(OH)_2.20H_2O$

A= Ca, Cu, Fe, Mn, Mg, Zn, Co, Ni

B= Al, Fe, Cr.

Sulfate group can be partially replaced by selenite, phosphate, arsenate oxyanions.

Some examples:

argentojarosite	$(K,Ag)\ Fe_3^{3+}(SO_4)_2(OH)_6$
alunite	$K\ Al_3^{3+}(SO_4)_2(OH)_6$
jarosite	$K\ Fe_3^{3+}(SO_4)_2(OH)_6$
plumbojarosite	$(Pb,K)\ Fe_3^{3+}(SO_4)_2(OH)_6$
osarizawaite-beaverite	$(Pb,Cu)_2(Al,Fe^{3+})_2\ (SO_4)_2(OH)_6$

[1] Or equivalent amorphous phase

[2] Acid consuming potential is given as being the weight of the mineral required to have the same neutralizing capacity as 100 g of calcite.

Table 3.4: Principal pH-buffering phases for ARD observed in this study

Mineral	Formula	Acid Consumption Potential[2]
Carbonates		
Calcite	$CaCO_3$	100
Dolomite	$CaMg(CO_3)_2$	92
Siderite	$FeCO_3$	120
Ankerite	$Ca(Fe,Mg)(CO_3)_2$	108
Hydroxides		
Gibbsite[1]	$Al(OH)_3$	26
Goethite	FeO□OH	89
Ferrihydrite[1]	$Fe(OH)_3$	96
Manganite	MnOOH	88
Aluminosilicates		
Chlorite	$(Mg,Al,Fe)_6(Si,Al)_4O_{10}(OH)_8$	124
Muscovite	$KAl_2(Si_3Al)O_{10}(OH,F)_2$	154
Alkali Feldspars	$(K,Na)AlSi_3O_8$	169
Plagioclase Feldspars	$NaAlSi_3O_8$-$CaAl_2Si_2O_8$	137
Pyroxene group		120-155
Amphibole group		110-150
Clay mineral groups		105->200

The order of carbonate neutralizing capacity is dolomite>calcite>ankerite> siderite. This order of reactivity is partly controlled by equilibrium mass-action constraints and partly by kinetic limitations. In the case of calcite, dissolution is rapid (Garrels & Christ, 1965; Appelo & Postma, 1993). Generally, the rate of dissolution is sufficient to maintain water pH in the range 7.5-7.8. Dolomite dissolution is slower, and in the case of ankerite and siderite disequilibrium is common.

If all available calcite is removed then pH will decrease to a dolomite buffer range of pH 6.9-7.9. When dolomite is depleted pH will fall to the siderite buffer regime of pH 4.8-6.3. In the carbonate buffer zones the precipitation of metal hydroxides is promoted with dissolved Fe derived from sulfides, Mn and Al from wallrock oxides and silicates. As acid generation continues and carbonate minerals are depleted, pH will fall until the hydroxide buffer zones are reached, for $Al(OH)_3$ this is the pH range 4-4.3 and for $Fe(OH)_3$ the pH range 2-4.

Under very low pH conditions, the dissolution of aluminosilicates can be an important acid neutralization mechanism. Dissolution is slow and also involve the additional contribution of dissolved secondary minerals as well.

3.4. Adsorption and Coprecipitation

This is the process of element binding at the mineral solution interface and like solubility is pH dependent. For example, the adsorption of arsenic species by goethite. Many oxide surfaces change from positive at low pH (thus attracting anions) to negative at high pH (attracting cations). This occurs through adsorption at the surface of hydroxyl groups with increasing pH. The pH at which the change occurs is termed the *point of zero charge* or pH_{pzc} (Table 3.5). This is a measure of a surface's ability to sorb ions from solution (Parfait, 1978; Bowell, 1994). Mine drainage chemistry and particularly, the level of As and heavy metals has been shown to be influenced by adsorption onto precipitated iron oxyhydroxides or "ochres" (Bowell et al., 1996).

Table 3.5: pH_{pzc} for Common Minerals Associated with Mine Ochres (Parfait, 1978)

Mineral	pH_{pzc}
Quartz	1.8-3.5
Kaolinite/Illite	3.3-6
Smectite	2.5-6
Hematite	6.5-8.6
Goethite	6.5-7.3
Ferrihydrite	6.9
Jarosite	6.7-8

The presence of other adsorbents, such as humic substances, will also affect adsorption potential by competing for available sites on the mineral surface or for dissolved species. Precipitation of insoluble salts can lead to reduced solubility due to co-precipitation. For example, anhydrite when Ca is added to a sulfate-rich solution, especially at high pH. Co-precipitation is influenced by solubility and adsorption properties indicating a similar bonding mechanism. An important control on the diversity of the precipitated mineral assemblage is pH For example, in the oxidation of sulfides at low pH, only Fe oxides and oxyhydroxides are formed while at higher pH other salts such as covellite, smithsonite and malachite are also precipitated.

Only a small proportion of the base metals present in low pH waters will be retained, sorbed onto the Fe hydroxide; however, elements such as As, Sb, W and Mo will be retained, adsorbed as oxyanions. During sulfide oxidation there is a tendency for Fe and base metals to diffuse towards the surface of the gangue minerals and precipitate by hydrolysis reactions, lowering pH and continuing the leaching process. These reactions occur some distance from the leaching surface to form Fe oxyhydroxide crusts. Precipitated Fe oxyhydroxides can adsorb substantial concentrations of liberated metals from the mine waters depending on solution pH. Many oxide surfaces including those of goethite, are positively charged at low pH and become negatively charged at higher pH due to the increased binding of hydroxyl groups. Consequently, at low pH, oxyanions such arsenate will be adsorbed while with a pH increase metal ions will be adsorbed when the mineral surface charge is negative. The point at which this change occurs, i.e. the point at which the surface has a net zero charge can be used as a measure of the adsorption potential at another pH. The presence of smectite ($Na_3(Al,Mg)_2Si_4O_{10}(OH)_2$?$H_2O$) and kaolinite ($2[Al_2Si_2O_5(OH)_4]$) in the flocculated material could explain the higher retention of base metals, even in very acidic waters, than has been recorded in ochres from other mine sites. Both of these clay minerals can have a pH_{zpc} (zero point charge) as low as 2.2 and up to 5. Consequently, they could provide negatively charged Helmholtz layers at their surfaces, leading to favourable conditions for sorption of positively charged base metals at pHs as low as 2.2. The surface properties of the different minerals will also be affected by other influences such as the presence of organic acids which can reduce metal adsorption by competitive adsorption and by complexation (Tipping and Cooke, 1990; Bowell, 1994).

Although pH is a major control, the structure of the precipitated ochres may also influence element adsorption as it is also variable with Eh-pH changes. Mineral precipitates formed in highly acidic waters tend to be more crystalline and as a result have a lower surface area, and consequently a lower adsorptive capacity. Conversely, mineral precipitates from lower acidity waters are poorly crystalline and as such will have a larger surface area and greater capacity to retain ions at mineral surfaces.

Fe^{2+} and SO_4^{2-} are most likely released through bacterially catalysed decomposition of iron sulfides. A variety of intermediate phases, such as melanterite, can be formed depending on conditions being stabilized during humid or arid conditions. For example, where evaporation occurs ferric sulfates have been shown to precipitate; and these intermediate phases, if accumulated over time, may form their own source of iron, sulfate and acidity if remobilised[16]. On oxidation and hydrolysis, or ferrolysis, ferric minerals are formed. If conditions involve low-pH, high dissolved sulfate and sustained bacterial activity jarosite, ferricopiapite, schwertmannite or coquimite may be formed. With jarosite precipitation controlled by the level of Na, K, and possibly sulfate as well as pH. Mildly acidic solutions may form ferrihydrite or lepidocrocite while higher alkalinity levels will influence the precipitation of goethite. The ubiquitous presence of goethite in mine ochres would suggest that most phases are only transient with respect to goethite. The mineral speciation of the produced ochres is important in influencing the retention of metals from drainage. The presence of clay minerals in the ochres may accelerate the oxidation of ferrous iron and production of ochres by polymerization of ferric oxyhydroxides.

The mineral speciation of precipitated ochres will influence the surface chemistry of the ochres, and the ability of the ochre to accumulate available metals or oxyanions. Surface reactions may also influence mineralogy with some transient phases stabilized by complexing outside the predicted environment from the above model. For example, the transformation of ferrihydrite may be temporarily delayed by stabilization through adsorption of SiO_4 or organic compounds. The pH of drainage waters will influence the prevailing surface chemistry of the ochres depending on the pH_{pzc} of constituent minerals in the ochres.

The presence of clays like montmorillonite would greatly increase the potential for adsorption of cations at acidic pHs due to the low pH_{pzc} (Table 3.4). However, mineralogy is not the only consideration. The immobilization of metals released from associated sulfides through gangue neutralization, and their availability and speciation will influence the extent to which they are attracted to the surface of the ochres. Below pH_{pzc}, mineral surfaces will be slightly positively charged and, therefore, attract oxyanion species; above this point, they will become more negative in character and, therefore, more likely to attract cations.

4 GROUND WATER CHEMISTRY

Ground water chemistry from the Copper Flat project area is shown in Table 4.1 for water around the pit and from the ground water monitor wells shown in Figure 2.1.

The data indicate that all ground water in the vicinity of the project area is alkaline (pH> 7) with alkalinity greater than 100 mg/l. The data plot on a Piper diagram as Mg-Ca-HCO3 waters (Figure 4.1) and on a Younger diagram (Younger, 1995) as sulfate-rich to sulfate-poor alkaline waters (Figure 4.2). The dominant Ca-Mg-bicarbonate signature of ground water is most likely a reflection of rock-water interactions with the regional host rocks - andesite, dolomite and limestone. (Hem, 1985; Postma & Appelo, 1993). The elevated F levels of 0.5-3 mg/l is characteristic of ground water leaching of calc-alkaline magmatic rocks (Bowell et al., 1996).

Table 4.1: Summary of Ground Water Chemistry of Copper Flat Area

Parameter	Range (in mg/l except where stated otherwise)
pH	7.25-8.11
Conductivity, µm/cm	293-2026
Bicarbonate	149-279
Nitrate	<1-5
Sulfate	12-720
Fluoride	0.36-1.4
Chloride	12-190
Total Dissolved Solid	190-1570
Calcium	48-270
Copper	<0.025-0.03
Iron	<0.05-3.7
Magnesium	1-56
Manganese	<0.03-4
Molybdenum	<0.05
Potassium	1-10
Sodium	28-460

Despite the presence of mineralized lithologies around the pit, no evidence of metal leaching or of acid generation is reflected in ground water chemistry, up or down gradient of the pit lake (Table 4.1). This observation would support the hydrogeological model proposed for the site which indicates the pit acts as a sump below the water table with no leakage into the ground water. The sulfate levels observed in ground waters is probably a combination of two factors:

- Some oxidation of sulfide to sulfate
- Conservative behaviour of sulfate where gypsum is undersaturated.

For the ground water chemistry reported in Table 4.1, the saturation indices of calcite, gypsum and anhydrite has been calculated (Table 4.2).

The minerals most likely to form can be predicted from their Saturation Indices. Saturation Indices can be used to predict mineral phases likely to precipitate with respect to water chemistry (SI>0). Indices which are low negative values are likely to precipitate if one or more of the constituents is increased slightly. Values which are large negative SIs (<-3) are unlikely to form and if present are most probably dissolving. From the above information it can be observed that the alkaline, Ca-rich nature of ground water is reflected in the prediction that calcite is very likely to precipitate, and if sulfate is only slightly elevated, anhydrite and gypsum will precipitate. Chalcanthite, however, is unlikely to be stable and would not be expected to form in the aquifer. This suggests that high levels of sulfate in ground water are unlikely to occur long term as active precipitation will take place. It is also unlikely that secondary acid volatile sulfates will form in the aquifer as they will be unstable with respect to gypsum and anhydrite and dissolved constituents.

Table 4.2: Saturation Indices for selected minerals in ground water wells

Mineral	Saturation Indices			
	GWQ96-22	GWQ96-23	GWQ94-13	MW-11
Anhydrite	-1.252	-1.416	-0.495	-2.234
Calcite	0.299	0.771	0.619	0.536
Chalcanthite	-8.937	-9.515	-8.298	-12.337
Gypsum	-1.041	-1.206	-0.284	-2.303

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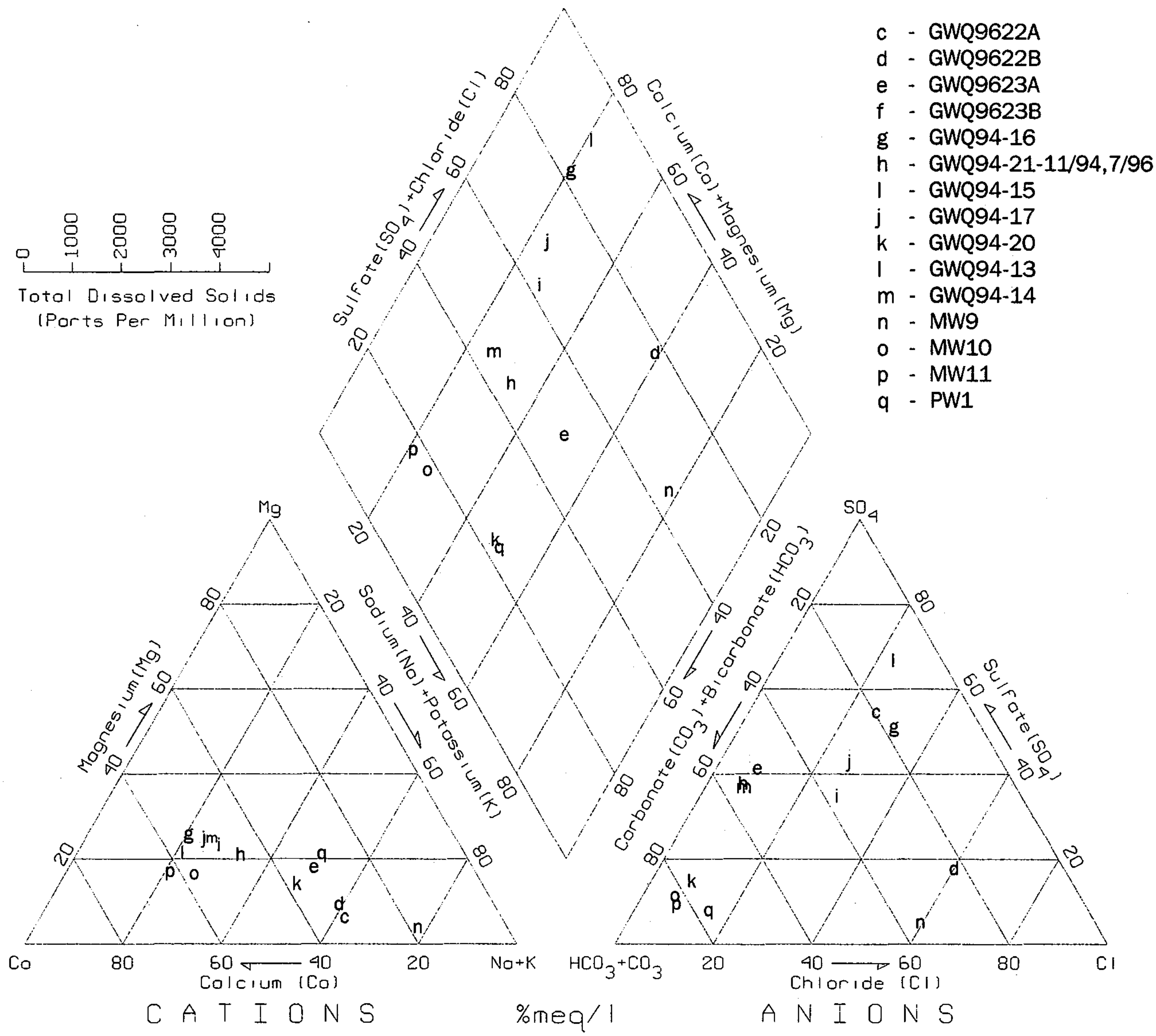

DATE: 12/3/96	PROJ. No. U857	COPPER FLAT	
SRK		**PIPER DIAGRAM OF GROUNDWATER FROM THE COPPER FLAT AREA**	Figure 4.1

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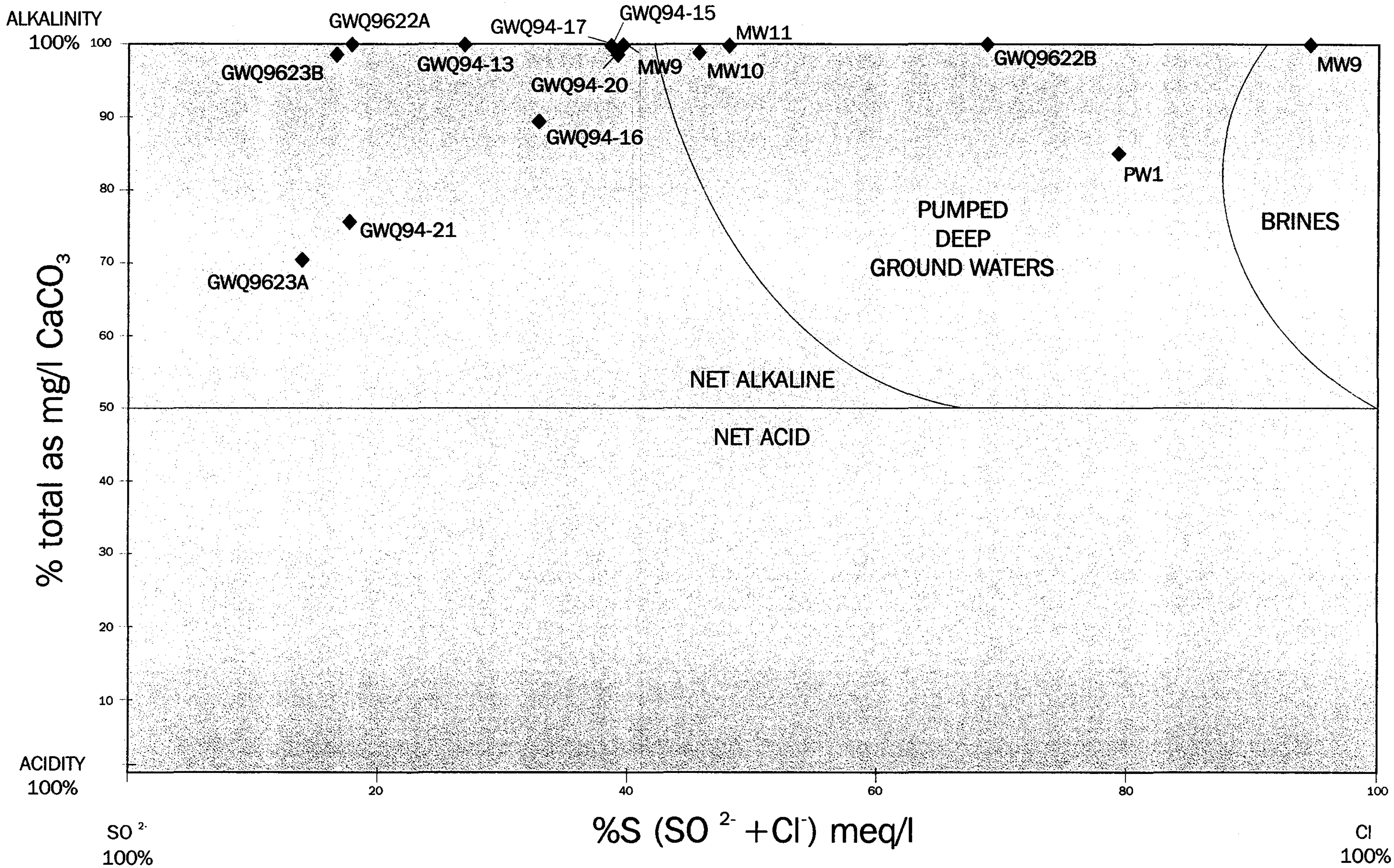

DATE: 4/12/96	PROJ. No. U857	COPPER FLAT	
SRK		YOUNGER DIAGRAM FOR COPPER FLAT GROUNDWATER	Figure 4.2

5 WASTE ROCK GEOCHEMISTRY

An assessment of the potential of waste rock to produce Acid Rock Drainage (ARD) has been made in the Hydrogeological investigations at Copper Flat by SRK (SRK, 1995 *Copper Flat Mine: Hydrogeological Studies*). Information on sampling and analytical protocol is given in that report and is not repeated herein.

5.1. *Bulk geochemistry of waste rock*

From whole rock analysis of waste rock samples (Appendix A), the primary constituents are Al, Ca, Fe, Mg and K. Trace metals of significance (> 10 ppm) are Ba, Cu, Co, Mn, Mo and Zn). Several million tons of waste rock are currently piled around the pit and along the southeast slope of Animas Peak. Although small seeps have been reported from these rock piles, none were observed during the present study. SRK has previously classified the waste rock in the area as oxidized, transitional and unoxidized (SRK, 1995). The difference is the proportion of pyrite observed in the material. The rock piles have been classed on the proportion of each type of material present with the west pile being primarily transitional waste, the north rock pile being a combination of unoxidized and oxidized waste and the south and eastern rock piles comprising essentially unoxidized sulfidic waste.

5.2. *Static test results*

Paste pH tests involving the mixing of approximately equal portions of solid sample and deionized water to produce a saturated paste are shown for material from the pit walls and waste rock dumps in Figure 5.1. Similar to the results reported in the 1995 study, low pH areas are observed in the West and North Waste Rock Dumps indicating release of stored acidity from ongoing oxidation and/or consumption of alkalinity from previous oxidation events. In the East dump material paste pH results suggest that insignificant oxidation has or is taking place with relatively neutral pH values recorded (Table 5.1). The acidic pH's from the West dump (pH 2.5) were observed in partially oxidized material which forms a cap to the sulfide mineralization. The values suggest that these materials are still undergoing oxidation.

Using a modified leach test, the total acid generating and consuming potential of material from the different waste rock piles has been assessed (Table 5.1). The results show that much of the material tested is acid generating in the waste rock piles and has the **potential** to produce an acidic metal-sulfate seep. An exception in the East Dump area is acid consuming and is primarily comprised of sulfidic quartz monzonite. This is reflected in the historical data on these dumps. With the exception of the small seep observed at the East Waste Rock Disposal Area, no other acidic seeps have been reported on any of the disposal areas, despite being exposed to water and oxygen for over 12 years.

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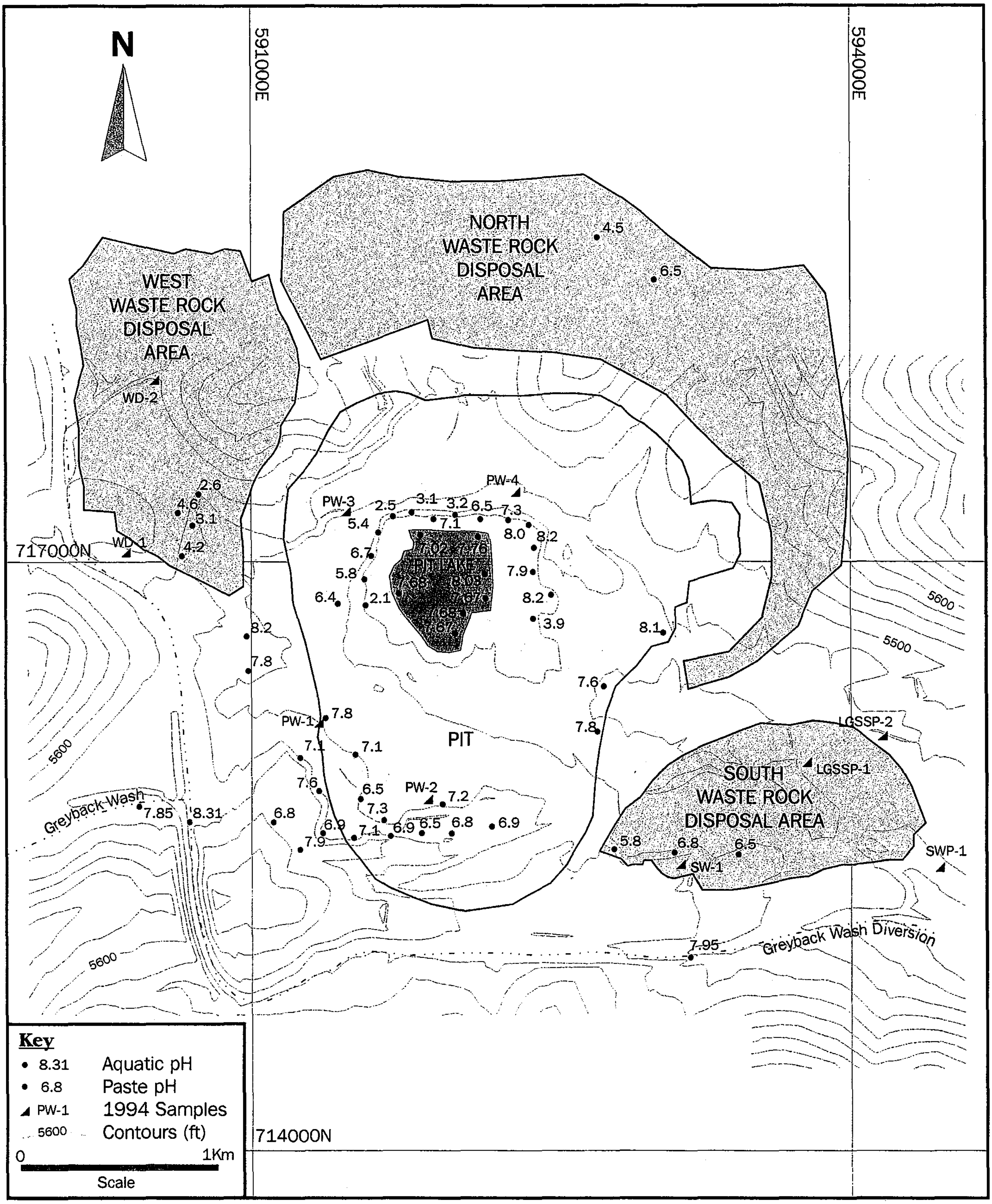


DATE: 3/12/96	PROJ. No. U857	COPPER FLAT	
SRK	PASTE AND MEASURED AQUATIC pH MAPS OF WASTE ROCK, PIT LAKEN AND SURFACE WATERS		Figure 5.1

Table 5-1: Summary of Static Test Results

Sample ID	Sample Description	Paste pH	Total Sulfur (%)	Pyritic Sulfur (%)	Sulfate Sulfur (%)	Neutralizing Potential (t/kt)	Sulfide Sulfur (%)	Undefined Sulfur (%)	Pyrite AP (t/kt)	Pyrite NNP (t/kt)	Pyrite NP/AP (t/kt)	Sulfide AP (t/kt)	Sulfide NNP (t/kt)	Sulfide NP/AP (t/kt)
Tailings														
T-10-12	Tailings from borehole SRKBH-1-94	7.8	1.26	0.68	0.03	24	1.23	0.55	21.25	2.75	1.13	38.44	-14.44	0.62
T-5-7	Tailings from borehole SRKBH-1-94	7.5	1.10	0.53	0.18	31	0.92	0.39	16.56	14.44	1.87	28.75	2.25	1.08
	Average		**1.18**	**0.61**	**0.11**	**28**	**1.08**	**0.47**	**18.91**	**8.59**	**1.50**	**33.59**	**-6.10**	**0.85**
Waste Rock														
WD-1	West Dump Area, QM Waste Rock	2.7	4.34	2.12	0.005	0.1	4.34	2.22	66.25	-66.15	0.00	135.47	-135.37	0.00
PW-3	Pit Wall, Northwest of Pit Lake	2.6	2.20	0.84	0.005	0.1	2.20	1.36	26.25	-26.15	0.00	68.59	-68.49	0.00
SW-1	***Sulfide Waste Pile, QM Waste Rock***		***1.36***	***0.47***	***0.005***	***36***	***1.36***	***0.89***	***24.69***	***21.31***	***2.45***	***42.34***	***-6.34***	***0.85***
PW-2	***Pit Wall, Oxidized Cap Rock***		***0.37***	***0.04***	***0.005***	***11***	***0.37***	***0.33***	***1.25***	***9.75***	***8.80***	***11.41***	***-0.41***	***0.96***
PW-4	Pit Wall, Northeast of Pit Lake	3.9	1.89	0.78	0.005	16	1.89	1.11	24.38	-8.38	0.66	58.91	-42.91	0.27
SWP-1	Sulfide Waste Pile, QM Rock	6.8	3.08	1.46	0.005	40	3.08	1.62	45.63	-5.62	0.88	96.09	-56.09	0.42
LGSSP-1	Sulfide Waste Pile, QM Rock	6.6	1.52	0.61	0.005	47	1.52	0.91	19.06	27.94	2.47	47.34	-0.34	0.99
LGSSP-2	***Sulfide Waste Pile, QM Rock***	***6.9***	***0.61***	***0.20***	***0.005***	***39***	***0.61***	***0.41***	***6.25***	***32.75***	***6.24***	***18.91***	***20.09***	***2.06***
WD-2	West Dump Area, QM Waste Rock		1.98	0.87	0.005	60	1.98	1.11	27.19	32.81	2.21	61.72	-1.72	0.97
IDC-24-222-241	***QM From IDC Drillhole 24, 222-241 Feet***		***1.74***	***0.75***	***0.005***	***31***	***1.74***	***0.99***	***23.44***	***7.56***	***1.32***	***54.22***	***-23.22***	***0.57***
CF10-177.8-190	Andesite From Drillhole CF10, 177.8-190		2.86	1.77	0.06	52	2.80	1.03	55.31	-3.31	0.94	87.50	-35.50	0.59
CF10-190-199	***QM From Drillhole CF10, 190-199***		***3.59***	***1.09***	***0.07***	***44***	***3.52***	***2.43***	***34.06***	***9.94***	***1.29***	***110.00***	***-66.00***	***0.40***
CF10-214-220	QM From Drillhole CF10, 214-220		3.92	2.05	0.005	65	3.92	1.87	64.06	0.94	1.01	122.34	-57.34	0.53
H75-53-42	QM, Reverse Circulation Cuttings	8.2	1.77	0.88	0.005	36	1.77	0.89	27.50	8.50	1.31	55.16	-19.16	0.65
H75-64-44	QM, Reverse Circulation Cuttings	7.2	1.69	0.69	0.005	39	1.69	1.00	21.56	17.44	1.81	52.66	-13.66	0.74
H75-51-34	QM, Reverse Circulation Cuttings	8.6	2.02	0.72	0.005	49	2.02	1.30	22.50	26.50	2.18	62.97	-13.97	0.78
H75-48-58	QM, Reverse Circulation Cuttings	7.2	1.18	0.38	0.005	16	1.18	0.80	11.88	4.13	1.35	36.72	-20.72	0.44
H75-48-44	QM, Reverse Circulation Cuttings	7.4	1.06	0.15	0.005	9	1.06	0.91	4.69	4.31	1.92	32.97	-23.97	0.27
PW-1	Pit Wall, SW of Pit, Transition Zone, QM	6.1	3.61	2.0[illegible]	0.14	32	3.47	1.47	62.50	-30.50	0.51	108.44	-76.44	0.30
	Average		**2.15**	**0.94**	**0.02**	**33**	**2.13**	**1.19**	**29.39**	**3.36**	**1.97**	**66.51**	**-33.77**	**0.62**

Notes:
Sulfate sulfur non-detect reported as 1/2 of the detection limit
Neutralization potential non-detect reported as 1/10 of the detection limit
Sulfide Sulfur = Total Sulfur - Sulfate Sulfur
Samples in *italics* selected for kinetic testing

AP pyrite) = Pyritic Sulfur x 31.25
AP (sulfide) = (Total Sulfur - Sulfate Sulfur) x 31.25

5.3. Kinetic test results

Kinetic testing on a representative suite of samples in a humidity cell (Figure 5.2) using 29-7 day cycles with 3 days humidified air, 3 days dry air.

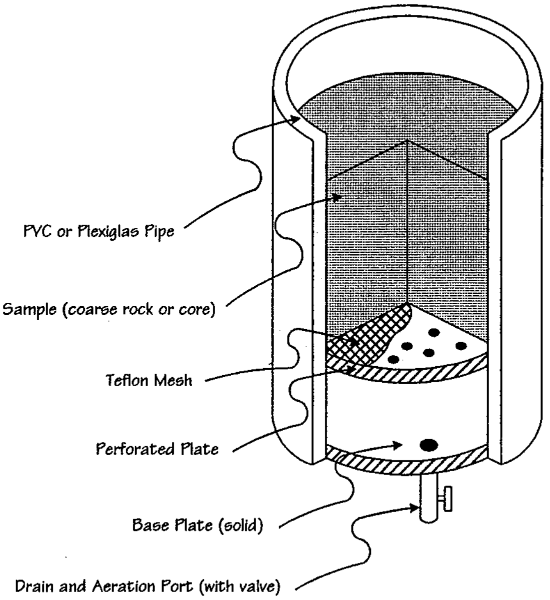


Figure 5.2 Humidity Column Design

The results of these tests are presented in the 1995 hydrogeological report and only those of significance will be discussed herein. In both samples collected from the waste rock disposal areas, pH was above 7 except at week 20 when a sharp decrease occurred, believed to be in response to contamination of the distilled water used in the experiments. When tests resumed in week 27 pH levels were again above 7. Oxidizing conditions were indicated to have occurred throughout the experiments, based on the positive Eh readings.

The initially high conductivity in sample LGSSP-2 gradually dropped, possibly due to dissolution of sulfate salts (a similar pattern in leached sulfate, and initially Fe and acidity, are also observed suggesting initially dissolution of Fe-sulfates followed by dissolution of Na-, Mg- or Ca-salts). Alkalinity shows a gradual decrease with time, suggesting any contained alkalinity is used up, possibly to buffer acid generation. However acid generation from the samples is slow and is always an order of magnitude lower than alkalinity trends.

Initially acid generation shows a rapid increase (up to 8 mg/l total acidity), possibly due to dissolution of some Fe-sulfates.

The data indicate that if these materials are left exposed indefinitely, then the neutralizing potential will be consumed before the acid potential.

5.4. Water Quality and Environmental Implications

In the waste rock material it would be predicted that acidic seeps should be observed based on the static tests and the abundance of pyrite in the material. However, this is not reflected in water chemistry from this area or in the kinetic test work.

Acid generation is taking place in the waste rock material at slow rates and, if left unmanaged, it may ultimately produce acidic seepage. However, the rate of acid

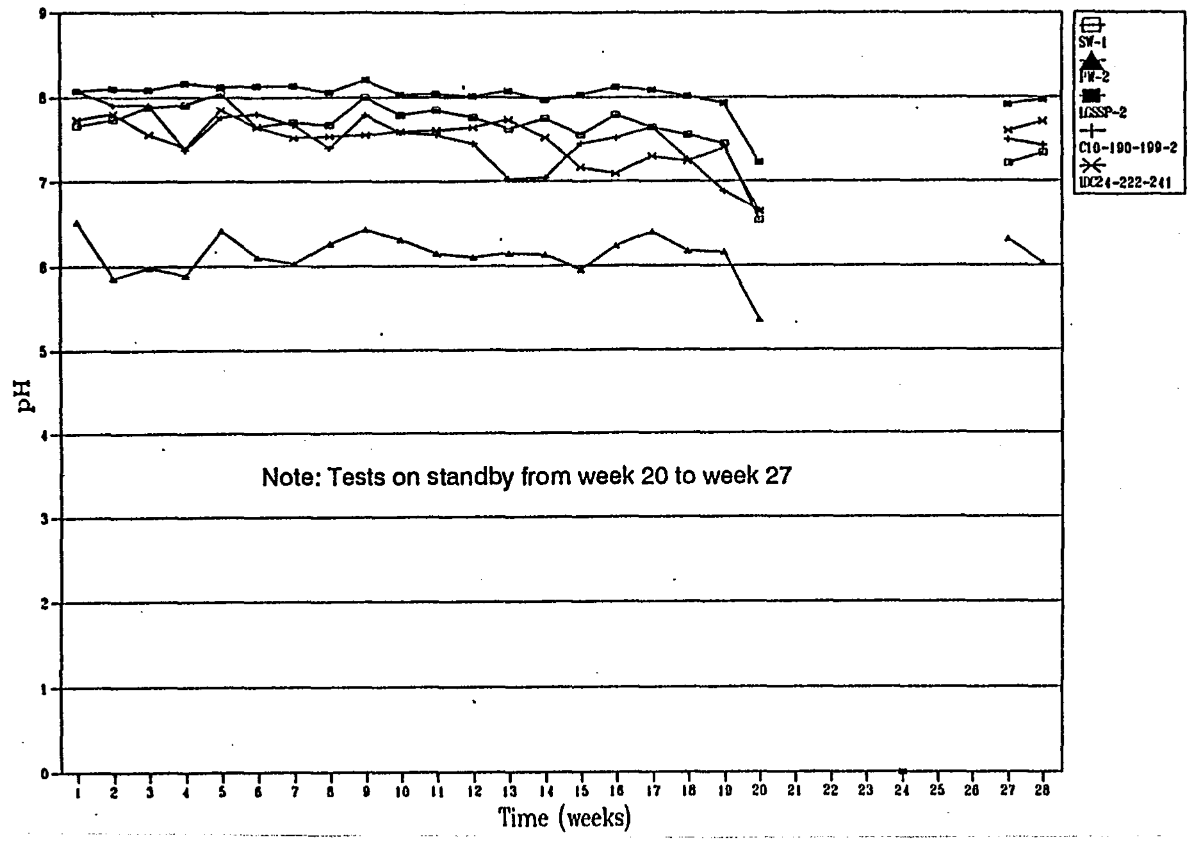


Figure 5.3 Kinetic Test Results - pH vs. Time

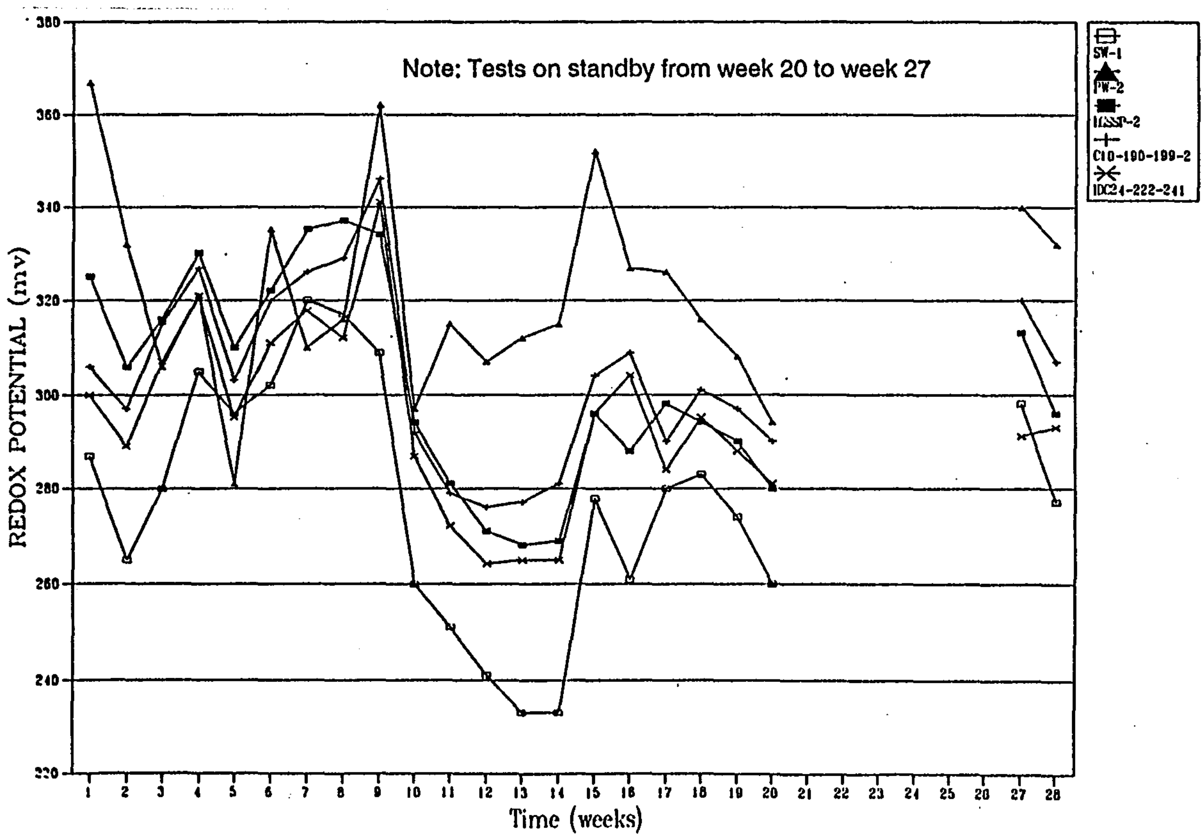


Figure 5.4 Kinetic Test Results - Redox Potential vs. Time

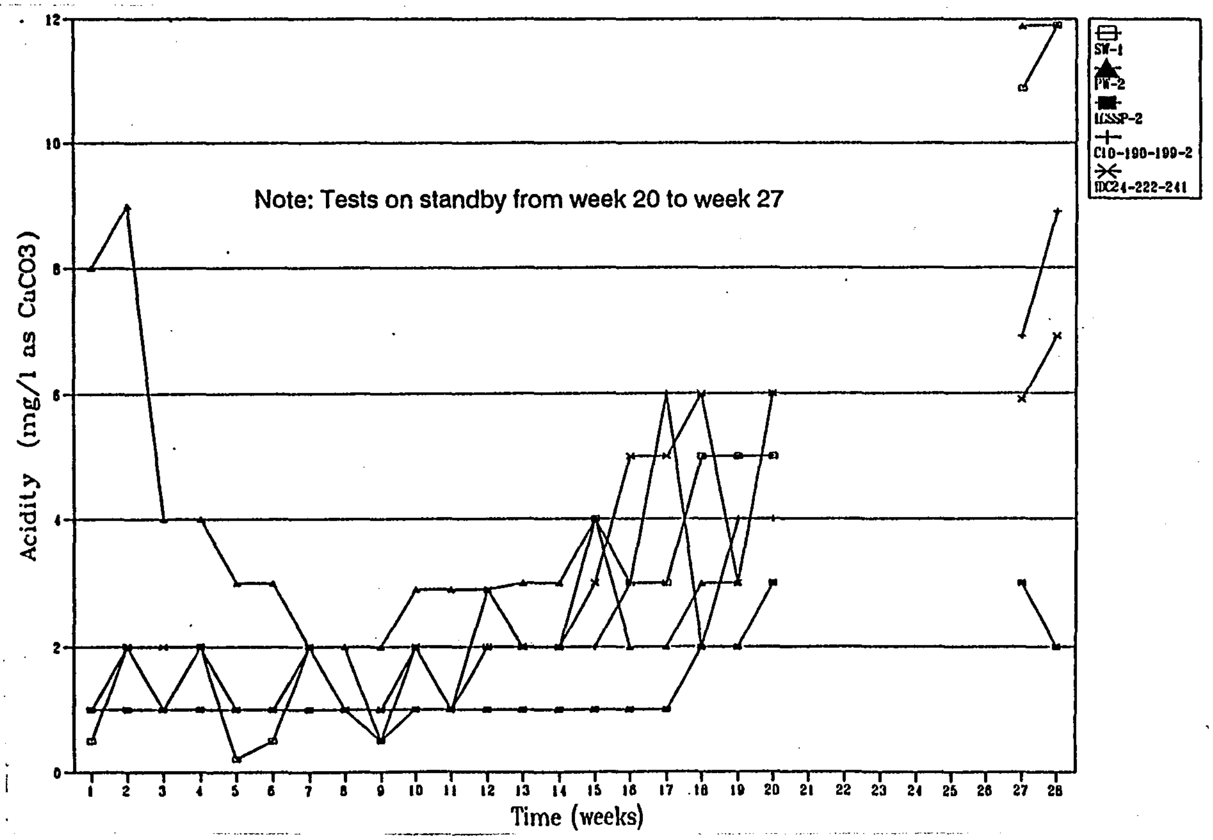


Figure 5.5 Kinetic Test Results - Acidity vs. Time

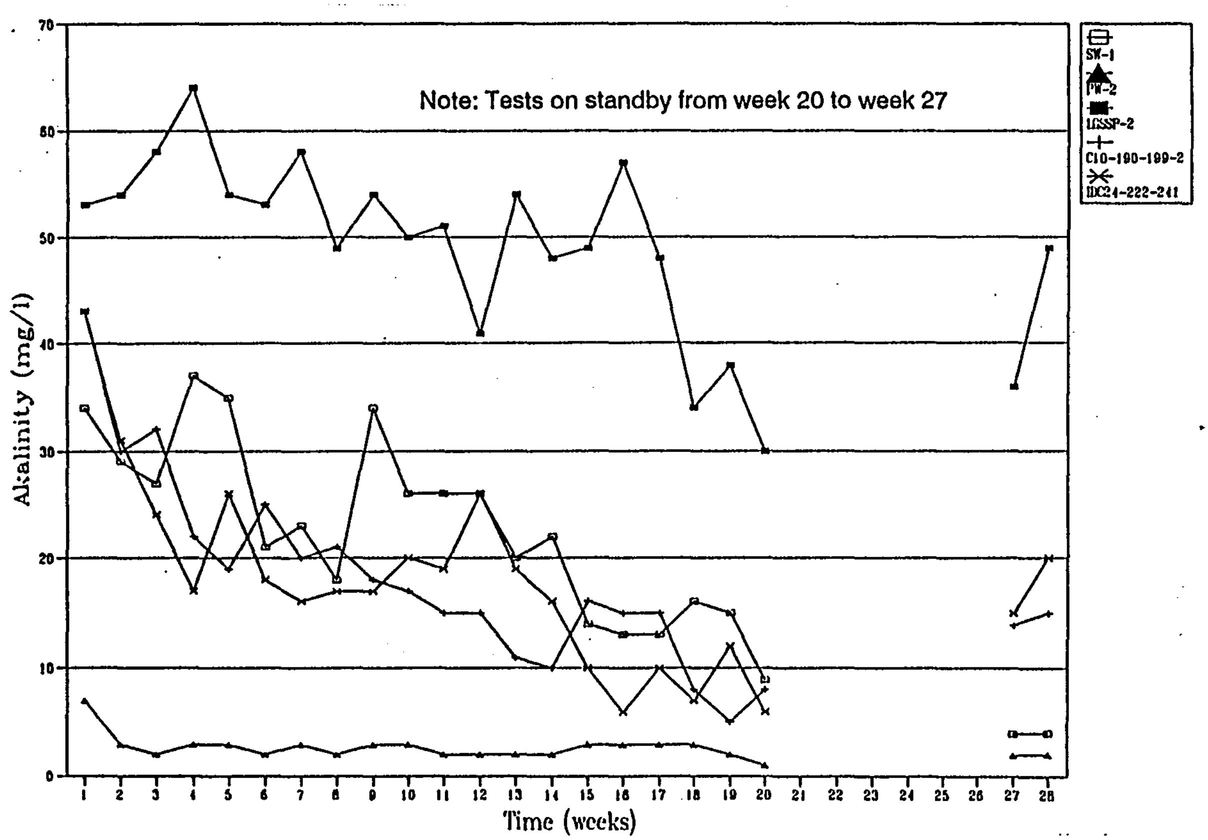


Figure 5.6 Kinetic Test Results - Alkalinity vs. Time

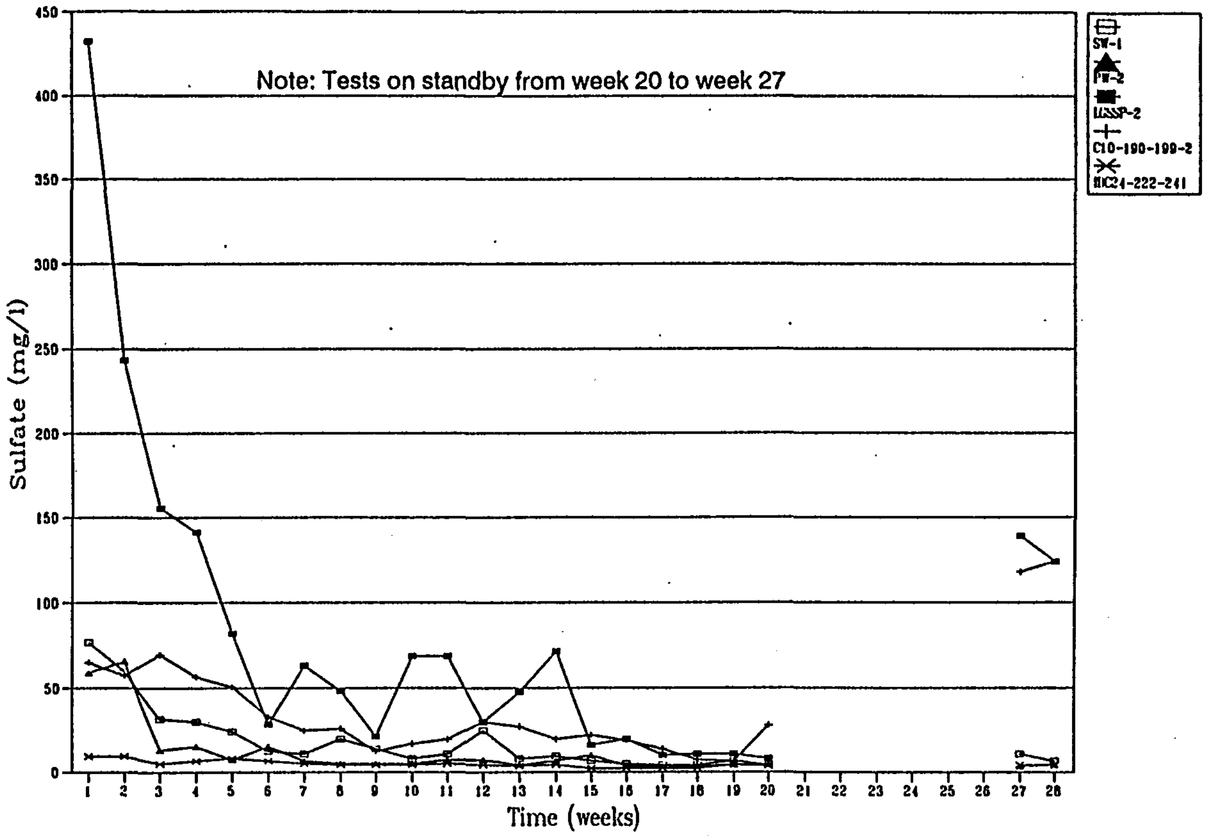


Figure 5.7 Kinetic Test Results - Sulfate vs. Time

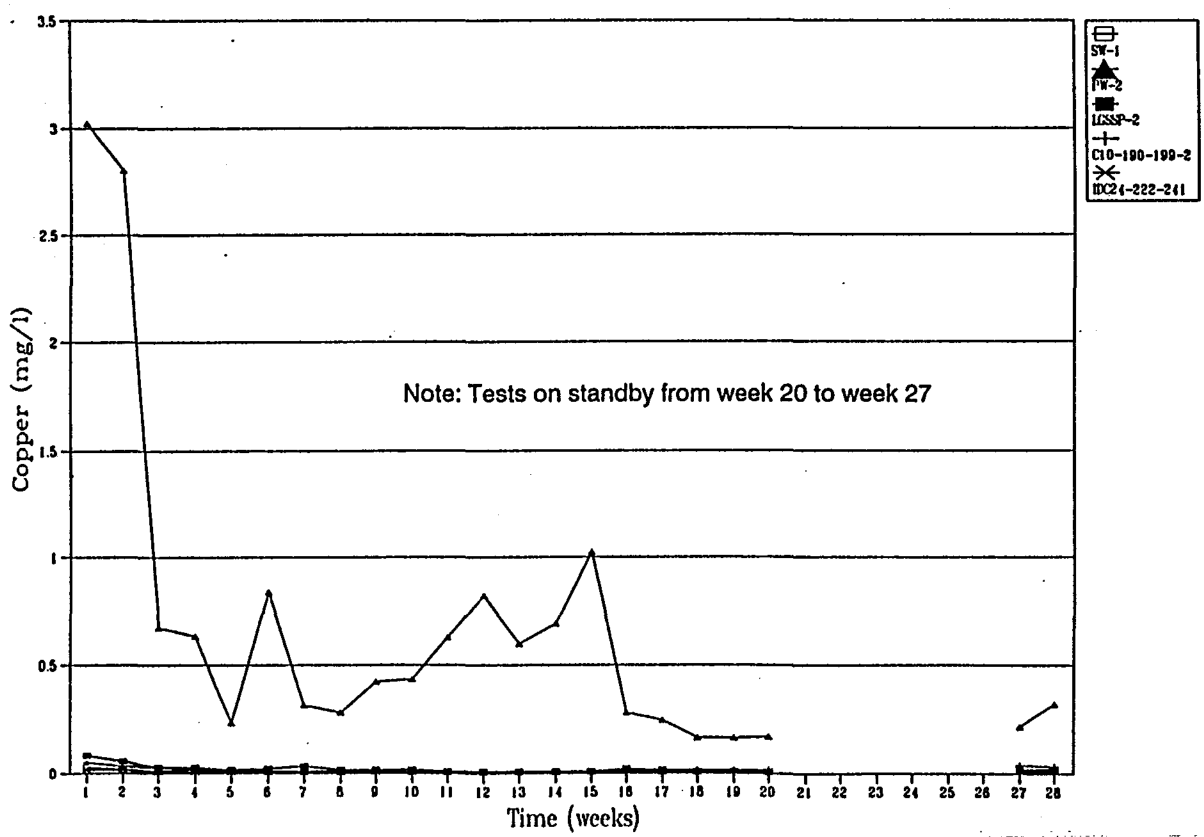


Figure 5.8 Kinetic Test Results - Copper vs. Time

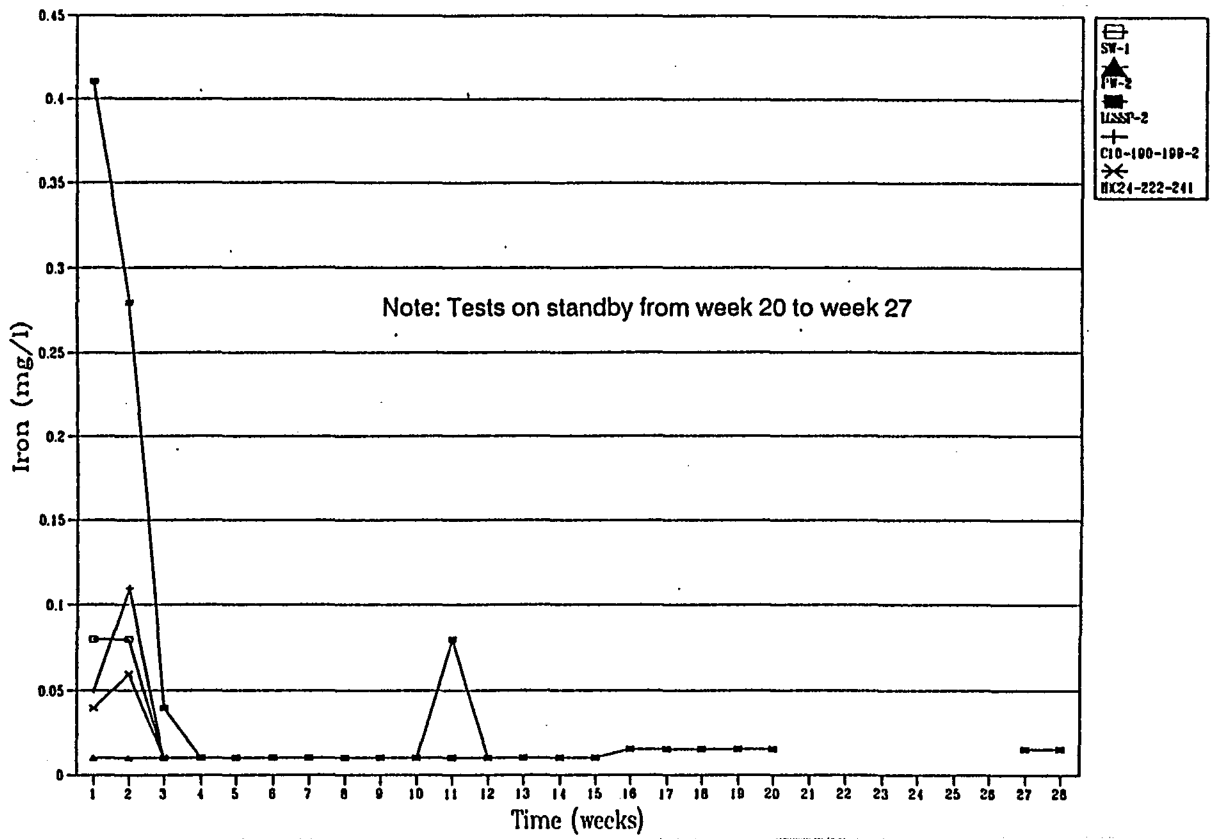


Figure 5.9 Kinetic Test Results - Iron vs. Time

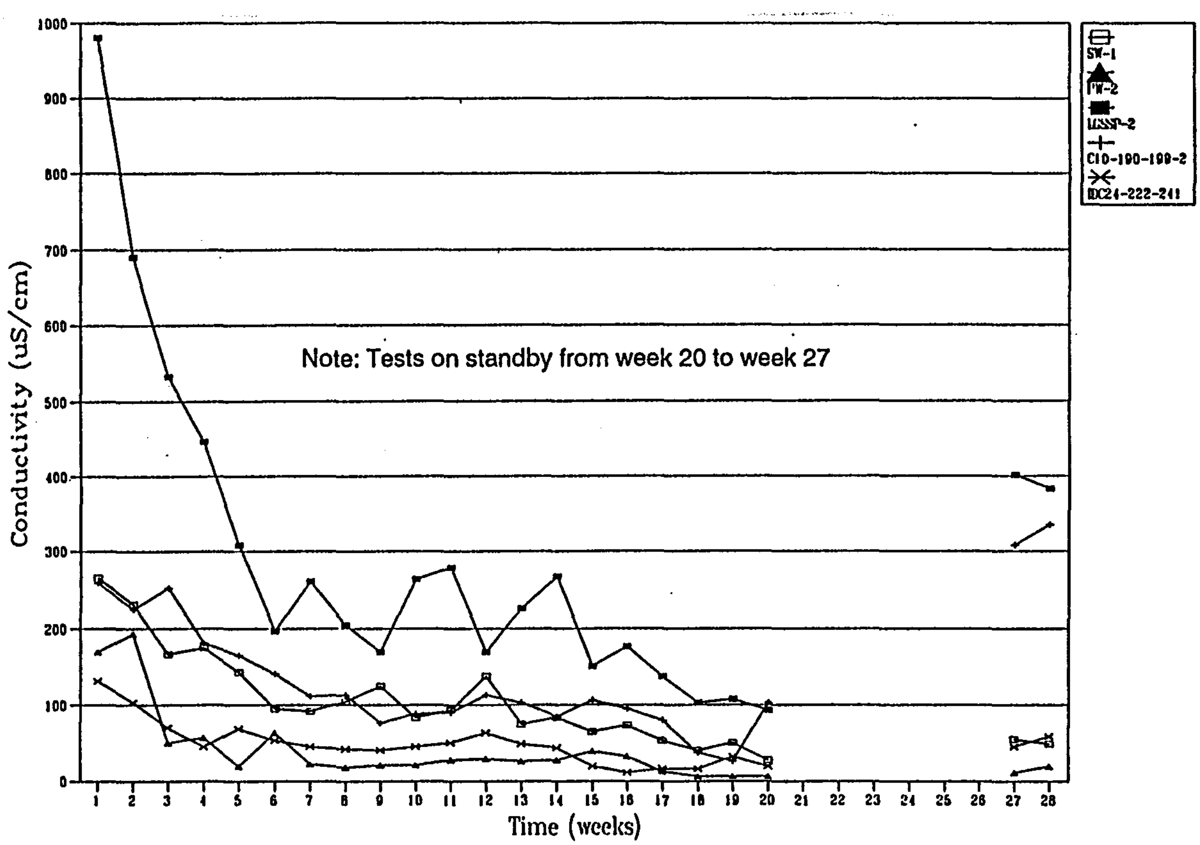


Figure 5.10 Kinetic Test Results - Conductivity vs. Time

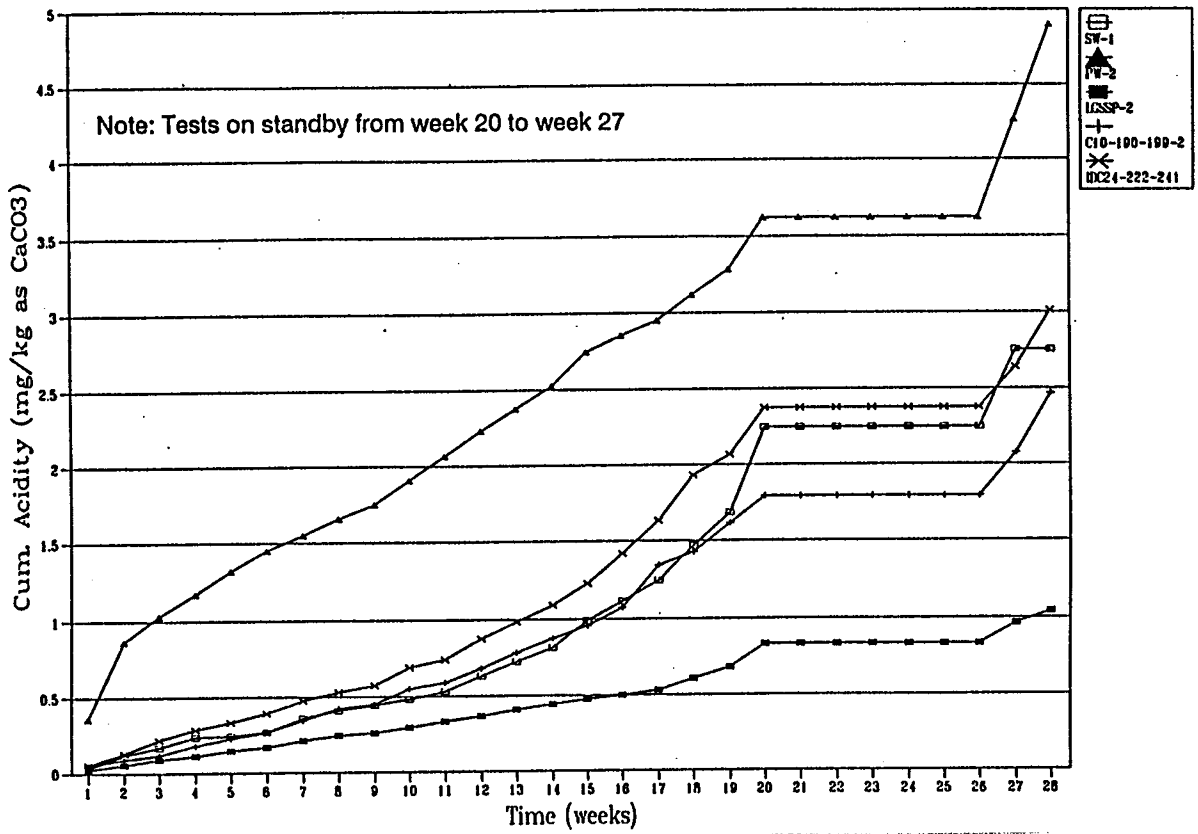


Figure 5.11 Kinetic Test Results - Cumulative Acidity vs. Time

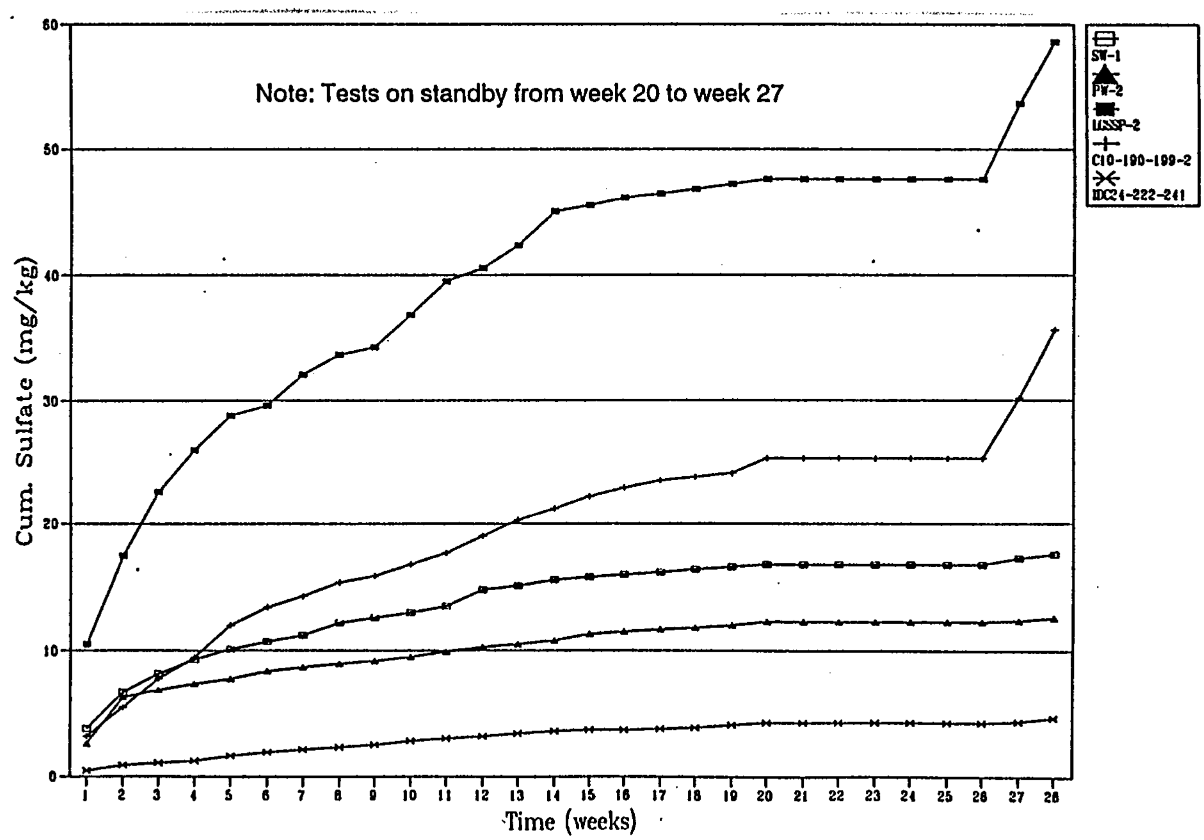


Figure 5.12 Kinetic Test Results - Cumulative Sulfate vs. Time

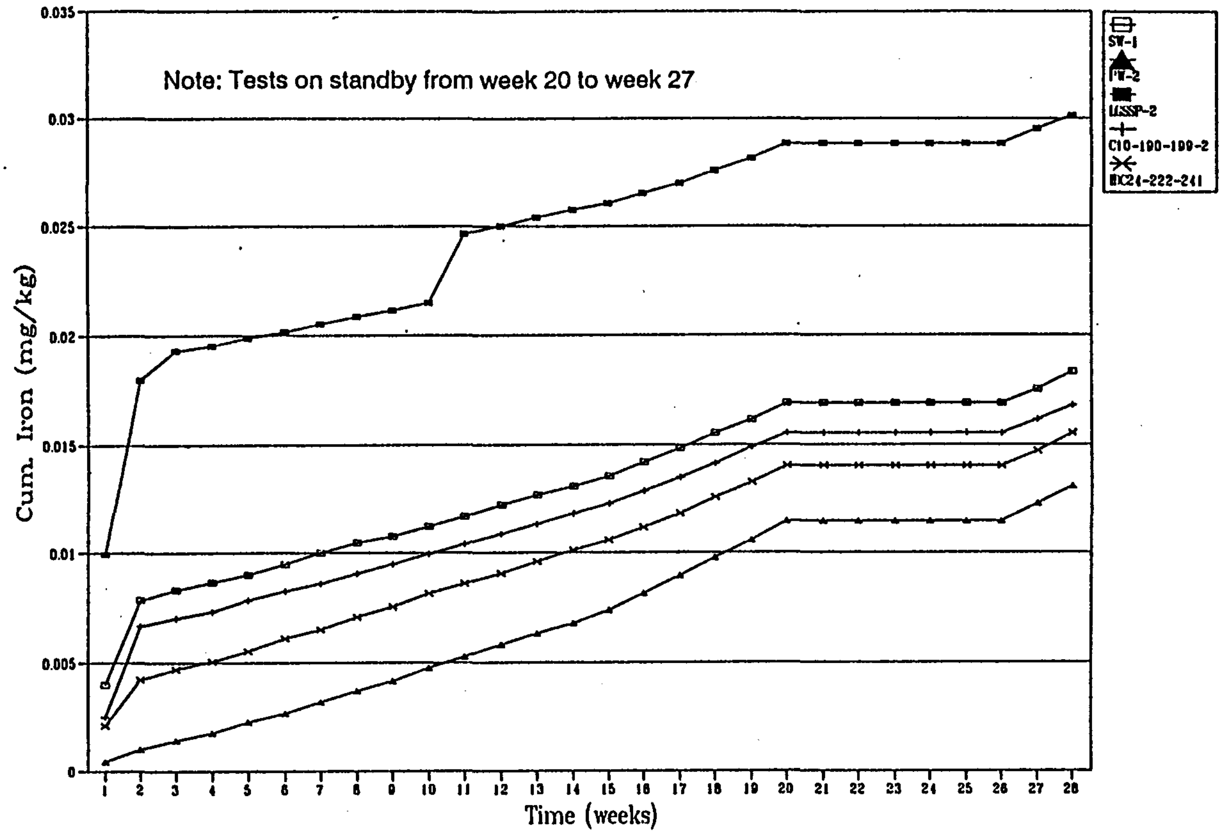


Figure 5.13 Kinetic Test Results - Cumulative Iron vs. Time

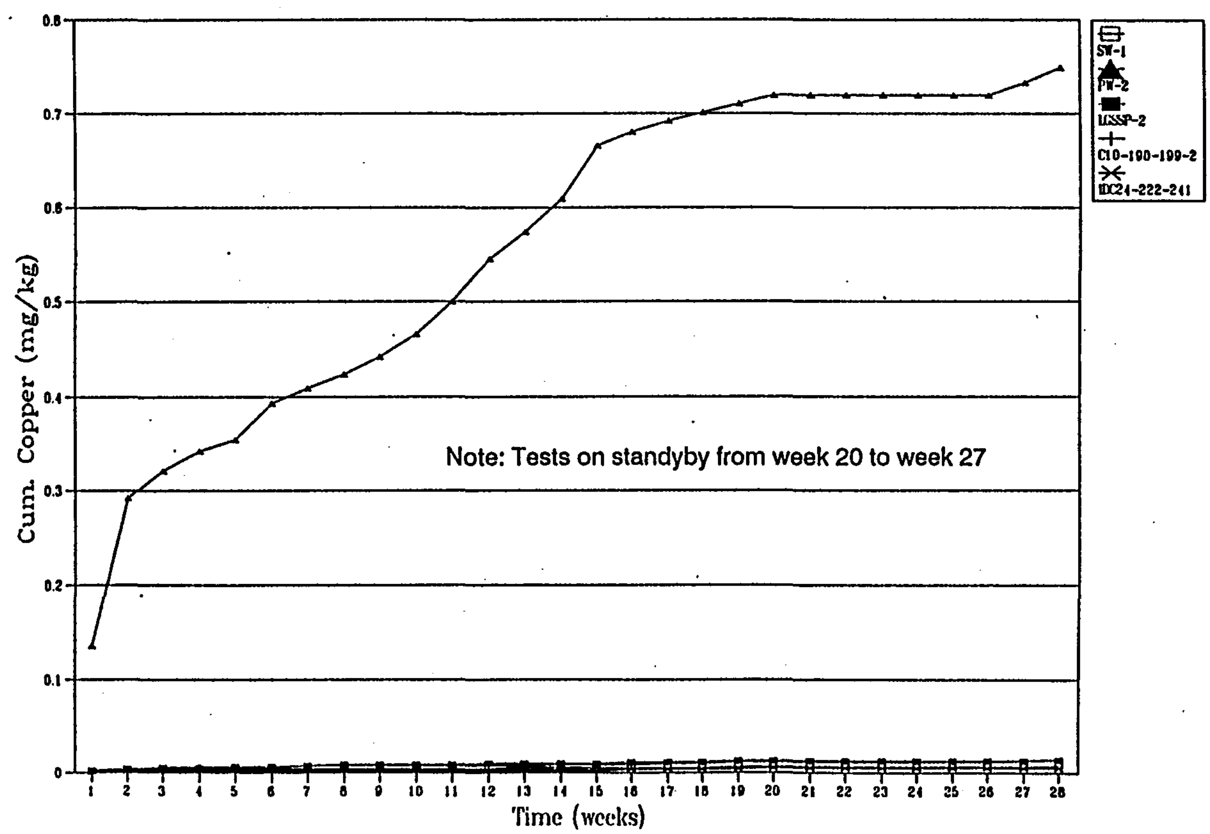


Figure 5.14 Kinetic Test Results - Cumulative Copper vs. Time

generation is much slower than the rate of acid consumption and consequently any acid generated is neutralized. The reasons for this are a combination of the:

- high crystallinity and coarse grain size of the pyrite
- isolated disseminated nature of the sulfide grains in the silicate-carbonate groundmass
- high evaporation over precipitation in the project area
- high levels of available phosphate fixing some of liberated iron as insoluble phosphate minerals.

However, there is only a finite volume of acidity and alkalinity in the material, and total acidity does exceed total alkalinity. The proposed closure activities for the water rock (regrading, covering and revegetating) will limit infiltration of water and diffusion of oxygen thereby slowing the rates of reaction and reducing the rate of seepage to insignificant levels.

To prevent acidic seepage in the long term, the waste rock will have to be covered by soil and vegetation to reduce oxygen diffusion. In addition, some of the highly sulfidic waste rock would make a useful substrate if Sulfur Reducing Bacteria (SRB) are introduced to the pit lake to encourage precipitation of sulfides. The storage under water would additionally reduce oxygen diffusion reducing or even preventing further sulfide oxidation or acid generation from this material. Any available oxygen would be utilized on sulfide surfaces assisting in the formation of an anoxic environment for the SRBs. The use of some sulfide in the manner would primarily be to assist in encouraging sulfide precipitation from the SRB process and in providing a bacterial substrate.

6 TAILINGS GEOCHEMISTRY

During 1982, approximately 1.2 million tons of tailings were deposited in existing tailings impoundments by Quintana Minerals. The material consisted of equal proportions of water and sand sized crushed rock and minerals. The facility is unlined and has largely drained. Samples from monitor wells located down gradient of the tailings indicate a noticeable increase in TDS and sulfate has occurred over time (see section 6.3).

To date, the evaluation of tailings behaviour has focused on the current condition of the tailings because it was not considered feasible, in the short term, to duplicate the field weathering and oxidizing conditions the tailings have been exposed to since deposition in the early 1980's. Testing and evaluations previously completed to assess tailings behavior included static (ABA) testing, paste pH tests, synthetic leaching tests and review of local monitoring well water quality data. These data are reported in the *Copper Flat Project, Hydrologic Studies* (SRK, 1995).

6.1. Static test results

Material has been taken from two boreholes into the 1982 tailings material and subjected to modified EPA 1312 static acid-base accounting tests. The average pyritic sulfur content for this material is 0.61 wt% (Table 5.2). From acid-base accounting the tailings material would be predicted to have a strong to moderate potential for net acid generation. Additional geochemical testing has been conducted on tailings samples obtained from five test pits in the existing tailings disposal area in July, 1996. Results of all static testing of tailings samples to date are summarized in table 5.2.

In general, two tailings materials were recovered from the test pits in July. These include gray, and yellow-brown tailings. The gray tailings (UTLS samples) are inferred to be derived from fresh quartz monzonite similar to that which will be mined in the future. The yellow-brown tailings (TTLS samples) are assumed to be derived from the oxidized and transition zone materials that formed the cap zone over the unoxidized quartz monzonite, and were mined concurrently with unoxidized rock during earlier operations. A bleached tailings sample (P5-BTLS) was also collected. The source of this material is unknown, however, it was likely derived from an alteration zone of limited extent.

Paste pH values in the July 1996 samples range from 6.2 to 7.8 with the majority of samples exhibiting a paste pH above 7.0. Paste conductivity is also low ranging from 298 to 686 μS/cm. In field tests performed in November 1996, paste pH ranged from 6 to 6.7 and paste pH from 502 to 691 μS/cm. The paste test data indicate low concentrations of stored acidity or oxidation products, and non-acidic to weakly acidic generating behaviour in the old tailings material.

The July tailings samples exhibit net neutralization values that range from 15.69 to -7.81 T/KT based on sulfide sulfur (total minus sulfate) content. The average acid neutralization to acid generating potential ratio (NP/AP) values are 1.21:1 and 0.94:1 for the unoxidized and transition tailings, respectively, based on sulfide sulfur content. The average reduction in the NP/AP ratio of the transition tailings is assumed to be a result of weathering and oxidation of the parent rock, and the depletion of neutralizing potential during weathering over geologic time. A sample of bleached tailings obtained from an isolated exposure in one of the test pits exhibited an NP/AP ratio of 1.72:1.

Values for NNP and NP/AP calculated on the basis of pyritic sulfur content are also shown on the attached table. Based on pyritic sulfur content, NP/AP ratios range from 1.07:1 to 3.73:1, with most samples exhibiting ratios near 1.5:1.

Four tailings samples (three UTLS samples and 1 TTLS sample) were subjected to modified EPA method 1312 synthetic leaching tests to assess leachable metal concentrations. Tests were modified to include a 2:1 liquid to solids ratio to enhance detection of leachable metals. Deionized water was used as the leaching agent to simulate leaching under field conditions (Appendix A).

Test results indicate the primary leachable constituents are calcium, magnesium, potassium and sodium. Metals detected in the leach test extracts in trace concentrations (less that 0.5 mg/l) include aluminum, barium, copper, iron, manganese, molybdenum and zinc. These metals occur at concentrations that are not anticipated to be of concern, considering the aggressive nature of the 1312 leach test procedure.

In general, leachable metal concentrations are low in the tailings samples collected to date, and together with the paste pH and conductivity data, do not indicate that the tailings are currently acid generating.

Based on the results of the testing presented above, the existing tailings do not appear to be acid generating at present. NNP values in the range of -20 to +20 T/KT are generally considered indicative of materials with undefined potential for acid generation.

6.2. *Kinetic test results*

Kinetic testing of these materials is typically required to evaluate field behaviour. Disposal under field conditions is in essence, a large scale and extended duration kinetic test. On the basis of the extended period of weathering which the tailings have been exposed to, and the results of the static tests presented in Table 5.1, the tailings appear to have a low potential for acid generation, or are very slowly reactive.

Due to the fine grained nature of the tailings the acid generating potential may be enhanced in comparison to the waste rock. Testing completed to date indicates that the behaviour of the waste rock and tailings are very similar following an extended period of exposure to identical potential oxidizing conditions. Future tailings are expected to exhibit similar characteristics, as the ore will be derived from the same source, and it will be subjected to processing by similar methods.

Alta will conduct ongoing field scale kinetic testing of future tailings as well as waste rock piles in order to provide greater confidence in the existing geochemical models constructed from the present information.

6.3. *Water quality and Environmental implications*

Subsurface seepage recorded from the tailings monitor wells continues to show high levels of sulfate (~1200-1500 mg/l). This reflects the continued dispersion of water by subsurface seepage from the deposited tailings.

During the time of operations by Quintana the decant liquid from the tailings impoundment had a pH of 7.8, a TDS of 2230 mg/l, sulfate of 1440 mg/l and fluoride of 1.46 mg/l. The water appears to be a Ca-sulfate water, and paste pH of the material suggests it is non-acid generating or has a slow rate of acid generation.

The proposal to cover the tailings to prevent water penetration will lead to pore waters supersaturated with Ca and sulfate which will precipitate out gypsum within the tailings further reducing porosity. Any Ca and sulfate leachate will be collected in the leachate channels and used as part of the reclaimed water in the process plant.

7 PIT LAKE CHEMISTRY

7.1. *Surface Water Chemistry*

Surface water quality has already been discussed in detail previously in the 1995 Hydrogeological report and will not be discussed again here except for the Pit lake and Greyback wash.

Water quality in the Greyback wash is good. Upstream of the mining area TDS is in the range 780-965 mg/l, sulfate 275-300 mg/l, bicarbonate, 400-500 mg/l and pH is in the range 7.4-8.3.

Downstream of the mining area surface water quality has been modified with TDS increased to the range 2300-3000 mg/l and sulfate to 1150-1650 mg/l but pH remained unchanged and metal levels were all very low. The increases in TDS and sulfate are most likely due to evapo-concentration of surface water, but may also be affected by runoff from the plant area and by rock-water interactions within the Greyback channel.

In 1991 the pit lake had a pH of 7.2, in 1992 a sample taken along the margin of the lake during a period of high precipitation indicated this had fallen to 4.4-4.9 and the rose in 1993 to pH 5.6 (Newcomer et al., 1993). Current pH levels in the pit lake are at pH 7.7-8.3 and appear to have attained an equilibrium (Table 7.1). Total dissolved solids in the lake has increased from 1991 levels of 2700 mg/l, to 4200 mg/l in 1993, peaked in 1995 at around 5000 mg/l and currently have fallen to around 3500 mg/l. This is a reflection of the increased Ca (580 mg/l in 1991 to 620 mg/l in 1995) and sulfate (2800 mg/l in 1991 and 3170 mg/l in 1995) levels in the pit. The recent drop in TDS may be in response to a drop in water level, thus increasing salinity in residual water and consequently precipitation of gypsum. This is supported by recent field observations of the abundance of gypsum precipitated around the pit walls and at the edge of the pit lake.

At the present time, the pit water exceeds the current New Mexico human health drinking water standards for pH, sulfate, TDS, fluoride, manganese, zinc, copper and cadmium, but meets surface water standards for livestock and wildlife watering, the current use.

Table 7.1: Pit Lake Water Quality (all values in mg/l except where stated otherwise)

Parameter	Pit lake, 1994	Pit Lake, 1996	Greyback, 1996
pH	7.52	8.31	7.61
Conductivity, µm/cm	4690	5230	3860
Bicarbonate	104	122	620
Nitrate	5	<5	6.2
Sulfate	2970	3170	1730
Fluoride	8.1	10	1.4
Chloride	130	150	94
TDS	4380	5230	3450
Sodium	320	430	360
Magnesium	250	300	140
Aluminium	<0.05	0.13	0.033
Potassium	18	21	2.1
Calcium	550	620	490
Manganese	3.4	3	0.17
Iron	<0.05	<0.05	0.057
Copper	0.032	<0.025	<0.025
Molybdenum	<0.05	<0.05	<0.05
Cadmium	0.017	0.014	<0.0025

7.2. *Geochemical Model of Pit Lake Chemistry*

There are two parts to the modelling approach used in analyzing pit water quality at the Copper Flat site. The first part of the model requires calibration to reproduce the current conditions in the existing pit. Physiochemical parameters derived from the first part of the modelling effort are used in the second part of the modelling procedure. The purpose of the second part was to predict future pit water chemistry after mine closure.

7.2.1. Model Description

After cessation of historical mining activity, the existing mine pit received inflows from ground water and surface runoff. Most of the surface runoff in the catchment area probably discharges to the mine pit within a short period of time after a major rainfall event, allowing only minimal time in contact with sulfide bearing material. A fraction of the runoff, however, infiltrates rocks in the vicinity of the pit and flows into the pit as seepage. These oxygenated waters react with sulfides to form Acid Rock Drainage (ARD). All dissolved species contributed by ground water, unreacted surface runoff and ARD contact water are then concentrated by evaporation. As the pit water becomes saturated with respect to minerals or amorphous solid phases, some dissolved constituents are removed from solution by precipitation. The concentrations of these constituents are thus limited by the solubility of certain minerals.

Based on the model described above, the chemical evolution of the existing pit water can be simulated by mixing three types of water, concentrating the mixture by evaporating pure water and equilibrating the resultant solution with an assemblage of gases and solid phases. The model calibration process involved adjusting evaporation rate and volumes of component waters until the simulated water chemistry from the model approximates to the analytical measurements for pit water chemistry. Specifically, there are four parameters that were determined during model calibration. These parameters are:

- Groundwater inflow rate
- Surface water inflow rate
- Contact water (ARD) inflow rate
- Net evaporation rate

To determine values for these parameters, there must be four constraints to the geochemical model. These constraints can be physical or chemical. The following criteria were used in the calibration of the Copper Flat pit water model:

- At the end of 6 years, the volume of water accumulated by the model must approximate the volume determined from pit geometry and the 1994 water level in the pit.
- At steady state, the net evaporation rate must equal the sum of the inflow rates. Steady state must be reached in six years.
- At the end of 12 years, the solution chemistry simulated by the model must be similar to the average chemistry of the pit water, particularly with respect to pH, calcium, and sulfate.
- The pit rocks are assumed to offer no buffering capacity to the solution (i.e. no mineral phase can precipitate unless it is precipitated first).

7.2.1.1. Calibration Procedure

A modified version of PHREEQE was used to simulate chemical changes over time in a sequential batch mode. Each batch represented an increment of time and consisted of five operations:

- Addition of groundwater
- Addition of surface water
- Addition of contact water
- Evaporation of pure water
- Solution equilibration

The first step of the procedure was to compute solution volumes using constraints 1 and 2.

$$G_s + G_i + 2S_t - 2E = V / t \qquad \text{Constraint 1}$$

and

$$S_t + G_s = E \qquad \text{Constraint 2}$$

Where: E = net evaporation rate (ft^3/yr)
G_i = initial groundwater inflow rate (ft^3/yr)
G_s = steady-state groundwater inflow rate (ft^3/yr)
S_t = total surface inflow rate (ft^3/yr)
V = volume of pit water (ft^3)
t = time to fill pit half way (yr)
= 3.0 yr

Three mixing models were considered:

1. Low evaporation (Table 7.2)
2. Moderate evaporation (Table 7.2)
3. High evaporation (Table 7.2)

The second step of the procedure was to define chemical compositions for three types of water that comprise the components of inflow to the chemical model:

1) Groundwater inflow (Table 7.3)
2) Uncontaminated surface inflow (Table 7.3)
3) Contact water (Table 7.3)

The third step of the procedure was to use PHREEQE to model the chemical evolution of pit water for each mixing model developed in the first step. Because Mixing Model 1 produced a net groundwater outflow from the pit, it was eliminated from further consideration, and geochemical modeling was restricted to Mixing Models 2 and 3. Mixing Model 1 is unlikely to produce any significant evaporative effects and is inconsistent with hydrologic data, which indicate that groundwater flows into the pit. During this step of the analytical procedure, four chemical calibration models were developed and evaluated:

TABLE 7.2: 6-Year Water Budget

Year	Ground Water	Surface	Net Evaporation	Volume Change	Total Volume
Low Evaporation					
1	2,097,539.840	2,446,329.600	2,414,269.440	2,129,600	2,129,600
2	1,710,339.840	2,446,329.600	2,414,269.440	1,742,400	3,872,000
3	1,323,139.840	2,446,329.600	2,414,269.440	1,355,200	5,227,200
4	935,939.840	2,446,329.600	2,414,269.440	968,000	6,195,200
5	548,739.840	2,446,329.600	2,414,269.440	580,800	6,776,000
6	161,539.840	2,446,329.600	2,414,269.440	193,600	6,969,600
ss	-64,120.320	4,892,659.200	4,828,538.880	0	6,969,600
Precipitation Rate = 13 in/yr Evaporation Rate = 65 in/yr Runoff Coefficient = 0.500					
Moderate Evaporation					
1	3,244,736	1,812,096	2,927,232	2,129,600	2,129,600
2	2,857,536	1,812,096	2,927,232	1,742,400	3,872,000
3	2,470,336	1,812,096	2,927,232	1,355,200	5,227,200
4	2,083,136	1,812,096	2,927,232	968,000	6,195,200
5	1,695,936	1,812,096	2,927,232	580,800	6,776,000
6	1,308,736	1,812,096	2,927,232	193,600	6,969,600
ss	2,230,272	3,624,192	5,854,464	0	6,969,600
Precipitation Rate = 12 in/yr Evaporation Rate = 75 in/yr Runoff Coefficient = 0.400					
High Evaporation					
1	4,621,232	1,132,560	3,624,192	2,129,600	2,129,600
2	4,234,032	1,132,560	3,624,192	1,742400	3,872,000
3	3,846,832	1,132,560	3,624,192	1,355,200	5,227,200
4	3,459,632	1,132,560	3,624,192	968,000	6,195,200
5	3,072,432	1,132,560	3,624,192	580,800	6,776,000
6	2,685,232	1,132,560	3,624,192	193,600	6,969,600
ss	4,983,264	2,265,120	7,248,384	0	6,969,600
Precipitation Rate = 10 in/yr Evaporation Rate = 88 in/yr Runoff Coefficient = 0.300					
NOTE: Steady state is indicated by the symbol "ss". A steady-state condition is reached at the end of the sixth year.					

TABLE 7.3: Solution Chemistry

Parameter	Units	Concentration
Type 1 - Inflow Ground Water		
Calcium (Ca)	mg/l	92.065
Magnesium (Mg)	mg/l	25.018
Sodium (Na)	mg/l	74.052
Potassium (K)	mg/l	2.001
Iron (Fe)	mg/l	< 0.001
Bicarbonate (HCO_3)	mg/l	260.183
Sulfate (SO_4)	mg/l	220.155
Chloride (Cl)	mg/l	30.021
pH	-log	7.200
pE	-log	5.071
pO_2	-log	34.036
NOTE: This water is supersaturated with respect to CO_2 gas; undersaturated with respect to magnesite and gypsum; and in equilibrium with calcite and $Fe(OH)_3$.		
Type 2 Inflow - Uncontaminated Surface Water		
Calcium (Ca)	mg/l	50.019
Magnesium (Mg)	mg/l	8.003
Sodium (Na)	mg/l	40.015
Potassium (K)	mg/l	2.001
Iron (Fe)	mg/l	< 0.001
Bicarbonate (HCO_3)	mg/l	200.075
Sulfate (SO_4)	mg/l	66.025
Chloride (Cl)	mg/l	10.004
pH	-log	7.200
pE	-log	13.167
pO_2	-log	1.652
NOTE: This water is supersaturated with respect to CO2 gas; undersaturated with respect to calcite, magnesite and gypsum; and in equilibrium with $Fe(OH)_3$.		
Type 3 Inflow - Acid Rock Drainage (Contact Water)		
Calcium (Ca)	mg/l	360.203
Magnesium (Mg)	mg/l	25.014
Sodium (Na)	mg/l	10.006
Potassium (K)	mg/l	4.002
Iron (Fe)	mg/l	100.056
Bicarbonate (HCO_3)	mg/l	0.000
Sulfate (SO_4)	mg/l	3,051.718
Chloride (Cl)	mg/l	14.008
pH	-log	1.700
pE	-log	18.661
pO_2	-log	1.677
NOTE: This water is supersaturated with respect to CO_2 gas; undersaturated with respect to magnesite and calcite; and in equilibrium with gypsum and Na-Jarosite.		

TABLE 7.4: Simulated Solution Chemistry after 12 Years Scenario 2 - Unbuffered

Parameter	Units	Concentration
Calcium (Ca)	mg/l	547.073
Magnesium (Mg)	mg/l	110.620
Sodium (Na)	mg/l	321.715
Potassium (K)	mg/l	13.564
Iron (Fe)	mg/l	61.261
Bicarbonate (HCO_3)	mg/l	20.432
Sulfate (SO_4)	mg/l	2,844.870
Chloride (Cl)	mg/l	122.600
pH	-log	2.342
pE	-log	9.938
pO_2	-log	34.000
pCO_2	-log	2.000
ARD added (Percent)		22.196
Na-Jarosite precipitated (kg):		4,685.616
Gypsum precipitated (kg):		81,455.882
NOTE: Equilibrium was imposed for CO_2 and O_2. Equilibrium was imposed for gypsum and Na-Jarosite after saturation was exceeded.		

TABLE 7.5: Simulated Solution Chemistry after 12 Years Scenario 2 - Buffered by $Fe(OH)_3$

Parameter	Units	Concentration
Calcium (Ca)	mg/l	581.273
Magnesium (Mg)	mg/l	124.558
Sodium (Na)	mg/l	< 0.001
Potassium (K)	mg/l	0.006
Iron (Fe)	mg/l	362.441
Bicarbonate (HCO_3)	mg/l	20.680
Sulfate (SO_4)	mg/l	2,345.046
Chloride (Cl)	mg/l	125.120
pH	-log	4.183
pE	-log	8.097
pO_2	-log	34.000
pCO_2	-log	2.000
ARD added (Percent)		50.000
$Fe(OH)_{3a}$ dissolved (kg):		915,878.864
Na-Jarosite precipitated (kg):		1,229,041.843
K-Jarosite precipitated (kg):		38,577.514
Gypsum precipitated (kg):		278,699.113

NOTE: Equilibrium was imposed for CO_2, O_2 and $Fe(OH)_3$. Equilibrium was imposed for gypsum, Na-Jarosite and K-Jarosite after saturation was exceeded.

TABLE 7.6: Simulated Solution Chemistry after 12 Years Scenario 2 - Buffered by Calcite

Parameter	Units	Concentration
Calcium (Ca)	mg/l	360.203
Magnesium (Mg)	mg/l	25.014
Sodium (Na)	mg/	10.006
Potassium (K)	mg/l	4.002
Iron (Fe)	mg/l	100.056
Bicarbonate (HCO3)	mg/l	152.701
Sulfate (SO4)	mg/l	3051.718
Chloride (Cl)	mg/l	14.008
pH	-log	7.035
pE	-log	5.245
pO_2	-log	34.000
pCO_2	-log	2.000
ARD added (Percent)		50.000
$Fe(OH)_{3a}$ precipitated (kg):		59,170.365
Calcite dissolved (kg):		543,688.794
Gypsum precipitated (kg):		1,221,524.884
NOTE: Equilibrium was imposed for CO_2, O_2, calcite and $Fe(OH)_3$. Equilibrium was imposed for gypsum after saturation was exceeded.		

TABLE 7.7: Simulated Solution Chemistry after 12 Scenario 3 - Unbuffered

Parameter	Units	Concentration
Calcium (Ca)	mg/l	647.399
Magnesium (Mg)	mg/l	155.271
Sodium (Na)	mg/l	456.848
Potassium (K)	mg/	15.350
Iron (Fe)	mg/l	0.003
Bicarbonate (HCO_3)	mg/l	153.380
Sulfate (SO_4)	mg/l	2,789.615
Chloride (Cl)	mg/l	180.042
pH	-log	7.028
pE	-log	5.252
pO_2	-log	34.000
pCO_2	-log	2.000
ARD added	Percent	22.074
Fe(OH)3 precipitated (kg):		16,325.674
Calcite precipitated (kg):		34,964.369
NOTE: Equilibrium was imposed for CO_2, O_2, calcite and $Fe(OH)_3$. In the 12th year, the solution was in equilibrium with gypsum.		

- Chemical Model 1: Unbuffered Mixing Model 2 (Table 7.4)
- Chemical Model 2: Mixing Model 2 Buffered by Fe(OH)3 (Table 7.5)
- Chemical Model 3: Mixing Model 2 Buffered by Calcite (Table 7.6)
- Chemical Model 4: Unbuffered Mixing Model 3 (Table 7.7)

The output of each chemical model was compared to water-quality analyses to determine the validity of the model with respect to the third calibration criterion. The water quality analysis most representative of average pit water is summarized in Table 7.8. Table 7.9 presents data that represent localized conditions that occur along the pit shore where pit water contains a high concentration of acid rock drainage from seepage after a precipitation event.

7.2.1.2. Calibration Results

Results of model calibration indicate that acid rock drainage constitutes an important source of sulfate to the existing pit water, but a high evaporation rate is necessary to concentrate the sulfate to observed levels without lowering solution pH. Specific results for each calibration model are discussed below:

- **Chemical Model 1 (rejected):**

The output for this model run is the result of several iterations. In the iterative process, the percent ARD was adjusted until the model simulated a sulfate concentration within the analytical range of 2700 to 2900 mg/l. Model results indicate that an ARD inflow of 22 percent would produce about 2800 mg/l of sulfate, which is within the analytical range for average pit conditions. However, the simulated pH for the unbuffered model is very much lower than any analyzed pH. For this reason, this run does not satisfy calibration criteria.

- **Chemical Model 2 (rejected):**

The second calibration model assumes the presence of amorphous ferric hydroxide in the system. Because this assumption contradicts the fourth calibration criterion, the second model cannot represent the pit as a whole. However, it may provide some insight into some localized conditions that have been observed along the pit shore. The output for this model was generated with a single run using an ARD inflow volume of 50 percent. This produced a sulfate concentration of only 2300 mg/l. Additional ARD would affect this value very little because the precipitation of gypsum and jarosite limit sulfate concentration. The simulated values of pH, calcium, bicarbonate and sulfate are all consistent with analytical values for pit shore samples. In addition, all precipitates simulated by this model have been observed locally within the pit.

- **Chemical Model 3 (rejected):**

The third calibration model assumes the presence of calcite within the system. This assumption is not realistic for the Copper Flat pit because the rocks at Copper Flat contain virtually no carbonate minerals. Nevertheless, this model is the only Scenario 2 model capable of generating sulfate concentrations above

TABLE 7.8: Average Pit Water Solution Chemistry Sample NLP 3m

Parameter	Units	Concentration
Calcium (Ca)	mg/l	650
Magnesium (Mg)	mg/l	230
Sodium (Na)	mg/l	290
Potassium (K)	mg/l	16
Iron (Fe)	mg/l	0.26
Bicarbonate (HCO_3)	mg/l	72
Sulfate (SO_4)	mg/l	2,700
Chloride (Cl)	mg/l	110
pH	-log	7.8

TABLE 7.9: Local Pit Water Solution Chemistry - Pit Shore Average

Parameter	Units	Concentration
Calcium (Ca)	mg/l	597
Magnesium (Mg)	mg/l	169
Sodium (Na)	mg/l	223
Potassium (K)	mg/l	13
Iron (Fe)	mg/l	0.2
Bicarbonate (HCO3)	mg/l	35
Sulfate (SO4)	mg/l	2,400
Chloride (Cl)	mg/l	76
pH	-log	4.4
NOTE: Average concentrations were weighted to reflect the lowest pH solution. This solution represents the greatest contribution of acid rock drainage.		

2500 mg/l at near neutral pH. This model was eliminated from further consideration because it did not satisfy the fourth calibration criterion. In addition, the calcium concentration simulated by the model is considerably lower than analytical values representing average pit water chemistry.

- **Chemical Model 4 (accepted):**

The fourth calibration model represents an evaporative system. The surface-inflow and evaporation rates for this model are consistent with climatological data from the Caballo Reservoir. The chemical model did not require the presence of any solid phases in the system and was able to generate sulfate, calcium and pH levels that were very close to analytical values. All calibration criteria were satisfied. This model required 22 percent ARD to establish observed sulfate concentrations.

7.2.2. Water-Quality Predictions

The geochemical model used to predict post-closure water quality in the proposed pit incorporated data from several sources. The assumptions and data employed by the predictive geochemical model are summarized below:

- The initial rate of groundwater inflow to the proposed pit is approximately 115 gpm based on the numerical groundwater flow model;
- The rate of groundwater inflow at a pit-water level of 5440 ft msl (pre-1982 water table) is 0.06 gpm;
- The surface area and volume of the pit lake are computed from pit-water level using pit-geometry functions determined from the design of the proposed pit under the reduced stripping alternative;
- The net evaporation rate (evaporation rate minus precipitation rate) is 5.92 ft/yr based on model calibration and Caballo Reservoir data;
- The surface runoff coefficient is 0.30 based on model calibration and independent surface-runoff calculations using the SCS Method;
- The precipitation rate is 0.83 ft/yr based on model calibration and Caballo Reservoir data;
- The surface-runoff catchment area for the proposed pit is 152 acres based on surface topography;
- The inflow rate from Greyback Wash is 77.4 gpm based on a hydrologic analysis of Greyback Gulch;
- All inflow from Greyback Wash was assumed to enter the pit without contacting acid-generating material;
- ARD (i.e. contact water) was assumed to comprise 25 percent of local surface runoff, and
- Waste rock piles were assumed to be uncovered.

The inflow rate of acid rock drainage for the existing pit was estimated to be approximately 22 percent of the surface runoff rate based on geochemical model calibration. In the proposed mine closure scenario, it is unlikely that the ARD content of surface water will exceed 25 percent. This assumption considers the following factors:

- Although surface inflow to the proposed pit may potentially contact more wall rock, the wall rock remaining after mine closure will likely have a much lower ARD potential than the wall rock in the existing pit;
- Observations made during site inspections indicate that most of the ARD in the existing pit is probably generated when surface runoff contacts highly reactive "transition" waste rock. The proposed mine closure plan minimizes the amount of this material exposed to runoff; and
- The proposed mine site will be reclaimed in a manner that will minimize surface water contact with sulfide-bearing material. The model assumes that the amount runoff contacting potentially acid-generating waste rock following closure will be similar to current conditions. Covering of the waste during mine closure should preclude surface water runoff from contacting waste rock in the disposal areas.
- 1996 field paste pH sampling of representative materials currently exposed in the pit walls indicate that approximately 25% of the material will generate low pH solutions when contacted by water (Figure 5.1).

Subsequent to model calibration, water-quality analyses were received for new monitor wells, which were drilled in proximity to the existing pit. For predictive simulations of pit water quality, the chemical composition of the Type 1 inflow was revised to be consistent with the water quality analysis for Well GWQ 96-22a (Table 7.10). This analysis was considered to be more representative of ground water in the vicinity of the mine pit.

Results of predictive simulations (Tables 7.11 and 7.12) indicate that the water quality in the proposed pit should be better than existing pit-water quality for about 120 years after mine closure. This improvement in water quality can be attributed to the proposed pit's relatively low ratio of surface area to volume. The best water quality can be obtained by diverting runoff from Greyback Wash into the proposed pit. The resulting dilution will tend to further offset the effects of evaporation. Figure 7.1 illustrates the time-dependent changes in sulfate concentration and pH for the post-closure scenario involving the diversion of Greyback Wash.

The results of the predictive geochemical model indicate a trend towards increasing sulfate concentration with time, and in the absence of inflow from Greyback Wash, a trend towards decreasing pH. These trends are considered to be realistic for the physical and geochemical environment analyzed. Although the long term trends and general behavior of pit lake geochemistry can be reasonably modeled, the estimate of precise values of simulated future concentrations may vary according to field conditions.

TABLE 7.10: Revised Solution Chemistry for Type 1 Inflow Ground Water

Parameter	Units	Concentration
Calcium (Ca)	mg/l	71.049
Magnesium (Mg)	mg/l	6.705
Sodium (Na)	mg/l	130.089
Potassium (K)	mg/l	2.502
Iron (Fe)	mg/l	< 0.001
Bicarbonate (HCO_3)	mg/l	135.092
Sulfate (SO_4)	mg/l	250.171
Chloride (Cl)	mg/l	89.061
pH	-log	7.500
pE	-log	5.071
pO_2	-log	32.836

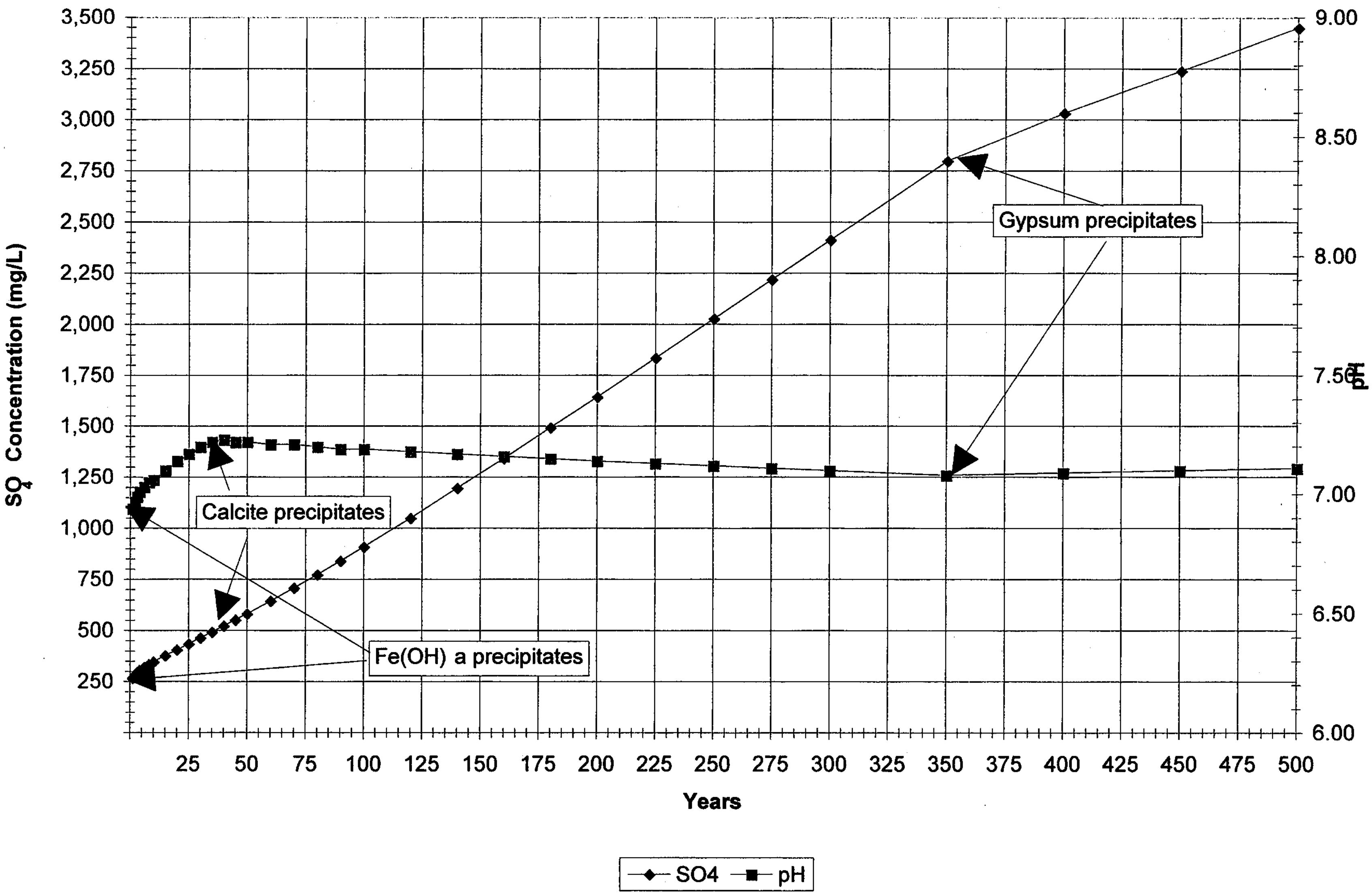
TABLE 7.11: Simulated Solution Chemistry after 120 Years Post Closure, Scenario 1 - Greyback Wash Diversion In Place

Parameter	Units	Concentration
Calcium (Ca)	mg/l	554.030
Magnesium (Mg)	mg/l	54.359
Sodium (Na)	mg/l	750.399
Potassium (K)	mg/l	17.260
Iron (Fe)	mg/l	1.303
Bicarbonate (HCO_3)	mg/l	20.487
Sulfate (SO_4)	mg/l	2,469.052
Chloride (Cl)	mg/l	500.622
pH	-log	3.885
pE	-log	8.395
pO_2	-log	34.000
pCO_2	-log	2.000
Na-Jarosite precipitated (kg):		336,526
Gypsum precipitated (kg):		264,744
NOTE: Equilibrium was imposed for CO_2, O_2, Na-jarosite, and gypsum.		

TABLE 7.12: Simulated Solution Chemistry after 120 Years Post Closure, Scenario 2 - Greyback Wash Diversion Removed

Parameter	Units	Concentration
Calcium (Ca)	mg/l	235.965
Magnesium (Mg)	mg/l	37.374
Sodium (Na)	mg/l	342.032
Potassium (K)	mg/l	10.494
Iron (Fe)	mg/l	0.002
Bicarbonate (HCO_3)	mg/l	192.112
Sulfate (SO_4)	mg/l	1,051.469
Chloride (Cl)	mg/l	187.301
pH	-log	7.177
pE	-log	5.104
pO_2	-log	34.000
pCO_2	-log	2.000
$Fe(OH)_{3a}$ precipitated (kg):		211,335
Calcite precipitated (kg):		1,540,726
NOTE: Equilibrium was imposed for CO_2, O_2, calcite and $Fe(OH)_3$.		

D:\SR\U857\Fig7-1.cdr



DATE: 4/12/96	PROJ. No. U857	COPPER FLAT	
SRK		Copper Flat Pit Water Chemistry Estimation 25% Acid Rock Drainage Case (Greyback diverted)	Figure 7.1

These variations may include ARD content, runoff coefficient, precipitation and evaporation. To assure conservative predictions, parameters were selected to favor low runoff, high evaporation and high ARD generation. These conditions over-predict solute concentrations.

7.3. Future Trends

In planning the future operating and closure activities to minimize geochemical impact of the operation on the environment, it should be noted that:

- As mining progresses the most acid producing material, the ore, will be removed and processed.
- It has been agreed already by Alta that the waste rock disposal areas will be covered by 12 inches of soil and revegetated to limit infiltration by water, reduce oxygen diffusion and reduce seepage from the pile to insignificant levels. Based on the geochemical work, this cover will be acceptable to reduce acid generation and leakage from the waste rock piles.

Based on the review of the historical data and the above geochemical model it is recommended that the Greyback Wash be diverted into the pit following cessation of mining. This dilution will occur only during high rainfall which is when acidic seepage would be greatest. The dilution will also assist in the lowering of sulfate levels in the pond.

The relatively high sulfate levels could be reduced by encouraging communities of Sulfate Reducing Bacteria in the pit. Desulfovibrio desulfuricans readily reduce sulfate to sulfide and can participate in secondary sulfide production (Kleinnman and Pacelli, 1991).

The mechanisms resulting in dissolved metal immobilization are two stages:

$$CH_2O + SO_4^{2-} = HS^- + HCO_3^-$$

where CH_2O is the labile organic material. Bisulfide is produced which reacts with dissolved metals (Me=divalent metal cation) by a mechanism such as:

$$Me^{2+} + HS^- = MeS_s + H^+$$

Organic carbon is replenished by annual growth of aquatic plants and degradation products. Cattails (*Typha laxifolia*) are currently established along the northern part of the pit). In the first few years while the community is immature it will be necessary to add a nutrient supplement such as sewage waste or the mulch produced by brewing or cider production. The local apple farms should be a good source of this material.

As a bi-product, bicarbonate is produced assisting in neutralizing any acid seepage. This mechanism has been used extensively in wetlands and treatment of heaps, waste rock piles and tailings effluent to remove pollutants (Klienmann and Pacilli, 1991; Bowell et al., 1996).

8 RECOMMENDATIONS

From the studies conducted at the site, an understanding of the geochemistry of the Copper Flat environment can be gained. During the operations at Copper Flat it will be useful to further validate the geochemical model discussed above through the use of field-sized kinetic test work.

From the hydrogeological studies undertaken by Adrian Brown it is known that the pit acts as a water sump with no outlet into ground water. Consequently, on closure the pit will refill. In order to prevent a long term build up of sulfate in the pit lake, the feasibility of in-situ sulfate reduction and/or continuous gypsum precipitation as possible reclamation options after closure should be investigated.

9 CONCLUSIONS

The mineralization at Copper Flat contains acid generating sulfide and sulfate minerals and acid consuming minerals such as carbonates, silicates and hydroxides.

From the static tests it can be observed that pyritic material in the waste rock, pit walls and tailings material have the potential to generate substantial acidity. However, some host rocks will consume significant levels of acidity.

Regional ground water is good quality and is well buffered with high alkalinity reflecting the dominance of dolomite and limestone country rocks.

Kinetic testing of acid generation reflects the high crystallinity of pyrite, the low humidity and high buffering potential of the Copper Flat environment. Test work demonstrates that acid generation is extremely slow and is more than compensated by rock buffering and ground water input.

The diversion of the Greyback Wash will assure in the long term, that pit water quality will remain good with well buffered water of reasonable quality. The dilution will reduce all constituents, except sulfate to below New Mexico human health and domestic use levels. The potential benefit of Sulfate Reducing Bacteria to water quality strongly supports the need for further investigation during operations.

The controlled precipitation of gypsum from pumped water from the tailings will assist management of the floatation circuit and provide an additional useful geological cover on closure. Field testing of this material should be undertaken during operations.

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Sr. Geochemist

T. Braun PE
Sr. Hydrogeologist

G.Mudder PE
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Appendix A - Waste Rock Tests

lient : Steffen Robertson and Kirsten
ddress : 3232 S. Vance St., Ste. 210
Lakewood, CO 80227
ttn. : Gene Muller
roject : 68605, Copper Flat

JUL 28 1994

ample Matrix: Waste Rock
ample ID: 68605, WD 1
ample Date Time: Unknown

Lab No. : 94 RT/00594
Date Received: 06/10/94

Parameters			
Moisture %	0.2	%	
Phosphorus, total	0.01	%	
Aluminum, total	1890.	mg/kg	4
Antimony, total	-0.10	mg/kg	4
Arsenic, total	0.4	mg/kg	4
Barium, total	10.	mg/kg	4
Boron, total	-2.	mg/kg	4
Cadmium, total	-0.5	mg/kg	4
Calcium, total	700.	mg/kg	4
Chromium, total	-1.	mg/kg	4
Cobalt, total	11.	mg/kg	4
Copper, total	186.	mg/kg	4
Iron, total	41600.	mg/kg	4
Lead, total	2.	mg/kg	4
Magnesium, total	200.	mg/kg	4
Manganese, total	8.	mg/kg	4
Mercury, total	-0.02	mg/kg	4
Molybdenum, total	7.	mg/kg	4
Nickel, total	-2.	mg/kg	4
Potassium, total	1200.	mg/kg	4
Selenium, total	3.9	mg/kg	4
Silver, total	-1.	mg/kg	4
Sodium, total	200.	mg/kg	4
Vanadium, total	1.	mg/kg	4
Zinc, total	7.	mg/kg	4

4 EPA SW846, Method 3051 Digestion.

Remarks:

Note: Negative sign "-" denotes that the value is less than "<"

Scott Habermehl, Project Manager

Frank E. Polniak, Inorganic Laboratory Supervisor /FE

Client : Steffen Robertson and Kirsten
Address : 3232 S. Vance St., Ste. 210
Lakewood, CO 80227
Attn. : Gene Muller
Project : 68605, Copper Flat

Sample Matrix: Waste Rock
Sample ID: 68605, PW-3
Sample Date Time: Unknown

Lab No. : 94-RT/00595
Date Received: 06/10/94

Parameters			
Moisture %	0.3	%	
Phosphorus, total	0.04	%	
Aluminum, total	2950.	mg/kg	4
Antimony, total	-0.10	mg/kg	4
Arsenic, total	1.9	mg/kg	4
Barium, total	24.	mg/kg	4
Boron, total	-2.	mg/kg	4
Cadmium, total	-0.5	mg/kg	4
Calcium, total	700.	mg/kg	4
Chromium, total	-1.	mg/kg	4
Cobalt, total	9.	mg/kg	4
Copper, total	226.	mg/kg	4
Iron, total	40800.	mg/kg	4
Lead, total	4.	mg/kg	4
Magnesium, total	800.	mg/kg	4
Manganese, total	39.	mg/kg	4
Mercury, total	-0.02	mg/kg	4
Molybdenum, total	57.	mg/kg	4
Nickel, total	3.	mg/kg	4
Potassium, total	1300.	mg/kg	4
Selenium, total	9.0	mg/kg	4
Silver, total	-1.	mg/kg	4
Sodium, total	200.	mg/kg	4
Vanadium, total	5.	mg/kg	4
Zinc, total	14.	mg/kg	4

4 EPA SW846, Method 3051 Digestion.

Remarks:

Note: Negative sign "-" denotes that the value is less than "<"

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Tony Melon

Lab Sample ID:	*L10307-12*
Client Sample ID:	*P5-TTLS*
Client Project ID:	*68610*
ACZ Report ID:	*RG29617*
Date Sampled:	*7/8/96 00:00*
Date Received:	*7/12/96*
Date Reported:	*8/14/96*
Sample Matrix:	*Soil*

Metals Analysis

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Aluminum (1312-DI)	M6010 ICP	0.04	B	mg/L	0.03	0.2	8/12/96	rs
Antimony (1312-DI)	M200.7 ICP		U	mg/L	0.02	0.1	8/12/96	rs
Arsenic (1312-DI)	M7060 GFAA		U	mg/L	0.001	0.006	7/18/96	sh
Barium (1312-DI)	M200.7 ICP	0.026		mg/L	0.003	0.01	8/12/96	rs
Boron (1312-DI)	M6010 ICP		U	mg/L	0.01	0.06	8/12/96	rs
Cadmium (1312-DI)	M200.7 ICP		U	mg/L	0.003	0.02	8/12/96	rs
Calcium (1312-DI)	M200.7 ICP	177.0		mg/L	0.2	1	8/12/96	rs
Chromium (1312-DI)	M200.7 ICP		U	mg/L	0.01	0.06	8/12/96	rs
Cobalt (1312-DI)	M200.7 ICP		U	mg/L	0.01	0.06	8/12/96	rs
Copper (1312-DI)	M200.7 ICP	0.01	B	mg/L	0.01	0.06	8/12/96	rs
Iron (1312-DI)	M200.7 ICP	0.01	B	mg/L	0.01	0.06	8/12/96	rs
Lead (1312-DI)	M200.7 ICP		U	mg/L	0.02	0.1	8/12/96	rs
Magnesium (1312-DI)	M200.7 ICP	12.4		mg/L	0.2	1	8/12/96	rs
Manganese (1312-DI)	M6010 ICP	0.157		mg/L	0.006	0.03	8/12/96	rs
Molybdenum (1312-DI)	M200.7 ICP	0.14		mg/L	0.01	0.06	8/12/96	rs
Nickel (1312-DI)	M200.7 ICP		U	mg/L	0.01	0.06	8/12/96	rs
Potassium (1312-DI)	M200.7 ICP	10.9		mg/L	0.3	1	8/12/96	rs
Selenium, (1312-DI)	M7742 Modified, AA-Hydride	0.004	B	mg/L	0.001	0.005	7/22/96	rd
Silver (1312-DI)	M200.7 ICP		U	mg/L	0.006	0.03	8/12/96	rs
Sodium (1312-DI)	M200.7 ICP	1.6		mg/L	0.3	1	8/12/96	rs
Vanadium (1312-DI)	M6010 ICP		U	mg/L	0.006	0.03	8/12/96	rs
Zinc (1312-DI)	M200.7 ICP	0.01	B	mg/L	0.01	0.06	8/12/96	rs

Soil Analysis

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Acid Generation Potential	Calc. M600/2-78-054	37		tons/KT	1	5	7/29/96	as
Acid Neutralization Potential	Calc. M600/2-78-054	26		tons/KT	1	5	7/29/96	as
Acid-Base Potential (calc)	M600/2-78-054 1.	-11		tons/KT	1	5	7/29/96	as
Neutralization Potential as CaCO3	M600/2-78-054 3.2.3	2.6		%	0.1	0.5	7/29/96	jm
Sulfur Forms	M600/2-78-054 3.2.4							
Sulfur Organic		0.29		%	0.01	0.1	7/27/96	jb
Sulfur Pyritic		0.53		%	0.01	0.1	7/27/96	jb
Sulfur Sulfate		0.37		%	0.01	0.1	7/27/96	jb
Sulfur Total		1.19		%	0.01	0.1	7/27/96	jb

Inorganic Qualifiers (based on EPA CLP 3/90)

U = Analyte was analyzed for but not detected at the indicated MDL
B = Analyte concentration detected at a value between MDL and PQL
PQL = Practical Quantitation Limit

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Lab Sample ID: *L10307-11*
Client Sample ID: *P4-UTLS*
Client Project ID: *68610*
ACZ Report ID: *RG29616*

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Tony Melon

Date Sampled: *7/8/96 00:00*
Date Received: *7/12/96*
Date Reported: *8/14/96*

Sample Matrix: *Soil*

Metals Analysis

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Aluminum (1312-DI)	M6010 ICP	0.05	B	mg/L	0.03	0.2	8/12/96	rs
Antimony (1312-DI)	M200.7 ICP		U	mg/L	0.02	0.1	8/12/96	rs
Arsenic (1312-DI)	M7060 GFAA		U	mg/L	0.001	0.006	7/18/96	sh
Barium (1312-DI)	M200.7 ICP	0.019		mg/L	0.003	0.01	8/12/96	rs
Boron (1312-DI)	M6010 ICP		U	mg/L	0.01	0.06	8/12/96	rs
Cadmium (1312-DI)	M200.7 ICP		U	mg/L	0.003	0.02	8/12/96	rs
Calcium (1312-DI)	M200.7 ICP	60.4		mg/L	0.2	1	8/12/96	rs
Chromium (1312-DI)	M200.7 ICP		U	mg/L	0.01	0.06	8/12/96	rs
Cobalt (1312-DI)	M200.7 ICP		U	mg/L	0.01	0.06	8/12/96	rs
Copper (1312-DI)	M200.7 ICP		U	mg/L	0.01	0.06	8/12/96	rs
Iron (1312-DI)	M200.7 ICP	0.01	B	mg/L	0.01	0.06	8/12/96	rs
Lead (1312-DI)	M200.7 ICP		U	mg/L	0.02	0.1	8/12/96	rs
Magnesium (1312-DI)	M200.7 ICP	6.4		mg/L	0.2	1	8/12/96	rs
Manganese (1312-DI)	M6010 ICP	0.013	B	mg/L	0.006	0.03	8/12/96	rs
Molybdenum (1312-DI)	M200.7 ICP	0.10		mg/L	0.01	0.06	8/12/96	rs
Nickel (1312-DI)	M200.7 ICP		U	mg/L	0.01	0.06	8/12/96	rs
Potassium (1312-DI)	M200.7 ICP	6.8		mg/L	0.3	1	8/12/96	rs
Selenium, (1312-DI)	M7742 Modified, AA-Hydride	0.003	B	mg/L	0.001	0.005	7/22/96	rd
Silver (1312-DI)	M200.7 ICP		U	mg/L	0.006	0.03	8/12/96	rs
Sodium (1312-DI)	M200.7 ICP	3.2		mg/L	0.3	1	8/12/96	rs
Vanadium (1312-DI)	M6010 ICP		U	mg/L	0.006	0.03	8/12/96	rs
Zinc (1312-DI)	M200.7 ICP		U	mg/L	0.01	0.06	8/12/96	rs

Soil Analysis

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Acid Generation Potential	Calc. M600/2-78-054	42		tons/KT	1	5	7/29/96	as
Acid Neutralization Potential	Calc. M600/2-78-054	25		tons/KT	1	5	7/29/96	as
Acid-Base Potential (calc)	M600/2-78-054 1.	-17		tons/KT	1	5	7/29/96	as
Neutralization Potential as CaCO3	M600/2-78-054 3.2.3	2.5		%	0.1	0.5	7/29/96	jm
Sulfur Forms	M600/2-78-054 3.2.4							
Sulfur Organic		0.41		%	0.01	0.1	7/27/96	jb
Sulfur Pyritic		0.46		%	0.01	0.1	7/27/96	jb
Sulfur Sulfate		0.47		%	0.01	0.1	7/27/96	jb
Sulfur Total		1.34		%	0.01	0.1	7/27/96	jb

Inorganic Qualifiers (based on EPA CLP 3/90)

U = Analyte was analyzed for but not detected at the indicated MDL
B = Analyte concentration detected at a value between MDL and PQL
PQL = Practical Quantitation Limit

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Client Sample ID:	P3-UTLS
Client Project ID:	68610
ACZ Report ID:	RG29615
Date Sampled:	7/8/96 00:00
Date Received:	7/12/96
Date Reported:	8/14/96
Sample Matrix:	Soil

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Metals Analysis

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Aluminum (1312-DI)	M6010 ICP	0.12	B	mg/L	0.03	0.2	8/12/96	rs
Antimony (1312-DI)	M200.7 ICP		U	mg/L	0.02	0.1	8/12/96	rs
Arsenic (1312-DI)	M7060 GFAA		U	mg/L	0.001	0.006	7/18/96	sh
Barium (1312-DI)	M200.7 ICP	0.023		mg/L	0.003	0.01	8/12/96	rs
Boron (1312-DI)	M6010 ICP		U	mg/L	0.01	0.06	8/12/96	rs
Cadmium (1312-DI)	M200.7 ICP		U	mg/L	0.003	0.02	8/12/96	rs
Calcium (1312-DI)	M200.7 ICP	14.9		mg/L	0.2	1	8/12/96	rs
Chromium (1312-DI)	M200.7 ICP		U	mg/L	0.01	0.06	8/12/96	rs
Cobalt (1312-DI)	M200.7 ICP		U	mg/L	0.01	0.06	8/12/96	rs
Copper (1312-DI)	M200.7 ICP		U	mg/L	0.01	0.06	8/12/96	rs
Iron (1312-DI)	M200.7 ICP	0.02	B	mg/L	0.01	0.06	8/12/96	rs
Lead (1312-DI)	M200.7 ICP		U	mg/L	0.02	0.1	8/12/96	rs
Magnesium (1312-DI)	M200.7 ICP	0.8	B	mg/L	0.2	1	8/12/96	rs
Manganese (1312-DI)	M6010 ICP	0.010	B	mg/L	0.006	0.03	8/12/96	rs
Molybdenum (1312-DI)	M200.7 ICP	0.06		mg/L	0.01	0.06	8/12/96	rs
Nickel (1312-DI)	M200.7 ICP		U	mg/L	0.01	0.06	8/12/96	rs
Potassium (1312-DI)	M200.7 ICP	8.2		mg/L	0.3	1	8/12/96	rs
Selenium (1312-DI)	M7742 Modified, AA-Hydride	0.003	B	mg/L	0.001	0.005	7/22/96	rd
Silver (1312-DI)	M200.7 ICP		U	mg/L	0.006	0.03	8/12/96	rs
Sodium (1312-DI)	M200.7 ICP	6.0		mg/L	0.3	1	8/12/96	rs
Vanadium (1312-DI)	M6010 ICP		U	mg/L	0.006	0.03	8/12/96	rs
Zinc (1312-DI)	M200.7 ICP	0.01	B	mg/L	0.01	0.06	8/12/96	rs

Soil Analysis

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Acid Generation Potential	Calc. M600/2-78-054	44		tons/KT	1	5	7/29/96	as
Acid Neutralization Potential	Calc. M600/2-78-054	23		tons/KT	1	5	7/29/96	as
Acid-Base Potential (calc)	M600/2-78-054 1.	-21		tons/KT	1	5	7/29/96	as
Neutralization Potential as CaCO3	M600/2-78-054 3.2.3	2.3		%	0.1	0.5	7/29/96	jm
Sulfur Forms	M600/2-78-054 3.2.4							
Sulfur Organic		0.45		%	0.01	0.1	7/27/96	jb
Sulfur Pyritic		0.69		%	0.01	0.1	7/27/96	jb
Sulfur Sulfate		0.26		%	0.01	0.1	7/27/96	jb
Sulfur Total		1.40		%	0.01	0.1	7/27/96	jb

Inorganic Qualifiers (based on EPA CLP 3/90)

U = Analyte was analyzed for but not detected at the indicated MDL
B = Analyte concentration detected at a value between MDL and PQL
PQL = Practical Quantitation Limit

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Lab Sample ID: *L10307-09*
Client Sample ID: *P2-UTLS*
Client Project ID: *68610*
ACZ Report ID: *RG29614*

Date Sampled: *7/8/96 00:00*
Date Received: *7/12/96*
Date Reported: *8/14/96*

Sample Matrix: *Soil*

Metals Analysis

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Aluminum (1312-DI)	M6010 ICP	0.05	B	mg/L	0.03	0.2	8/12/96	rs
Antimony (1312-DI)	M200.7 ICP		U	mg/L	0.02	0.1	8/12/96	rs
Arsenic (1312-DI)	M7060 GFAA		U	mg/L	0.001	0.006	7/18/96	sh
Barium (1312-DI)	M200.7 ICP	0.024		mg/L	0.003	0.01	8/12/96	rs
Boron (1312-DI)	M6010 ICP	0.01	B	mg/L	0.01	0.06	8/12/96	rs
Cadmium (1312-DI)	M200.7 ICP		U	mg/L	0.003	0.02	8/12/96	rs
Calcium (1312-DI)	M200.7 ICP	216.0		mg/L	0.2	1	8/12/96	rs
Chromium (1312-DI)	M200.7 ICP	0.01	B	mg/L	0.01	0.06	8/12/96	rs
Cobalt (1312-DI)	M200.7 ICP		U	mg/L	0.01	0.06	8/12/96	rs
Copper (1312-DI)	M200.7 ICP	0.01	B	mg/L	0.01	0.06	8/12/96	rs
Iron (1312-DI)	M200.7 ICP	0.01	B	mg/L	0.01	0.06	8/12/96	rs
Lead (1312-DI)	M200.7 ICP		U	mg/L	0.02	0.1	8/12/96	rs
Magnesium (1312-DI)	M200.7 ICP	10.4		mg/L	0.2	1	8/12/96	rs
Manganese (1312-DI)	M6010 ICP	0.084		mg/L	0.006	0.03	8/12/96	rs
Molybdenum (1312-DI)	M200.7 ICP	0.09		mg/L	0.01	0.06	8/12/96	rs
ickel (1312-DI)	M200.7 ICP		U	mg/L	0.01	0.06	8/12/96	rs
Potassium (1312-DI)	M200.7 ICP	13.1		mg/L	0.3	1	8/12/96	rs
Selenium (1312-DI)	M7742 Modified, AA-Hydride	0.003	B	mg/L	0.001	0.005	7/22/96	rd
Silver (1312-DI)	M200.7 ICP		U	mg/L	0.006	0.03	8/12/96	rs
Sodium (1312-DI)	M200.7 ICP	7.9		mg/L	0.3	1	8/12/96	rs
Vanadium (1312-DI)	M6010 ICP		U	mg/L	0.006	0.03	8/12/96	rs
Zinc (1312-DI)	M200.7 ICP	0.01	B	mg/L	0.01	0.06	8/12/96	rs

Soil Analysis

Parameter	EPA Method	Result	Qual	Units	MDL	PQL	Date	Analyst
Acid Generation Potential	Calc. M600/2-78-054	34		tons/KT	1	5	7/29/96	as
Acid Neutralization Potential	Calc. M600/2-78-054	27		tons/KT	1	5	7/29/96	as
Acid-Base Potential (calc)	M600/2-78-054 1.	-7		tons/KT	1	5	7/29/96	as
Neutralization Potential as CaCO3	M600/2-78-054 3.2.3	2.7		%	0.1	0.5	7/29/96	jm
Sulfur Forms	M600/2-78-054 3.2.4							
Sulfur Organic		0.21		%	0.01	0.1	7/27/96	jb
Sulfur Pyritic		0.43		%	0.01	0.1	7/27/96	jb
Sulfur Sulfate		0.46		%	0.01	0.1	7/27/96	jb
Sulfur Total		1.10		%	0.01	0.1	7/27/96	jb

Inorganic Qualifiers (based on EPA CLP 3/90)

= Analyte was analyzed for but not detected at the indicated MDL
B = Analyte concentration detected at a value between MDL and PQL
PQL = Practical Quantitation Limit

Ralph V. Poulsen
Vice President of Operations: Ralph Poulsen

Appendix 7-B

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

New Mexico Copper Corporation

Copper Flat Mine
Plan of Operations

Report Prepared for:

U.S. Department of the Interior
Bureau of Land Management
Las Cruces District Office
1800 Marquess Street
Las Cruces, NM 88005-3370

Report Submitted by:

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Office: (505) 382-5770

December 2010
Revised June 2011

THEMAC RESOURCES

New Mexico Copper Corporation

Copper Flat Mine
Preliminary Mine Waste Management Plan

Submitted by:

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Office: (505) 382-5770

December 2010

Appendix A

Waste Rock Characterization

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APPENDICES

1 INTRODUCTION

Two phases of waste rock characterization have been completed at the Copper Flat project in New Mexico. A preliminary assessment of the waste was conducted in 1994 for the Environmental Impact Statement (EIS). More detailed work was carried out in 1997 for use in development of this waste management plan. The numbers of tests completed in each phase of the waste rock characterization are listed in Table A.1.1.

1.1 Work Carried Out As Part of the EIS

The initial assessment of the waste rock dumps at Copper Flat (SRK, 1995; DEIS, 1996) was carried out in part to assess the current geochemical characteristics of waste rock from former operation sand to determine whether future waste rock has the potential for acid generation.

Nineteen samples were collected from the existing pit wall rock, waste rock piles, and drill core and cuttings. The locations of the surface samples are shown in Drawing 68612-001. Selected samples were subjected to:

- Paste pH and conductivity measurements to determine whether previous oxidation had produced acidic and/or soluble residues;
- Determination of total metals concentrations;
- Acid Base Accounting to assess the balance between potentially acid generating and potentially acid neutralizing minerals;
- Agitated leach extraction tests to measure the amount of immediately soluble metals;
- Humidity column testing to simulate long-term oxidation of the waste rock and evaluate drainage quality; and,
- Geotechnical testing to estimate the physical and hydraulic properties of compacted waste rock.

The conclusions of this work were that:

- Most of the material on the dumps had only superficial oxidation despite exposure to the atmosphere for over 14 years.

- No evidence of acid seeps was observed during 1994-5, although one seep had been reported in an earlier study (Newcomber et al., 1991) and another seep was identified in August 1997 after unusually heavy rainfall.
- The material on the East, South, and most of the North dumps was essentially “sulfide” material with little or no accumulation of secondary mineral salts. The West waste rock dump and the western portion of the North dump were more complex with a combination of “sulfide” and “transitional” ore.

1.2 Work Carried Out As Part of the Waste Rock Management Plan

In August 1997, field work was carried out with the aim of producing detailed geological and geochemical maps of the waste rock dumps and open pit. One hundred and twelve samples were collected from six-foot long channels along benches on the waste rock dumps. The locations of the 1997 samples are shown on Figure A.1.2. The material was characterized in the field by geological observation and by paste pH and TDS measurements. Forty-six samples were analyzed by Acid Base Accounting (ABA) tests and fifty-nine samples were analyzed by Net Acid Generation (NAG) testing. Table A.1.2 shows the numbers of samples of each rock type analyzed by each procedure.

2 METHODS

The testing methods for samples collected in the waste rock characterization studies are summarized in the following sections. Detailed protocols are presented in Appendix A.1.

2.1 Paste pH and Conductivity

Paste pH and conductivity tests were conducted by mixing a sample of the fine grained portion of the waste with deionized water in a ratio of 1:2 by volume to produce a saturated paste. Measurements were then taken directly from the paste.

A paste pH greater than pH 7 indicates either that the sample is not generating acid, or that any acidity produced is being neutralized. A paste pH below 5.0 indicates that the material contains soluble acidity from prior oxidation. The conductivity measurement indicates the amount of immediately soluble salts present in the sample. The soluble acidity and salts are normally the products of earlier oxidation reactions. Their presence indicates that water contacting the material could leach oxidation products, even in the absence of further oxidation.

Paste pH and conductivity tests were conducted in the field (1996-1997 data) or at the SRK Laboratory in Lakewood, Colorado (1994-1995 data).

2.2 Total Metals Concentrations

Total metals concentrations in the waste rock were determined by Inductively Coupled Plasma (ICP) following the EPA 3051 digestion (USEPA 1982; 1995a,b). The purpose of the total metal analyses was to determine what metals are present in the waste rock. The ICP analysis does not indicate the amount, if any, of each metal that would be soluble under conditions likely to arise in the field.

ICP analyses were conducted at ACZ Laboratory in Steamboat Springs, Colorado.

2.3 Acid Base Accounting

Acid base accounting (ABA) tests were conducted to assess the potential for the waste rock to become acid generating. ABA tests indicate the balance of potentially acid generating minerals (sulfides) and potentially acid consuming minerals (generally carbonates) present in the rock. The test involves analyzing for total sulfur and sulfur species (total, sulfate, and pyritic sulfur) to determine the acid generation potential

(AP), and then titration with acid to assess the neutralizing potential (NP) of the material. The units of the NP and AP are kg $CaCO_3$ equivalent/ton of material (kg/T), or tons $CaCO_3$ equivalent/kiloton of material (T/KT). The method employed during the 1994 testing was the Sobek method. The modified Sobek technique (Sobek et al., 1978; SRK, 1989) was used to evaluate the 1996 samples.

The ABA characteristics of different samples can be compared using the difference between the NP and the AP values (the net neutralizing potential, or NNP). An NNP of greater than 20 kg/t indicates that a sample contains sufficient NP to buffer the acidity that could be produced as a result of oxidation, and therefore, has a low potential for acid generation. An NNP value of less than –20 kg/T is considered indicative that a sample has the potential for acid generation. Values between +20 kg/T and –20 kg/T have uncertain acid generating potential and may require kinetic testing to evaluate field behavior.

The ratio of NP:AP can also be used to evaluate acid generating potential. As a general guideline, an NP:AP greater than 3:1 indicates that a sample has a low potential for acid generation. A value below 1:1 indicates that, if the sample is exposed to oxidizing conditions, it has the potential for acid generation. Waste rock samples exhibiting NP:AP values between 1 and 3 typically require kinetic testing to evaluate field behavior.

However, both of these methods for evaluating ABA data are guidelines only. Other characteristics of the rock, such as the grain size, sulfide species and morphology and the form and occurrence of the neutralizing minerals, can influence the tendency for the material to produce or neutralize acidity.

A total of 46 ABA tests were conducted during the two phases of the waste characterization program. Testing of 1995 samples was conducted at ACZ Laboratory in Steamboat Springs, Colorado, whereas 1997 samples were analyzed at Sierra Environmental Monitoring Laboratory in Reno, Nevada.

2.4 Net Acid Generation Tests (NAG)

An alternative method for evaluating acid generating potential is the net acid generation (NAG) test. Whereas ABA tests indirectly estimate acid generating potential by comparing the sulfide sulfur content to the acid neutralizing potential of a sample, NAG tests determine the balance without the need for sulfur analyses.

The test is conducted by mixing the sample with hydrogen peroxide, and heating until the mixture stops boiling. After cooling, the pH of the sample is measured to obtain the “NAG pH”. The NAG pH is then an estimate of the final pH of a sample if nearly all the sulfide present were oxidized, and is used in comparing the relative potential for generating acidity. The NAG pH is a qualitative indication of a sample’s potential for acid generation; however, NAG pH values of 4.0 or greater are often indicative of low acid generating potential. The solution can then be titrated to neutrality with a standard base to determine the net acidity or acid generated (NAG) upon complete oxidation of the samples. The NAG is expressed as kg H_2SO_4 equivalent/ton, and is analogous to the NNP. Where the NAG is zero, net acid neutralizing potential is indicated. Positive NAG values indicate net acid generating potential.

The NAG test assumes complete oxidation of all the sulfide in a sample. Although sulfide oxidation is seldom complete, and the NAG test can underestimate the amount of sulfide in a sample, the result provides a realistic indication of the amount of sulfide that would react in field.

NAG tests were conducted on 59 samples representing all the rock types in the deposit. All NAG tests were carried out at the School of Engineering, University College of Wales, Cardiff, United Kingdom.

2.5 Modified EPA 1312 Test

The objective of this procedure is to characterize and quantify the soluble metal and salt content of waste samples. The test involves mixing a pulverized sample with a leaching solution, agitating the mixture, filtering the liquid and analyzing the liquid extract for pH, conductivity, acidity, alkalinity, sulfate and soluble metal concentrations (USEPA, 1994). The EPA test uses a liquid to solids ratio of 20:1. However, at the standard test ratio, constituent concentrations may be diluted and undetectable. The procedure was, therefore, modified to include a 2:1 ratio liquid to solids ratio. Deionized water was also substituted for the standard leach solution (deionized water pH adjusted with nitric and sulfuric acid) to simulate leaching with rain water.

The modified EPA 1312 tests were conducted at ACZ Laboratory in Steamboat Springs, Colorado.

2.6 Humidity Column Tests

Humidity column tests were carried out to simulate long term weathering of waste rock samples. Each sample was placed in a column of PVC pipe. Warm, moist air was passed through the sample for three days, followed by three days of dry air circulation. On the seventh day of each weekly cycle, the sample was irrigated and the leachate was collected. The pH, Eh, conductivity, acidity and alkalinity were measured directly, and a portion of each leachate sample was then sent for analyses of metal concentrations. Testing was continued for 21 weeks.

Humidity column tests were conducted at Cominco Engineering Services Laboratory (CESL) in Vancouver, British Columbia, Canada.

3 RESULTS OF WASTE ROCK TESTING PROGRAM

The following section presents the general findings of the geochemical testing program. Detailed data are presented in Appendices A.2 and A.3.

3.1 Metal Content and Mineralogy

The mineralogy of the samples was determined visually. The most common sulfide was coarse crystalline pyrite, which is present in concentrations of less than 1% throughout the quartz monzonite, and up to 10% to 20% locally within the mineralized breccia and some quartz veins. Other sulfides include chalcopyrite ($CuFeS_2$), the most common copper mineral, bornite ($CuFeS_2$), tetrahedrite ($Cu_{10}(Cu, Fe, Zn)_2(As,Sb)_4S_{13}$), enargite ($Cu_3AsS_4$), and covellite (CuS). Molybdenite (MoS_2) is the most common molybdenum mineral. Gangue minerals associated with the sulfide mineralization include quartz, feldspar, and biotite. Accessory minerals include calcite (up to 5%), fluorite, siderite, magnetite, sericite, epidote, and chlorite.

Table A.3.1 lists the results of ICP analysis of two samples of quartz monzonite waste rock. Sample PW-3 was collected from the northwest wall of the open pit and WD-1 was collected from the west waste rock pile. Both samples show a similar chemistry with high aluminum, manganese, copper, and iron concentrations. Copper, molybdenum, sulfur, silver, zinc and cadmium are enriched in the sample analyzed with respect to crustal abundance.

3.2 EPA 1312

Although the total metals concentrations in the waste rock are important, the concentrations of metal salts that are soluble is often of more concern. Table A.3.2 lists the results of EPA 1312 test on sample WD-1. It should be noted that this sample was selected for EPA method 1312 leach testing because it is a transition waste rock sample that exhibited low field pH. Therefore, the leachable constituent concentrations would be anticipated to be higher than those expected from fresh, unoxidized waste rock samples.

The leachate from the sample had a pH of 3 and high sulfate concentration (3050 mg/L). No alkalinity was detected. The leachate also had higher concentrations of aluminum, copper, and iron, than the other sample, reflecting soluble metals in the solid sample. In addition, nickel and zinc in the solid sample appear to be soluble. However, the soluble metals concentrations are generally low.

3.3 Paste pH and Conductivity

Paste pH was measured on 141 samples from the waste rock dumps. The range of pH values for each rock type is shown in Figure A.3.1. The andesite sample analyzed had a paste pH above 9. All other rock types show a range of values between 2 and 9, indicating that portions of each lithology have undergone varying degrees of sulfide oxidation.

Paste pH is plotted against paste conductivity in Figure A.3.2 and listed in Appendix A.2. There is a strong correlation between low paste pH and high paste conductivity, as would be expected. Conductivity values generally remain below 500 µS/cm above a pH of 6, but increase when pH is lower.

3.4 Acid Base Accounting

NP values are plotted against AP values for the two testing programs in Figure A.3.3. The 1994 samples have higher NP than the 1997 samples. The discrepancy is a result of the use of the more conservative modified Sobek procedure for determining NP on the 1997 samples. For the purposes of this report, only the 1997 data will be used.

Figure A.3.4 shows the relationship data between NP and AP by rock type for the 1997 samples, with the diagonal line indicating where NP is equal to AP. The figure shows that most samples contain less than 3% sulfide (equivalent to an AP of 93kg $CaCO_3$ eq./t), and generally have less NP than AP. Therefore, most samples have a “theoretical” potential for acid generation. The andesite appears to be an exception.

From the correlation of Sulfate/Total Sulfur and paste pH four fields can be identified (Figure A.3.5):

- *Low paste pH, high Sulfate/Total Sulfur Ratio*: This field is characterized by samples that have a high proportion of secondary sulfate salts that are acid generating. As can be observed relatively few samples fall into this field.
- *High paste pH, low Sulfate/Total Sulfur Ratio*: This field is characterized by samples that have a low proportion of secondary sulfate salts but high sulfide content. Whilst having the potential to generate appreciable amounts of acid they are not on immediate reaction acid-generating and require a long period of interaction with air and water in the presence of a catalyst to be so.
- *Low Paste pH, Low Sulfate/Total Sulfur Ratio*: This field is characterized by high sulfide samples.

- *High Paste pH, High Sulfate/Total Sulfur Ratio*: This field delineates the oxide ore samples.

ABA data is presented in Appendix A.2.

3.5 Net Acid Generation (NAG) Testing

NAG tests were conducted on 59 samples and the resulting NAG pH values are plotted according to rock type on Figure A.3.6. Samples of biotite breccia, quartz breccia, and quartz monzonite had NAG values that ranged from acidic to alkaline. This suggests that each of these lithologies contain a wide range of sulfide concentrations. Quartz vein material, in contrast, had NAG values indicating Net Acid Generation, reflecting the common association within the deposit of sulfides with quartz veins. Low paste pH correlates to high NAG and low negative NNP (Figure A.3.7).

NAG test data are presented in Appendix A.2.

3.6 Kinetic Tests

Humidity column tests were conducted on five samples; four (4) different quartz monzonite samples and one (1) quartz breccia sample:

- Two samples obtained from the sulfide waste rock stockpiles (SW-1 and LGSSP-2);
- One sample of quartz breccia with jarosite stains from the pit wall (PW-2); and,
- Two samples of unoxidized quartz monzonite waste obtained from archived drill core (IDC 24-22-241 and CF10-190-199).

Sulfide waste samples (SW-1 and LGSSP-2) are representative of previously mined unoxidized materials that have been exposed to weathering conditions since 1982. These samples contain fresh pyrite and chalcopyrite which coat fractures and are disseminated throughout the rock.

The pit wall sample (PW-2) was collected from partially oxidized cap rock located west of the pit. While the sample was highly oxidized, it contained residual disseminated pyrite and, locally, chalcopyrite.

The core samples (IDC 24-22-241 and CF10-190-199) are representative of unoxidized quartz monzonite waste that will be mined during future operations. These samples were obtained from drilling at depth and have not been exposed to weathering or oxidizing conditions in the field. They contained fresh chalcopyrite and abundant fresh pyrite.

Results of ABA tests on the samples used for the humidity column tests are listed in Table A.3.3. Humidity column data are presented in Appendix A.3 and summarized in Figures 3.8 to 3.13.

3.6.1 pH and Eh

Figure A.3.8 illustrates leachate pH with time. For the initial 19 weeks of testing, all unoxidized quartz monzonite samples (all samples except column 2, PW-2) maintained a leachate pH in the range of 7.0 to 8.1. In column test PW-2, pH varied between 5.8 and 6.5 during the initial 19 weeks.

All samples show a sharp decrease in leachate pH in week 20. Because the pH depression was approximately equivalent in all tests, the laboratory was contacted to determine if the pH depression was attributable to laboratory operations as opposed to geochemical conditions. Independent investigations by the laboratory indicated that every column in the laboratory at that time (not just those for this project) experienced a similar leachate pH decrease. It was ultimately determined that the decrease in pH was the result of a decrease in pH of the deionized water used as inflow to the columns. Major servicing of the laboratory deionizing equipment caused the decreased pH of the deionized water in week 20.

The kinetic tests were resumed after a seven-week hiatus during which time the deionizing system was adjusted. The samples remained undisturbed during this period and were exposed to natural airflow that would have allowed oxidation to continue until the weekly cycles were resumed. Results for the last two weeks indicate that oxidation continued to occur at rates similar to those of the first 20 weeks.

3.6.2 Electrical Conductivity

Figure A.3.9 illustrates leachate conductivity versus time. Initially high conductivity was indicated for test LGSSP-2. This material was collected from the surface of the low grade sulfide stockpile and initial high leachate conductivity may result from leaching of secondary oxidation products. All the samples exhibit trends of decreasing leachate conductivity. By week 20, the conductivity of all test leachates was less than 100 μS/cm, suggesting limited oxidation or leaching of metals and sulfate. When the tests were resumed at week 27, samples LGSSP-2 (surface waste) and C10-190-199-2 (fresh sulfide material) exhibited increased conductivities indicating oxidation and production of soluble salts during the hiatus.

3.6.3 Acidity and Alkalinity

Acidity production slowly increased after week 9 in all columns (Figure A.3.10), as alkalinity began decreasing (Figure A.3.10). Figure A.3.10 illustrates the low leachate alkalinity of sample PW-2 throughout the 29-week test due to the oxidized nature of the sample.

3.6.4 Sulfate

The time dependent plot for sulfate (Figure A.3.11) shows a rapid decrease in the sulfate concentration over the first 5 to 10 weeks. This is a result of the flushing of readily soluble sulfate salts present in the waste rock prior to testing. After about week 15 the sulfate concentrations reach a pseudo steady state. As was reflected in the conductivity, leachates from columns containing samples LGSSP-2, and C10-190-199-2 show an increase in sulfate as the result of accumulation of oxidation products during the seven week hiatus during which the columns were not operating. The other columns showed no significant increase, suggesting a slower rate of sulfate production and release.

3.6.5 Metals

After initial flushing of secondary oxidation salts, most metals were produced at a low rate throughout the test period, most below detection limits (Figures A.3.12 and A.3.13).

3.6.6 Assessment of Oxidation and NP Depletion Rates

Sulfate release rates and alkalinity release rates were calculated for each column test to assess the relative oxidation and acid neutralization dynamics. For these calculations it was assumed that 30% of the waste rock in the test columns is contacted by infiltrating waters and that all the sulfide and NP are available for reaction. Average concentrations for weeks 16 to 20, inclusive, were used to calculate rates of depletion of sulfide and NP. The results are summarized in Table A.3.4.

Based on the estimated time to deplete the NP, it will take on the order of several hundred years for the columns to become acid generating under the accelerated laboratory conditions. Field conditions and the designated mitigation measures are anticipated to further prolong NP depletion. The results also suggest that the neutralizing potential originates predominantly from calcium and magnesium based carbonate minerals, with the possible exception of sample PW-2.

Also shown in Table A.3.4 are the specific sulfur release rates. The first rate is based on the specific release rate per unit mass of rock sample while the second rate has been normalized to the sulfide sulfur content of the sample. The release rates are in similar order of magnitude, indicating that all the samples are oxidizing at a slow rate. The most reactive sample appears to be LGSSP-2.

This could be explained by the higher pyrite content of total sulfides and finer grain size in this sample. Sulfate levels are negligible (0.01% out of 0.61% total sulfur) so the effects of secondary sulfates can be ruled out, although the presence of some sulfate indicates that at least a surface alteration has occurred on exposed pyrite.

4 HYDROGEOCHEMISTRY

The following section presents a brief discussion of local surface water and groundwater quality. Hydrogeological data are presented in detail in *Copper Flat Mine Hydrogeological Studies (SRK, 1995)* and *Copper Flat Project Hydrogeolgy Impact Evaluation (ABC, 1996)*.

4.1 Surface water

There are three main water courses in the vicinity of the proposed mine; these are Percha Creek, Las Animas Creek and Greyback Arroyo. Percha Creek lies to the south of the mine and Las Animas to the north. Both of these creeks drain to the Caballo reservoir to the east of the mine. The Greyback Arroyo is currently diverted around the existing pit.

The surface water quality in Las Animas and Percha Creeks and the reservoir is broadly similar. They all contain low dissolved solids (300-440 mg/l) and pH is slightly alkaline (7.2-7.9). The chemistry is dominated by calcium-bicarbonate ions. Sulfate is low (mean of 65 mg/l) and dissolved metal concentrations are below detection limit. The Greyback Arroyo contains somewhat higher calcium concentration (450-510 mg/l, compared to around 60 mg/l in the other surface waters) and sulfate (1410-1740 mg/l). Alkalinity is also elevated (up to 508 mg/l $CaCO_3$ equivalent). Trace element concentrations are close to or less than detection limit. The Greyback Arroyo cuts through the copper porphyry deposit, and therefore may be expected to contain higher sulfate concentrations than the other streams in the region. Greyback is an ephemeral stream, and dissolved constituents will be concentrated by evaporation.

4.2 Pit Lake

The pit lake chemistry is dominated by calcium-sulfate ions; sulfate reaches concentrations of up to 3600 mg/l. The pH is generally slightly alkaline (pH 7-8.5) although pH values of less than 7 (with a minimum of 4.4) were recorded during 1992-93. Most dissolved trace element concentrations are low; however fluoride and manganese are both elevated (with concentrations up to 11 mg/l and 4.9 mg/l respectively). No evidence of stratification was observed on the four occasions that depth samples were collected (SRK, 1997).

The high TDS in the pit lake is probably due to the evaporation accumulation of sulfide oxidation products and dissolution of secondary minerals. Evaporative concentration has increased the dissolved salt load to the point where gypsum (hydrated calcium sulfate) is at saturation.

The lower pH levels reported for a part of the lake (pH 6-6.5) are influenced by the local presence of an acid seep originating from the NW side of the pit wall in the Sternberg lode. The few recorded low pH values may also be related to dissolution of acid volatile salts (such as jarosite) during pit lake level fluctuations.

The climate and nature of the pit lake are such that the pit will act as an evaporative sump, so there will be no groundwater flow out from the lake (ABC, 1996). Surface runoff from the waste rock dumps will be directed to flow into the pit lake, where it will be contained.

4.3 Groundwater

The groundwater at the Copper Flat site is dominated by the bicarbonate ion, providing a high buffering capacity. The pH ranges from 7.5 to 8.15, indicating slightly alkaline water. Sulfate concentrations tend to be low to moderate (80-400 mg/l) and dissolved metal concentrations are also low. Iron and manganese were relatively high in one of the samples (GWQ96-23A) collected in April 1997 (6.5 mg/l iron, 1.425 mg/l manganese). However more recent sampling results (August 1997) indicate very low iron and manganese (<1 mg/l of both elements).

4.4 Seepage

During the August 1997 sampling event, a seep was observed at the east toe of the west waste rock dump. A sample was collected and the results of analysis are tabulated in Table A.4.1. Although the seepage contains very high dissolved metals and low pH it is important to note that the flow was very low (much less than a gallon/minute (measured during sampling at ~0.2 gpm)) and the seepage will therefore be rapidly diluted and buffered by groundwater and/or surface water.

The upper part of the seepage channel was coated by chalcanthite ($CuSO_4 7H_2O$), langite ($Cu_4SO_4(OH)_6{}^2U_2O$), woodwardite ($Cu_4Al_2SO_4(OH)_{12}$ 2-4H_2O(?)), goethite, cuprocopiapite ((CuFe$^{2+)}$ Fe$^{3+}{}_4(SO_4)6(OH)_2$ 2OH_2O) and amorphous Na-Ca-Mg-Cu-Zn--Fe-Mn salts. This indicates active buffering and evaporation, thus limiting metal and acid dispersion.

5 ACID ROCK DRAINAGE CHARACTERISTICS OF THE EXISTING WASTE PILES

5.1 ARD Characteristics of Different Lithologies

From whole rock analysis of waste rock samples (Table A.3.1), the primary constituents are Al, Ca, Fe, Mg and K. Trace metals of significance (> 10 ppm) are Ba, Cu, Co, Mn, Mo and Zn. Several million tons of waste rock are currently piled around the pit and along the southeast slope of Animas Peak. SRK has previously classified the waste rock in the area as oxidized, transitional and unoxidized (SRK, 1995). The basis for classification is the proportion of pyrite observed in the material, as well as its field behavior (as indicated by paste pH and conductivity).

The rock piles were initially classified (Draft EIS, 1996) on the proportion of each type of material present with the west pile being primarily transitional waste, the north rock pile being a combination of unoxidized and oxidized waste and the south and eastern rock piles comprising essentially unoxidized sulfide waste.

The ARD potential by lithology and by waste rock dump are discussed in the following sections.

5.1.1 Quartz Monzonite

The quartz monzonite frequently contains abundant pyrite and therefore may be a potential source of acid rock drainage. The paste pH measurements made on this lithology (94 taken in August 1997) ranged from 2.51 to 8.76 (Figure A.3.1). Several measurements were at the higher end of the range, suggesting that in some cases the monzonite may have some buffering capacity. However, the majority of the measurements were between pH 2 and 7, indicating initial acid generation. The net acid generation (NAG) results varied between 8 and 57 kg/T eq. H_2SO_4 (Figure A.3.6). Over 50 % of the tests generated a NAG value of between 20 and 40 kg/T eq. H_2SO_4. This indicates that the rock has potential to generate acid in certain circumstances. Observations indicate a visible pyrite content of between 0 and 8 %, with most samples containing around 3% (Figure A.5.1). This ties in well with the NAG test results.

5.1.2 Quartz Breccia

The quartz breccia is not as abundant as the quartz monzonite, which will form the bulk of the waste rock. Around 30 samples of this lithology were assessed for paste pH and paste EC (electrical conductivity, a measure of total dissolved solids). Nearly all the paste pH measurements were less than 7, and most of these were between pH 3 and 5 (Figure A.3.1). This was probably due to the dissolution of superficial salts. The NAG test results were similar to those of the quartz monzonite, with most measurements falling between 20 and 40 kg/T eq. H_2SO_4. However, more of the results from the quartz breccia were greater than 80 kg/T eq. H_2SO_4 (Figure A.3.6). One sample yielded a NAG potential of 223 kg/T eq. H_2SO_4, but this was exceptional. The visible sulfide in the quartz breccia was mostly between 3 and 4 %. The quartz breccia generally has a higher acid generating potential than the quartz monzonite.

5.1.3 Biotite Breccia

Ten measurements of paste pH were made on rock classified as biotite breccia. The paste pH values ranged from 2.45-7.38 (Figure A.3.1). All but one of these readings were less than pH 7 and the majority were less than pH 5. The biotite breccia generally has a greater proportion of sulfide than the other lithologies, with a quarter of the samples containing more than 6% visible sulfide. This is reflected by the NAG test results, which are up to 80 kg/T eq. H_2SO_4 (Figure A.3.6). However, only six NAG measurements were made on biotite breccia samples so it is inappropriate to make generalizations. This rock is considered an ore material and will be handled as such.

5.1.4 Quartz Vein

Six quartz vein samples were assessed for paste pH and percent visible sulfide. Of these only 3 NAG tests were possible. The paste pH measurements were dominated by acidic values, with ½ of the tests exhibiting a pH less than 3 (Figure A.3.1). Most of the samples contained around 5 % visible sulfide, one sample only contained around 1% (Figure A.5.1). The NAG test results were between 10 and 40 kg/t eq. H_2SO_4; these are slightly lower than may be expected for samples with relatively high sulfide content (Figure A.5.4).

5.1.5 Andesite

Only one andesitic sample was available for testwork. This reflects the relative scarcity of this lithology throughout the waste rock dumps. This sample yielded a very high paste pH value of 9.14, which demonstrates its excellent buffering capacity. This sample was not assessed for net acid generation.

5.2 ARD Characteristics of Different Waste Rock Dumps

Locations of samples collected for paste pH and paste conductivity measurements and NAG values are shown on Drawing 68606-001, and the frequency of acid generator indicators, paste pH, conductivity, NAG value and visible sulfide abundance are provided in Figures A.5.2 - A.5.5, respectively.

5.2.1 North Waste Rock Dump

The north waste rock dump contains a mixture of unoxidized, oxidizing and oxidized waste rock. The paste pH measurements are generally lower than those for the other waste rock dumps due to the presence of transitional material. The range of paste pH values are from 2.5 to 6 (significantly, no values above pH 7 were recorded) and more than 50 % of the values were less than pH 3. This suggests a higher proportion of soluble salts relative to material from the other waste rock dumps.

The NAG test results were not exceptionally high although one sample generated a value of 223 kg/t eq. H_2SO_4. The remainder of the samples were between 9 and 75 kg/t eq. H_2SO_4. The sample which generated the high NAG value (NRD 5620 014) was also noted as containing 20 % visible pyrite, which is unusual for the Copper Flat waste rock. Most waste rock samples from this dump contained on the order of <2% visible pyrite.

From the results to date, the north waste rock dump appears to have the greatest potential to generate acid. This is probably because this dump contains a greater proportion of partially oxidized (transition) rocks than the other dumps.

5.2.2 West Waste Rock Dump

The west waste rock dump has been described as containing mostly partially oxidized, transitional waste rock (SRK 1995) but more detailed investigation in 1997 indicated that much of the rock is relatively fresh and the oxidation is very superficial.

The paste pH measurements ranged from pH 2.3 to 7.8. Generally the rocks on this dump were less reactive than those on the other dumps, with nearly 50 % of samples generating a paste pH greater than 5. The NAG test results ranged from 15 to 75 kg/t eq. H_2SO_4, with over 80 % of samples generating a potential of less than 40 kg/t eq.

H_2SO_4. This relates well to the proportion of visible sulfide in the rocks which was less than 2% in nearly 80% of the samples.

Field observations and all the test results to date indicate that the west waste rock dump has the lowest potential to generate acidity.

5.2.3 South Waste Rock Dump or Lean Ore Stockpile

The south waste rock dump reportedly contains rocks with a higher proportion of sulfide compared with the other waste rock dumps. However, the samples collected during August 1997 do not support this. All the samples evaluated contained less than 7 % visible sulfide (estimated) and the acid base accounting (ABA) revealed no samples with a sulfide content greater than 1.5 %. An earlier sampling round (SRK 1994) produced similar results; the highest measured sulfide content was just over 3%.

The NAG potential is relatively low; 90 % of samples evaluated generated a value of less than 40 kg/t eq. H_2SO_4, and the highest potential measured was only 43 kg/t eq. H_2SO_4. This confirms the low sulfide content of the samples analyzed.

The paste pH results ranged from pH 2.5 to 8.8; over a fifth of the samples generated an alkaline paste pH which may indicate some buffering capacity. Most (75%) of the samples showed very low reactivity, generating paste conductivity values of less than 500 μS/cm.

The evidence presented here suggests that the south waste rock dump has an overall low acid generating potential.

5.2.4 East Waste Rock Dump

The samples collected from the east waste rock dump contain on average around 2 % visible sulfide. Sulfide analysis resulted in a similar figure (although fewer samples were evaluated). Ore samples contained up to 10 % sulfides.

The NAG potential of the samples analyzed was relatively small; 80% were less than 30 kg/t eq. H_2SO_4. This reflects the sulfide content of the rocks.

The paste pH range was from 2.71 to 9.14. Most (65%) of the samples generated a pH less than 6. This suggests that there are soluble salts available for dissolution. The average sulfate to total sulfur ratio is around 35%, which indicates a relatively low degree of oxidation.

The east waste rock dump, in common with the south waste rock dump, is likely to have a relatively low potential for acid generation.

6 DISCUSSION

6.1 Soluble Contaminants

Results of the EPA 1312 test indicate that the soluble metal concentrations in transition waste rock are relatively high; however, the sample represents only a limited volume of future waste rock. Leachates from kinetic tests conducted on unoxidized quartz monzonite samples exhibit very low soluble metal and salt concentrations. These leachates are considered more representative of potential unoxidized waste rock drainage quality in the foreseeable future.

Soluble metal concentrations in the tailings can also be used to infer behavior of the waste rock because the tailings are composed of similar material that has been crushed, increasing the surface area that is available to oxidation. Therefore, the soluble concentrations in the tailings exposed to weathering for over 14 years may provide a “worst-case” indication of the soluble load in the waste rock. As can be seen in Table B1.2 in Appendix B, the extractable metal concentrations in the tailings, as determined by modified method 1312 testing, are low.

6.2 Acid Generation

The degree to which material has oxidized, or its “weathering status”, can provide some indication of how the rock must be managed to alleviate ARD potential. The weathering status was identified visually by geologists according to the following classification (Table A.6.1):

- Oxide: No visible sulfides, loss of texture, strong oxide staining;
- Transitional: Visible sulfides, loss of texture, strong oxide staining;
- Low Sulfide: Few visible sulfides, fresh appearance, minor to no oxide staining; and,
- High sulfide: Abundant visible sulfides, fresh appearance, minor to no oxide staining.

Figure A.6.1 plots NP against AP according to weathering status of the material. The figure shows that oxidized material has low potential to generate acid since these samples have AP concentrations below 11, equivalent to a percent sulfide concentration of less than 0.4%.

This is also illustrated in Figure A.6.2. This figure plots the percent sulfur present as sulfide against percent sulfur as sulfate. The diagonal line in the figure is where concentrations of the two sulfur forms are equal. Samples having higher sulfate sulfur than sulfide sulfur are all oxide and transitional material. Samples plotting below the line are low and high sulfide material. This figure, along with Figure A.6.1, suggests that oxidized material will not pose an ARD problem. However, this material may contain soluble metals that could be leached from the rock in the short term.

For the transitional, low and high sulfide materials, there is evidence to suggest that some of the sulfides are less reactive than others. One piece of evidence is the waste rock piles themselves. During the 14 years of exposure, much of the sulfide has been oxidized to metal oxides that are stored in the rock. However, the waste still contains unoxidized sulfides, suggesting that there is some variability in the weathering rates of the sulfides. This is also illustrated in Figure A.3.1 by the wide range of paste pH values for every rock type, except andesite. The biotite breccia, quartz breccia, quartz monzonite, and quartz vein material all have paste pH values ranging from 2 to 9. If all the sulfides are uniformly distributed and had similar reactivity, the range of paste pH values would not be expected to be so broad.

Figure A.6.3 is a plot of NAG pH vs. total sulfur. NAG pH values range from 2 to 8 and have no relation to total sulfur concentrations. For example, samples with total sulfur contents of about 2.9% have NAG pH values either below 3 or greater than 6. This suggests variability in the reactivity of the sulfides contained in the samples.

Finally, of the waste rock humidity cells only LGSSP-2 became acidic during the 27 weeks of testing, despite containing very different materials. Since there is little neutralizing capacity in many of the kinetic test samples, the neutral drainage indicates low rates of sulfide oxidation in the cells. Thus, even under the relatively wet conditions of the humidity columns, the sulfides are slow to oxidize.

6.3 Field Identification of Waste

Results of the geochemical testing program indicate that field methods can be used to identify the different types of waste. The visual classification of oxide, transitional, low sulfide and high sulfide material correlated well to sulfate/total sulfur ratios, as shown in Figure A.6.4. Oxide samples have ratios above 75% and transitional material has ratios between 40% and 75%. Low and high sulfide values fall below 40% SO_4/S(T).

The figure also shows that low and high sulfide can be distinguished by sulfide concentrations. Three of the four low sulfide samples had sulfide concentrations below 0.6%. This means that during operations, low sulfide can be separated from high sulfide material based on visual estimation of sulfide concentration.

While the waste rock can be easily classified on the basis of visual inspection, periodic testing of sulfur content is recommended as a means of confirming the effectiveness of visual classification methods. Confirmation testing is recommended to evaluate the distinction between oxide and transition waste, and between low sulfide and unoxidized waste. Total sulfur analyses by Leco furnace are routinely used in waste management programs at many mine sites. Equating total sulfur content with sulfide sulfur content provides a rapid and highly conservative estimate of acid generating potential.

7 CONCLUSIONS

The primary conclusions of this work are:

- While a significant to moderate potential for acid generation is exhibited by the Copper Flat lithologies, the rate of sulfide oxidation is slow. Sulfide oxidation and acid generation has been and is active at the Copper Flat mine site. However, no environmental impact on surface streams or groundwater has been observed during this or any previous studies. Seasonal acidic and metal-sulfate rich seeps do form but tend to evaporate at the toe of the dumps.

- Available buffering through mineral-water reactions and from groundwater recharge is sufficient to neutralize generated acidity for much of the year. Acid seeps could develop during operations, after periods of heavy rainfall. However, these seeps will drain towards the pit area as either surface or sub-surface flow.

- Metal release from the lithologies is low and all kinetic leachates conformed to all applicable surface water and most groundwater standards.

- Sulfide oxidation is slow from the Copper Flat lithologies as evidenced by the abundance of sulfide minerals on the waste rock dump surfaces despite exposure since 1982.

Environmental concerns regarding waste rock at any mine site are generally two fold: leaching of soluble metals stored in the waste and generation of acidic drainage. At Copper Flat, leachable metals from the waste rock and tailings do not appear to be a concern, with the exception of the transition waste.

The results of the geochemical testing programs indicate that most of the waste rock at the site has the potential to generate acid, given sufficient time and exposure to oxidizing conditions. However, evidence from paste pH tests, NAG tests, and humidity columns suggest that the sulfides are not highly reactive. This is supported by the fact that much of the material on the waste rock dumps is neutral despite having been on the surface since 1982. This may be due to the coarse, crystalline nature of the sulfides at Copper Flat as well as arid site conditions. Crystalline minerals have a lower surface area and a more organized structure so consequently require more energy to oxidize. As a result they tend to be more stable than fine-grained semi-crystalline or subhedral minerals.

The rates of reactivity of the sulfides will need to be confirmed by humidity column tests on new waste rock generated from the pit. In the interim, waste can be managed using a conservative plan that includes visual classification and confirmatory measurement of the total sulfur content of the waste rock prior to its removal from the pit, with waste handling measures that address the short and long term management requirements. Once oxidation rates are obtained from the operational field test program then the humidity column test results reported here can be calibrated to a parameter that can be measured in the field, such as total sulfur, so as to refine the operational waste management plan

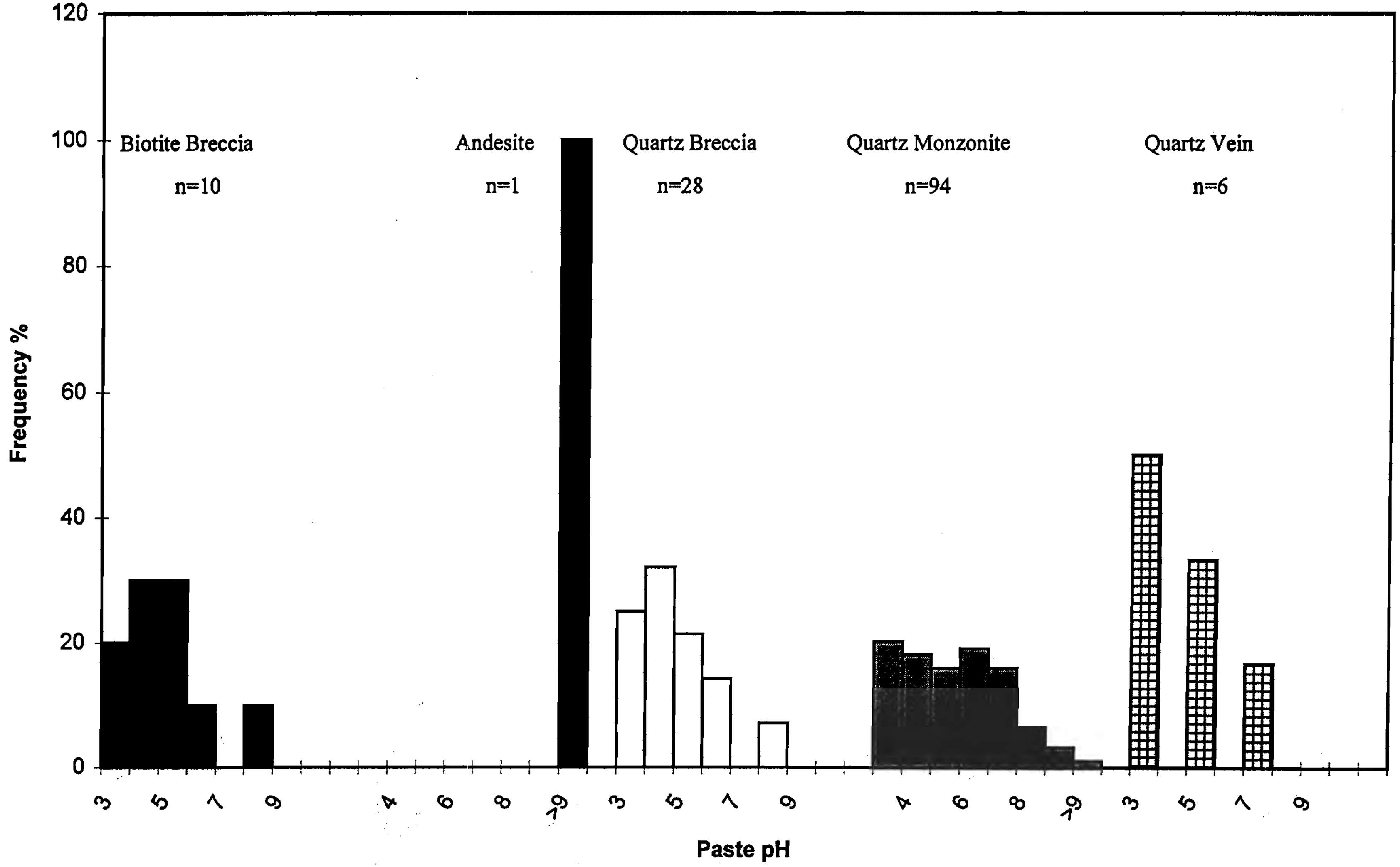

Figure A.3.1. Paste pH Frequency Distribution by Lithology

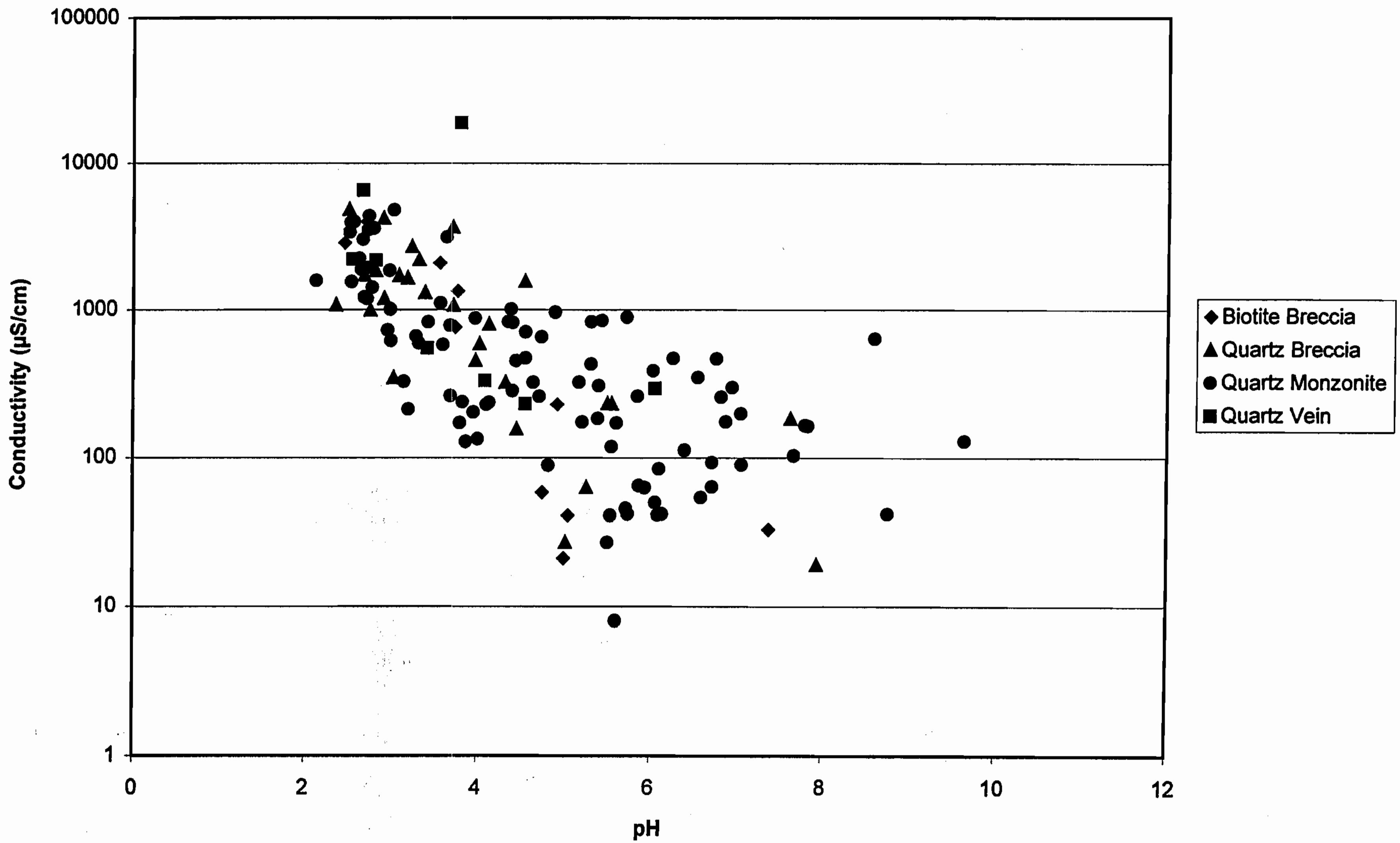

Figure A.3.2 - Paste pH vs. Conductivity

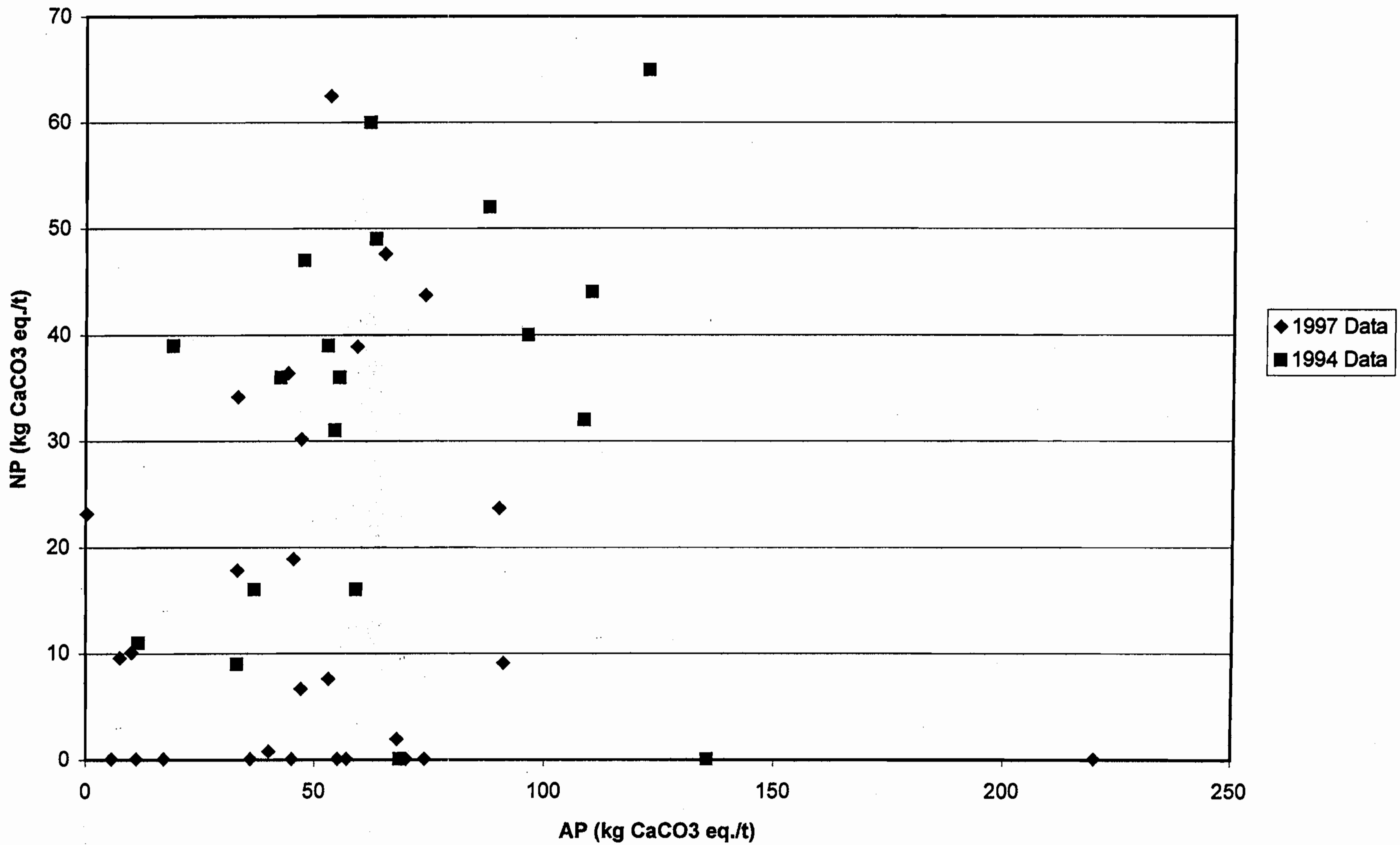

Figure A.3.3 - NP vs. AP for 1994 and 1997 data

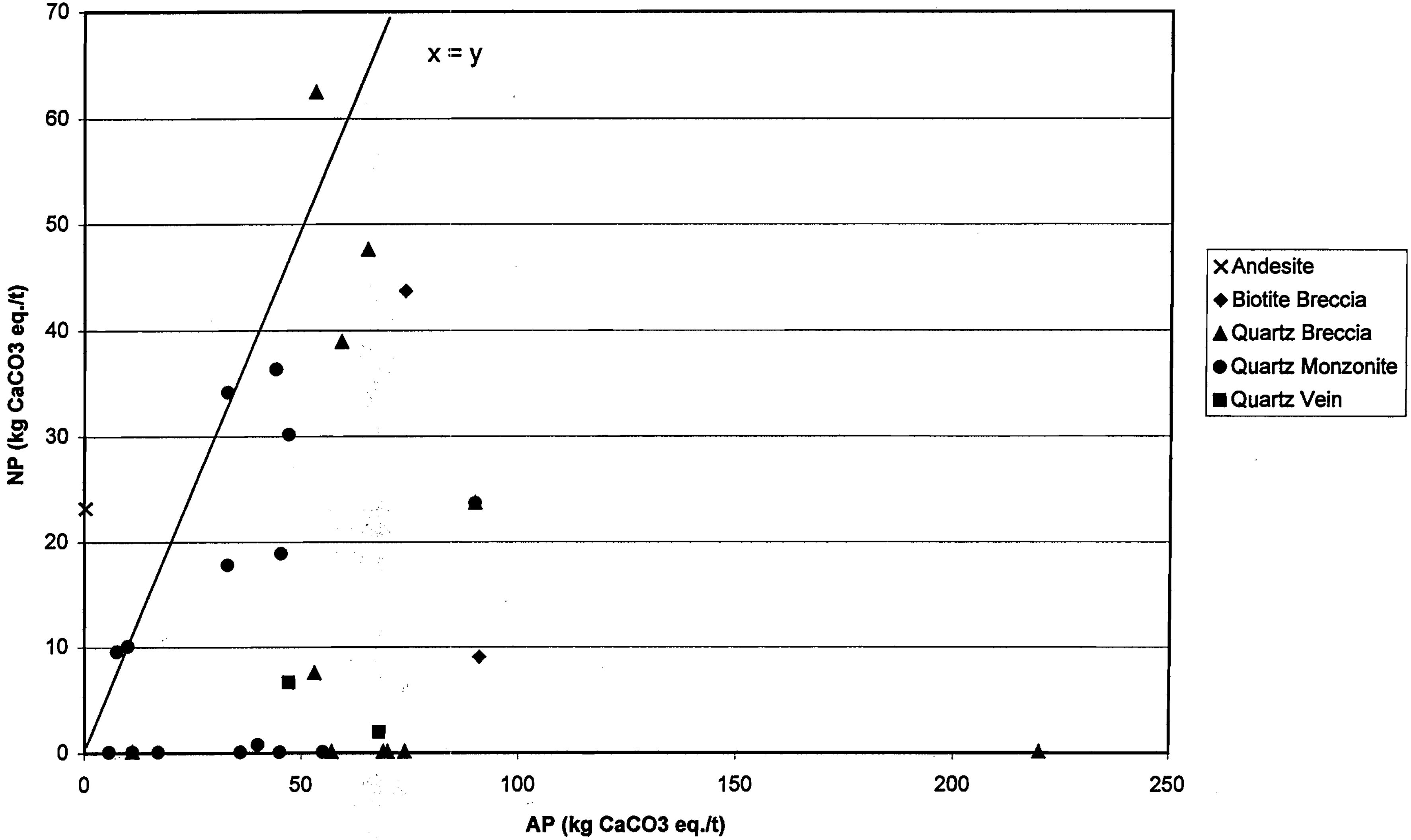

Figure A.3.4 - NP vs. AP

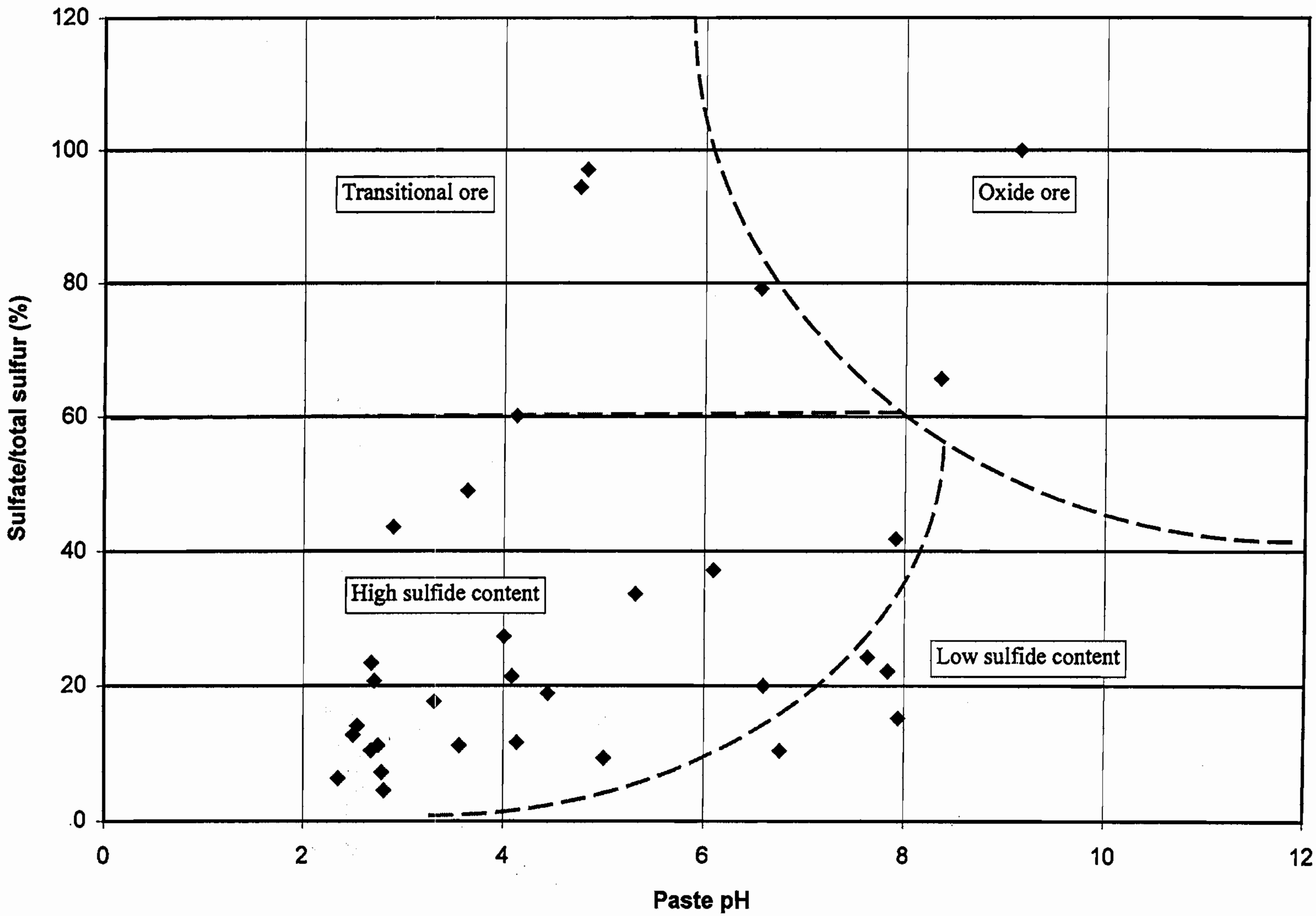

Figure A.3.5 - Total Sufate/Total Sulfur (%) vs. paste pH (SU)

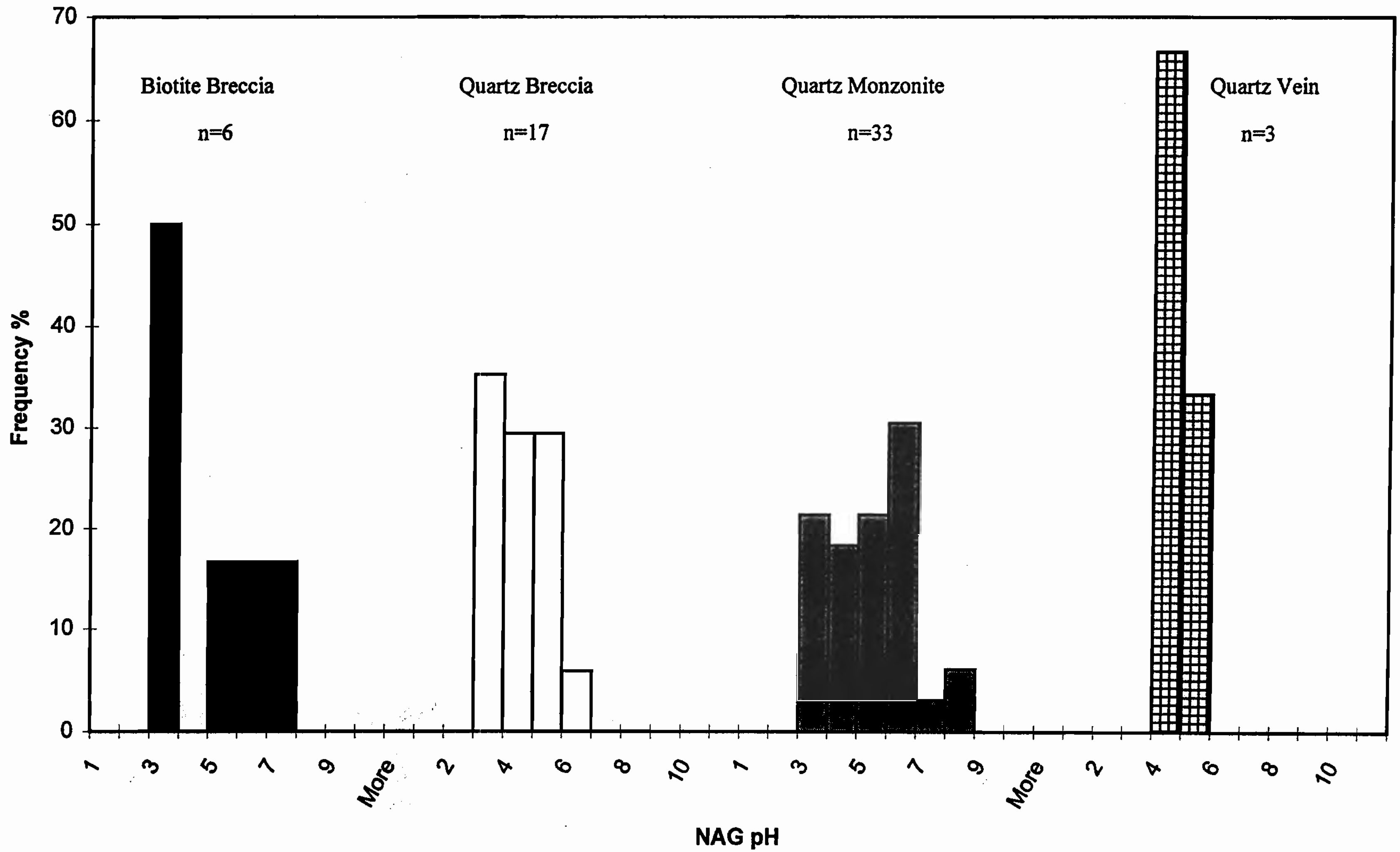

Figure A.3.6 - NAG pH Frequency Distribution by Lithology*

* No samples of andesite were analysed by NAG testing

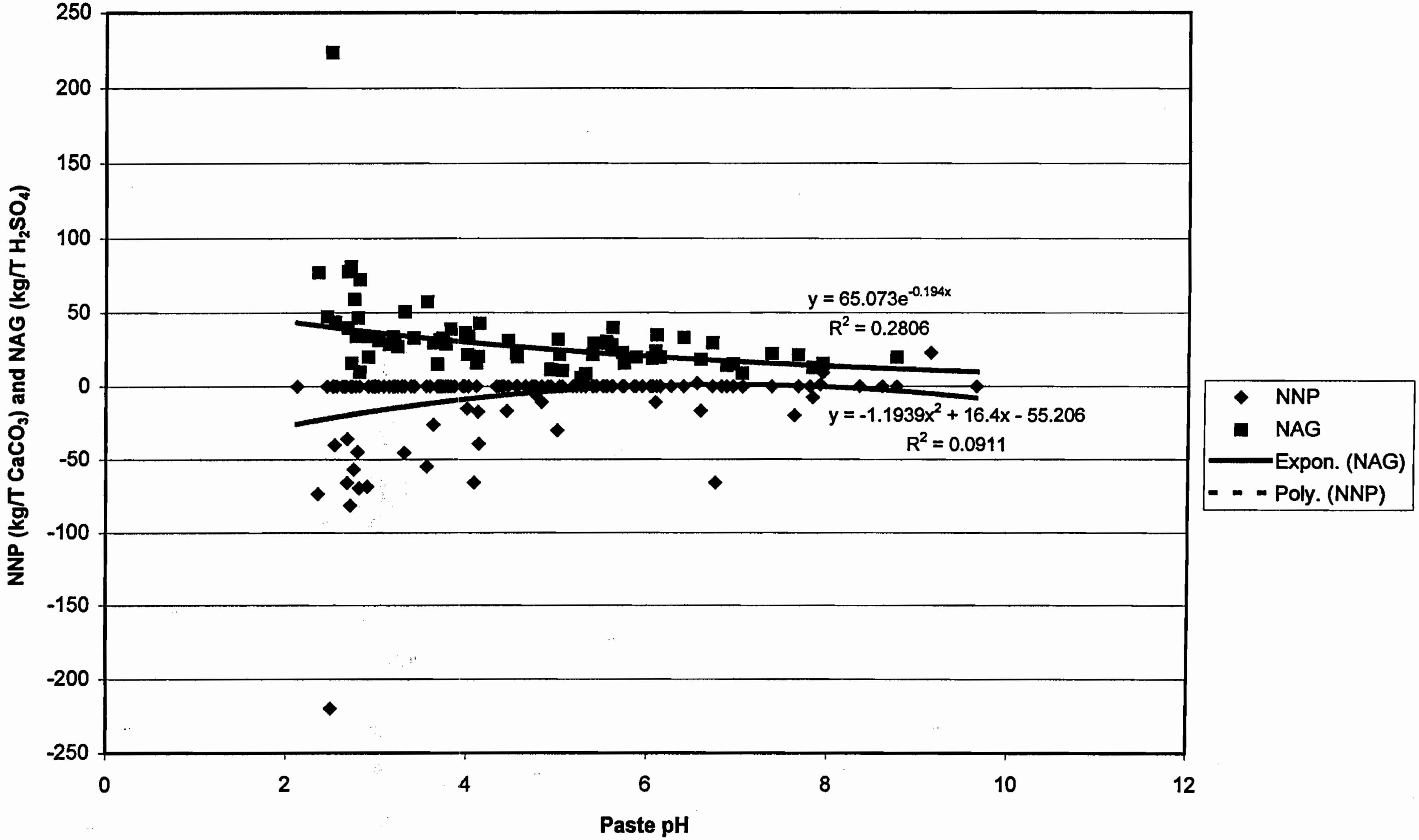

Figure A.3.7 - Paste pH vs. NNP, NAG

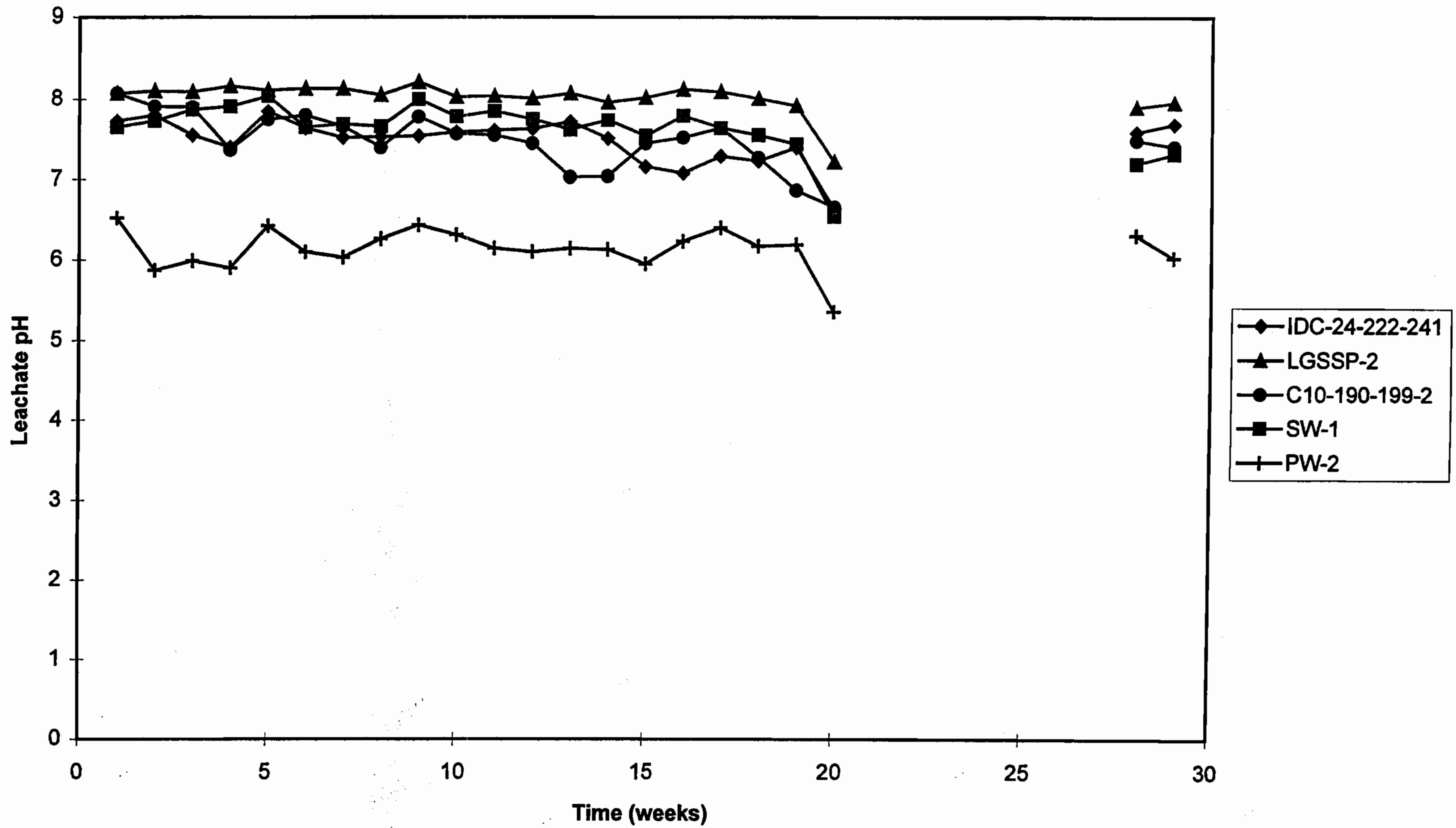

Figure A.3.8 - Kinetic Test Results for pH vs Time

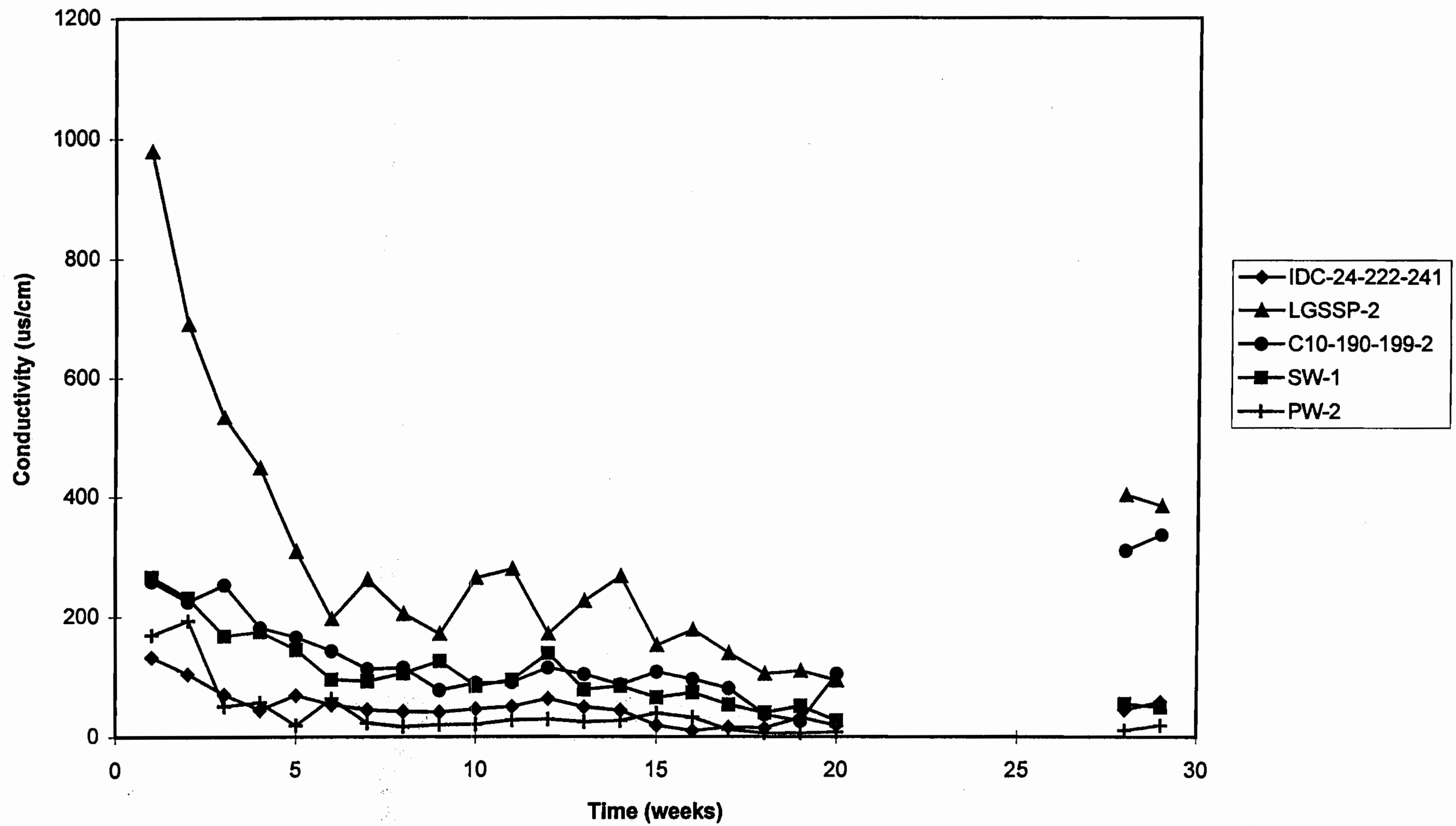

Figure A.3.9 - Kinetic Test Results for Electrical Conductivity vs Time

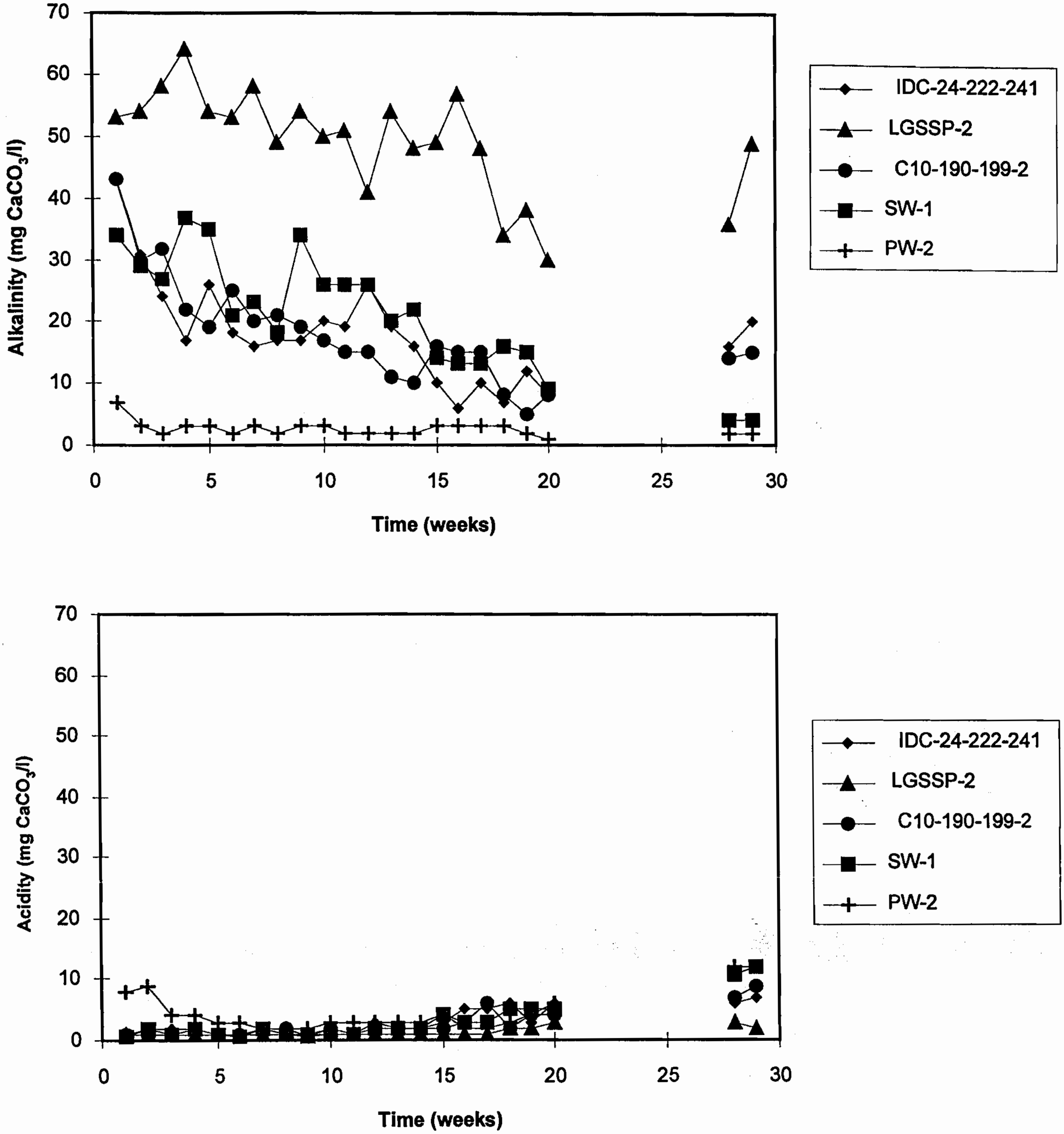

Figure A.3.10 - Kinetic Test Results Alkalinity and Acidity vs Time

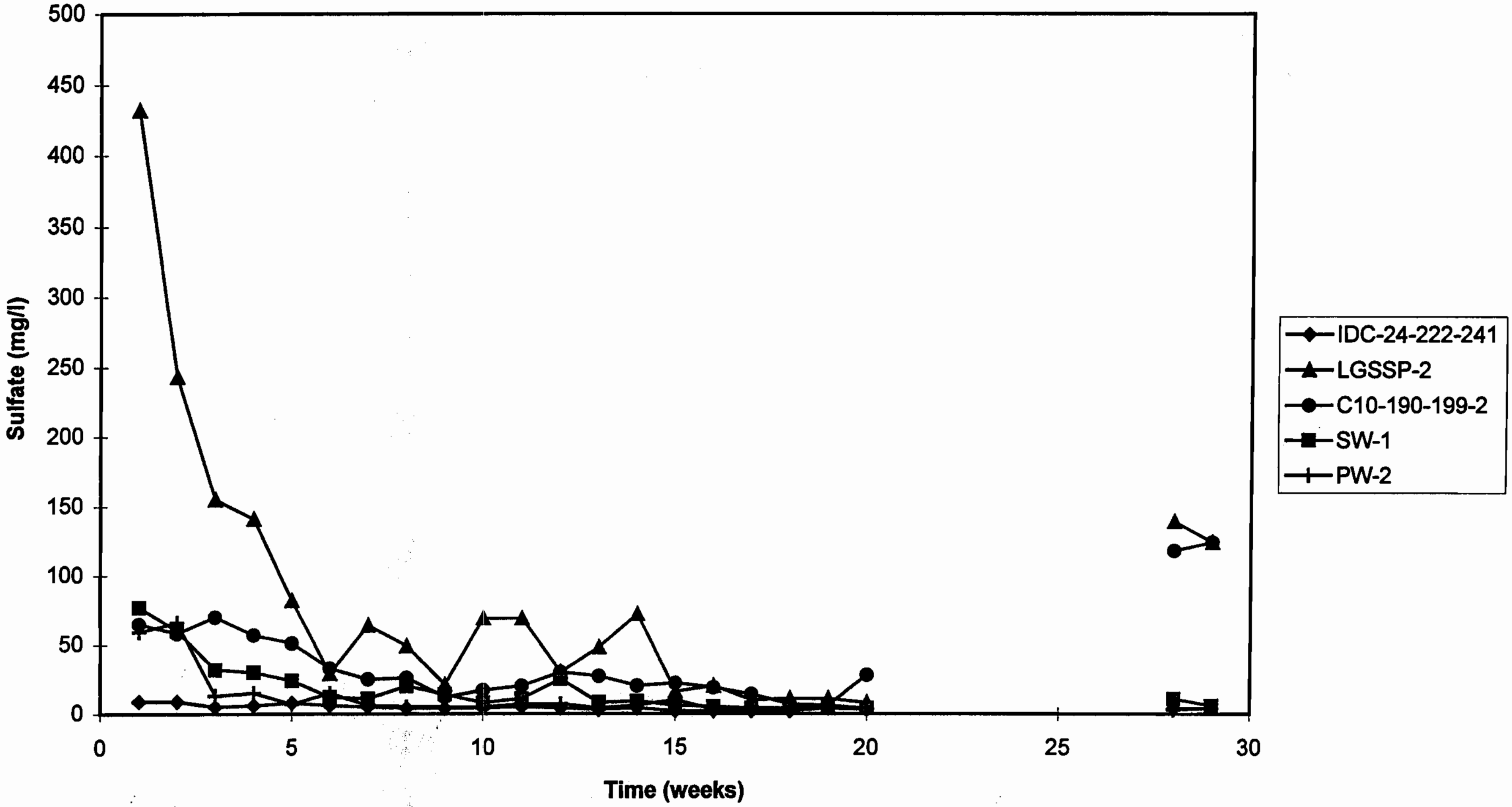

Figure A.3.11 - Kinetic Test Results for Sulfate vs Time

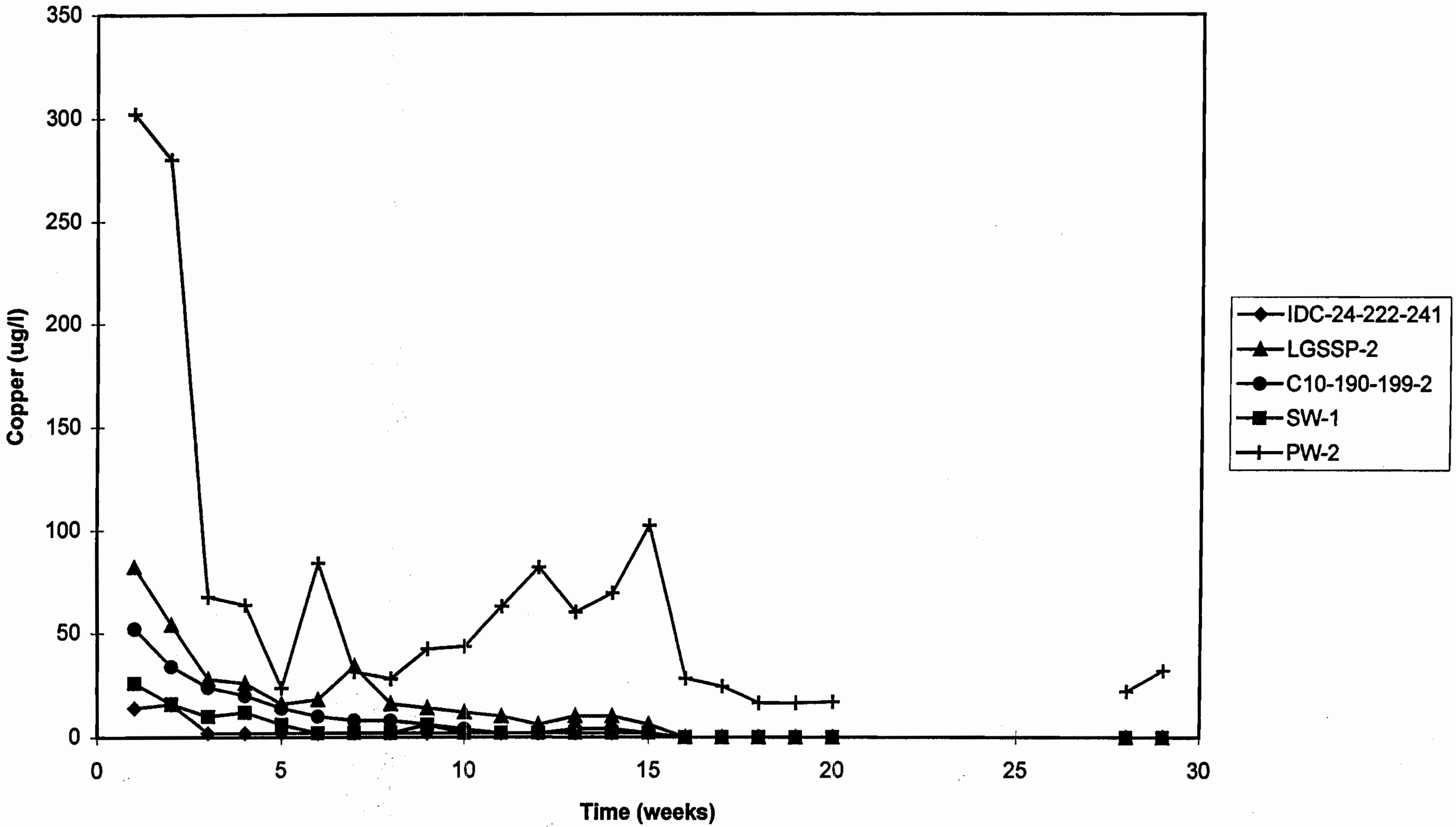

Figure A.3.12 - Kinetic Test Results Copper vs Time

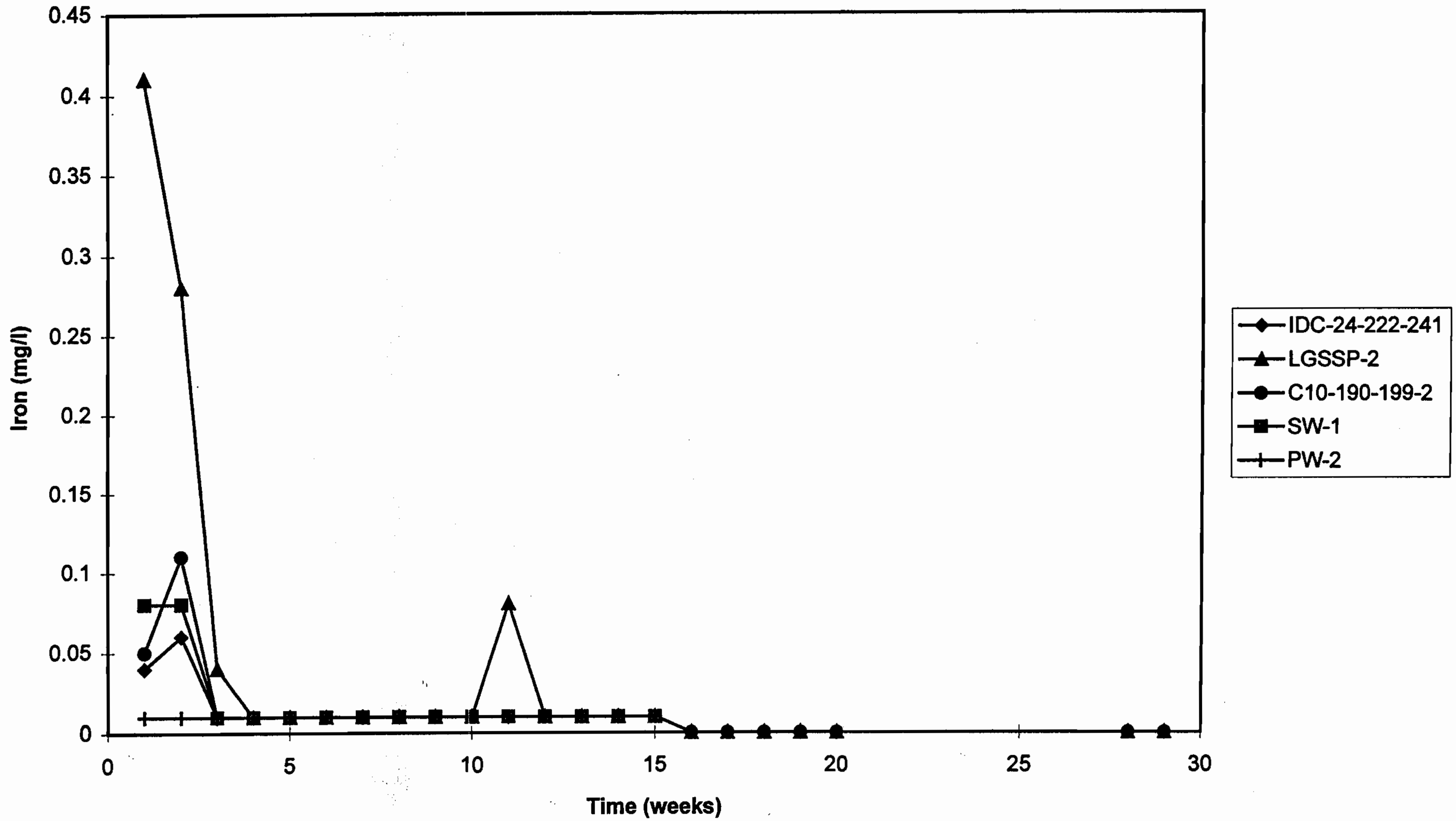

Figure A.3.13 - Kinetic Test Results for Iron vs Time

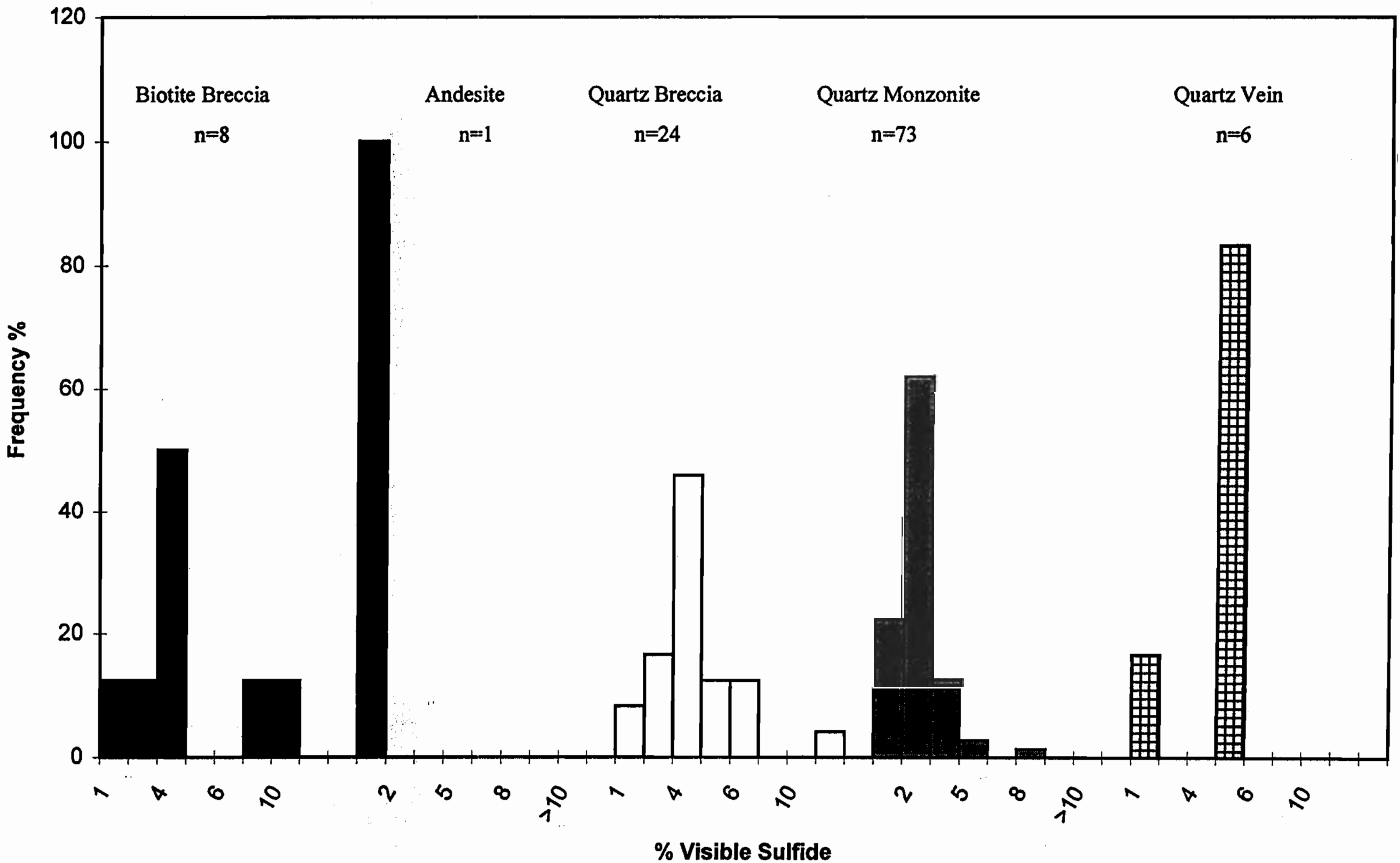

Figure A.5.1 - Percent Visible Sulfide Frequency Distribution by Lithology

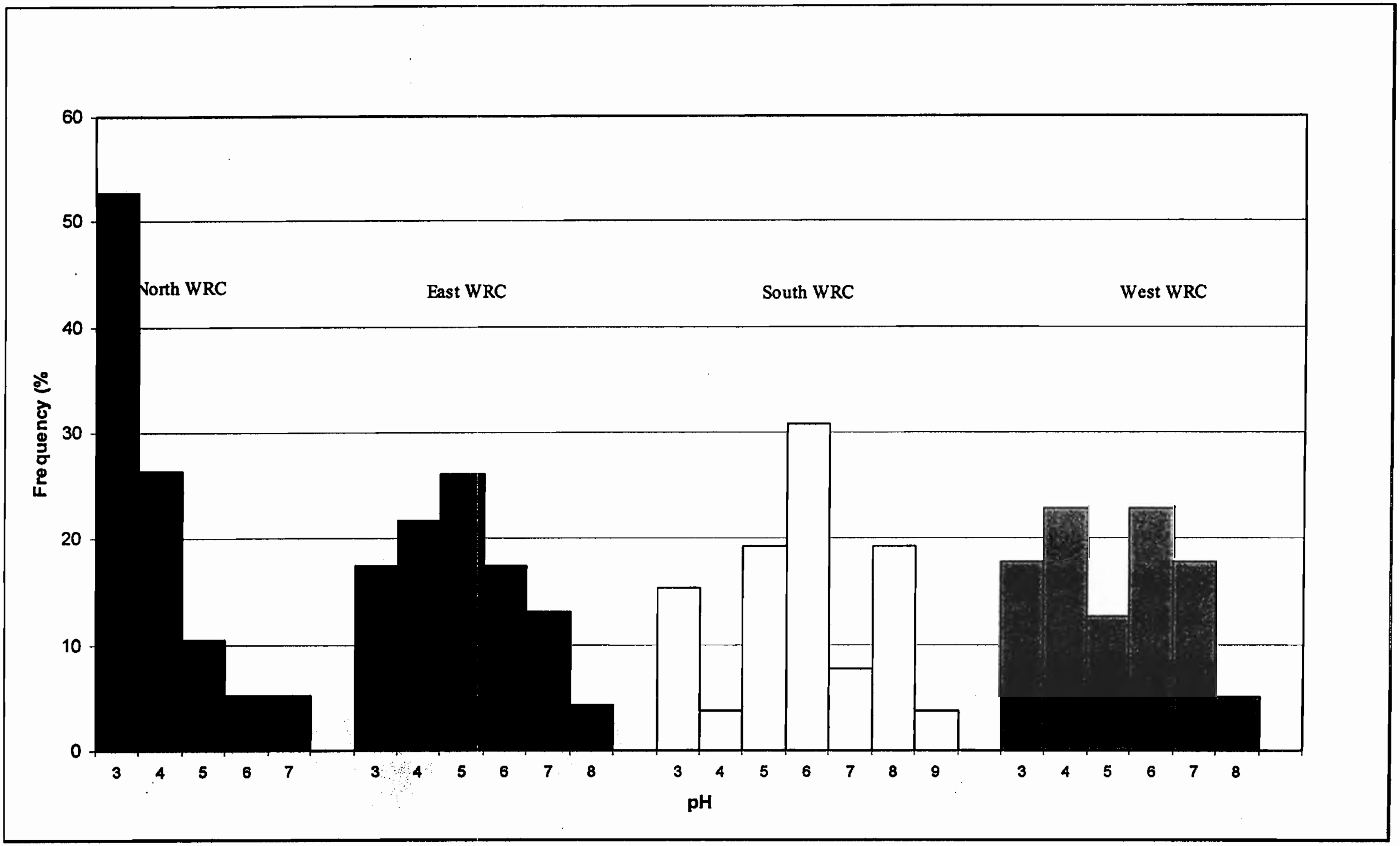

Figure A.5.2 - Histogram of Paste pH for All Dumps

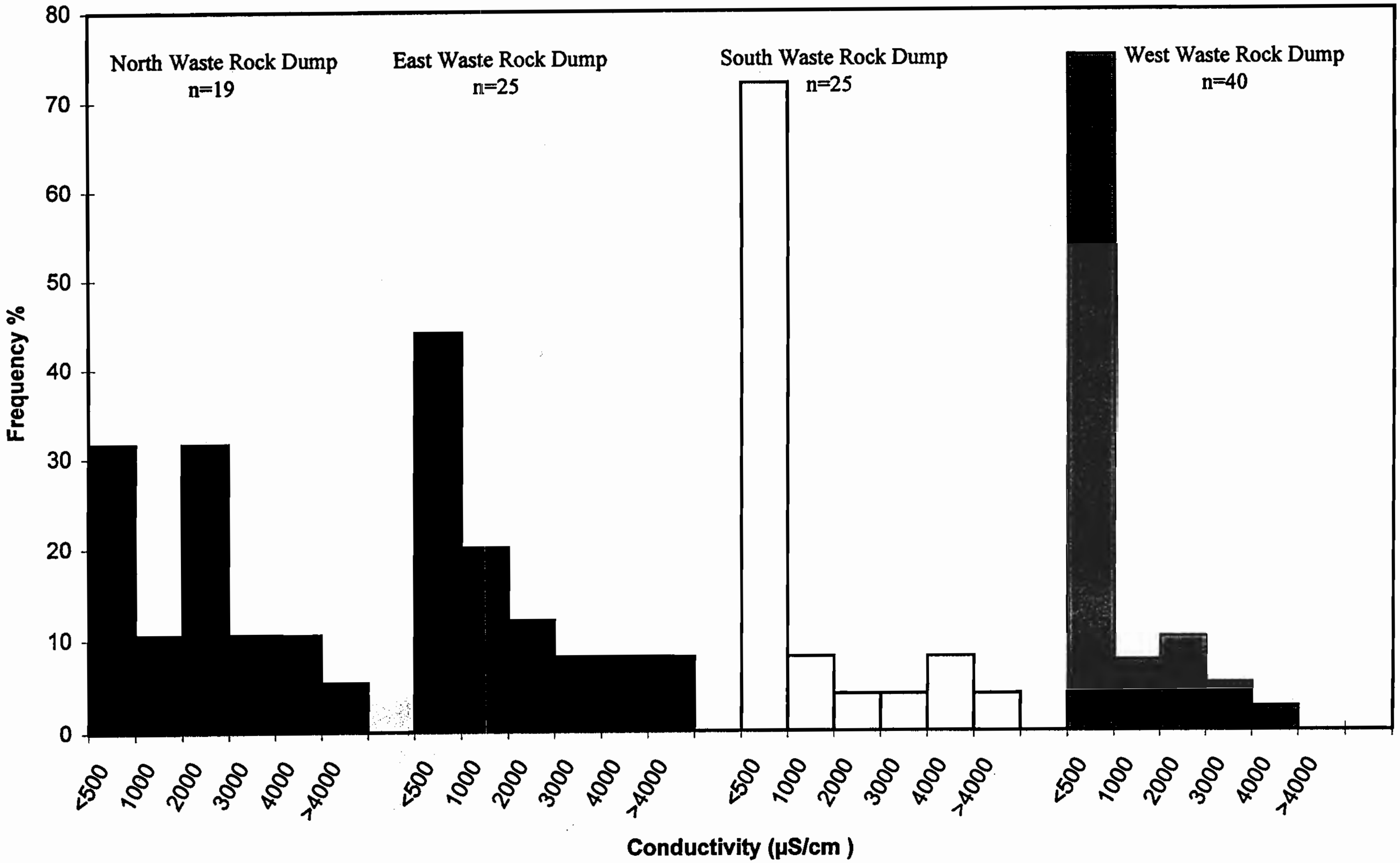

Figure A.5.3 - Paste Conductivity Frequency Distribution by Dump

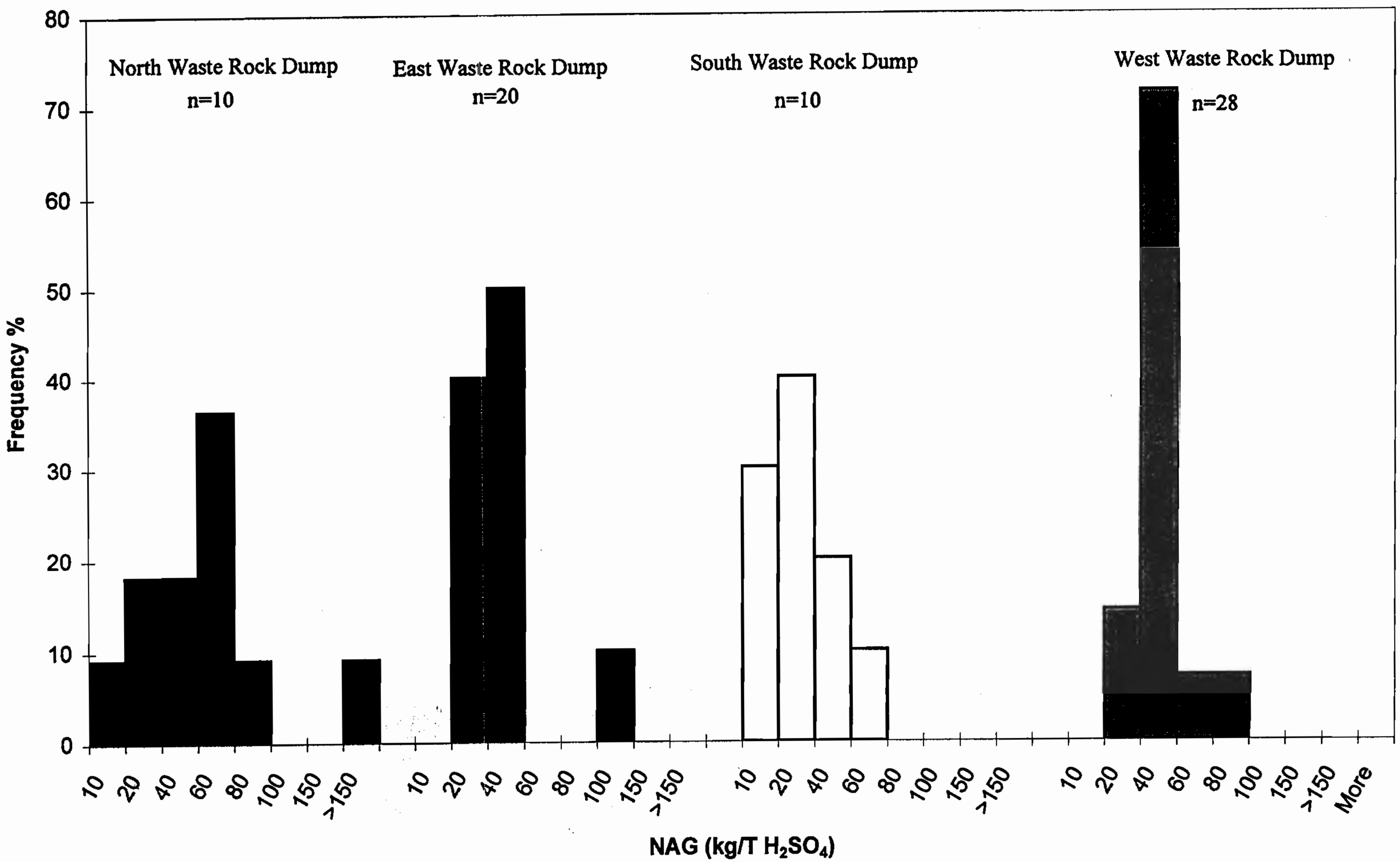

Figure A.5.4 - NAG Frequency Distribution by Dump

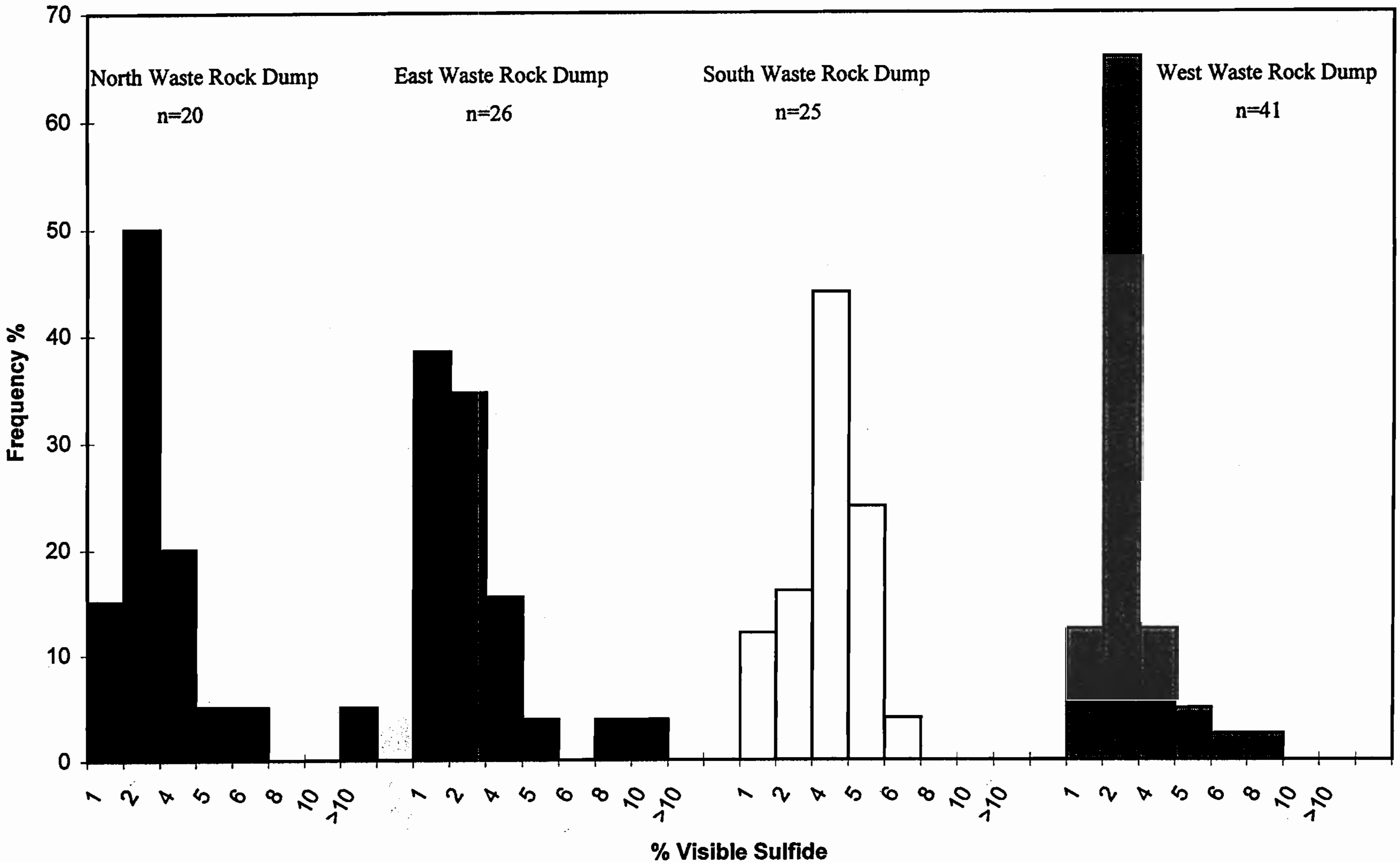

Figure A.5.5 - Percent Visible Sulfide Frequency Distribution by Dump

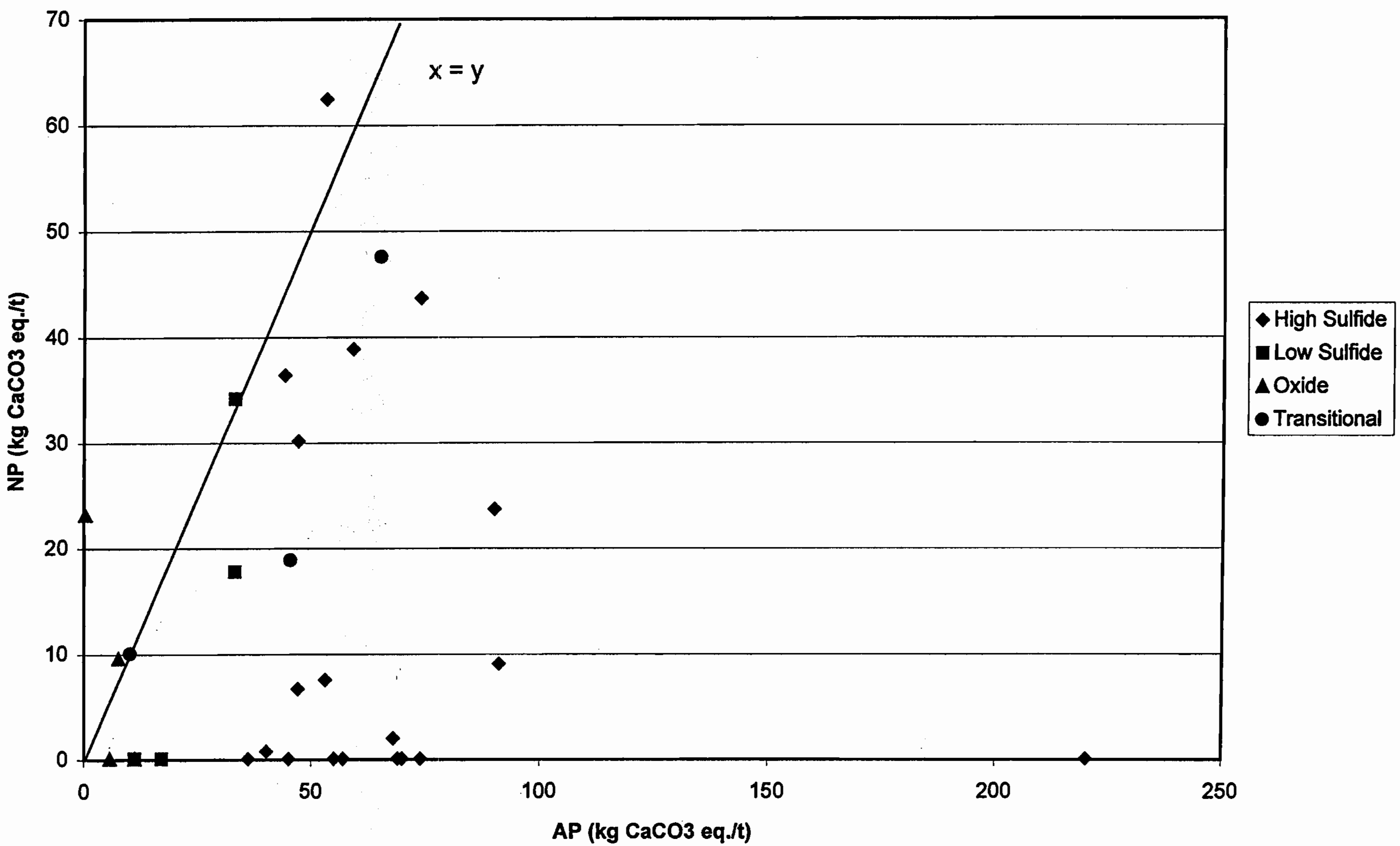

Figure A.6.1 - NP vs. AP by Weathering Status

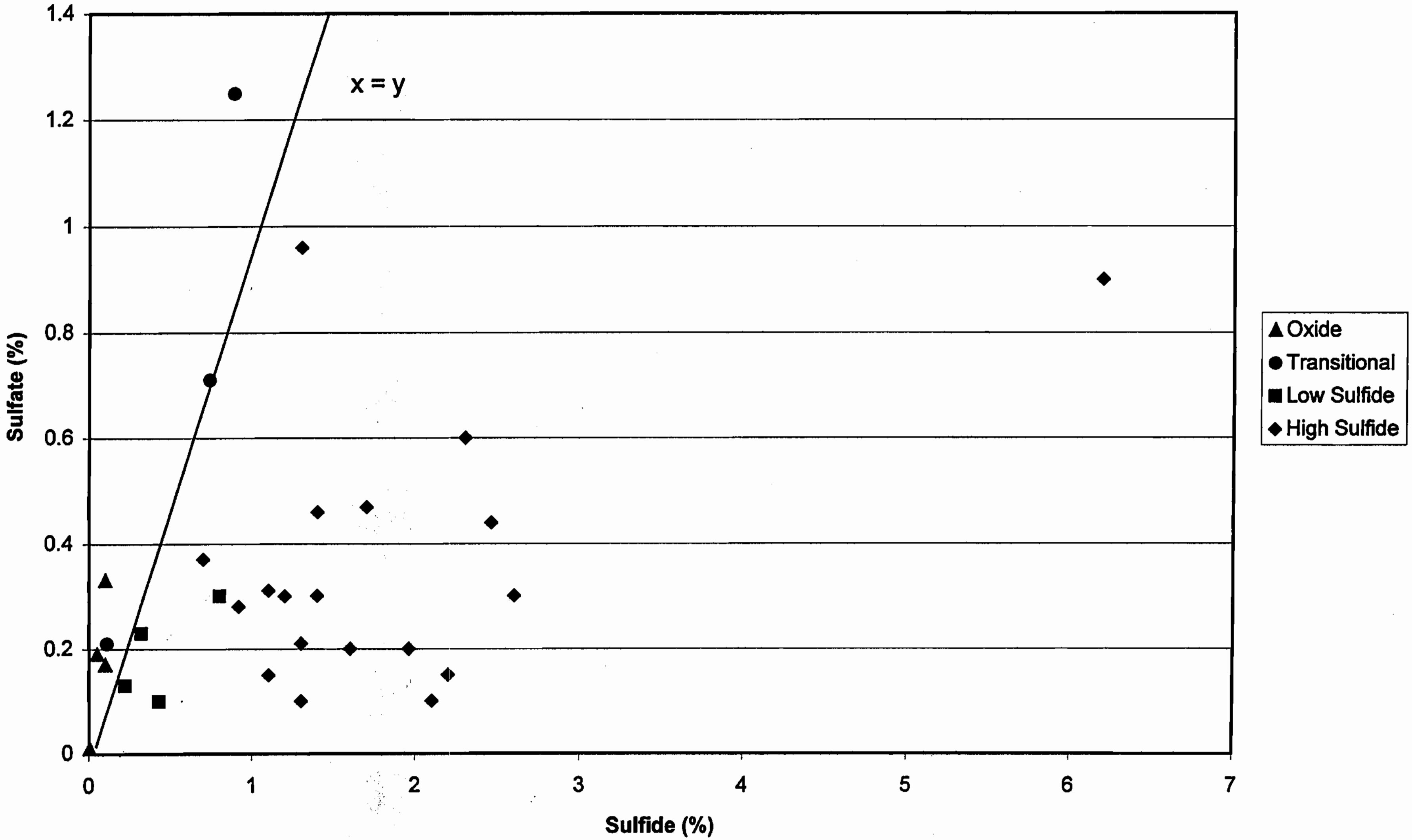

Figure A.6.2 - Sulfide vs. Sulfate by Weathering Status

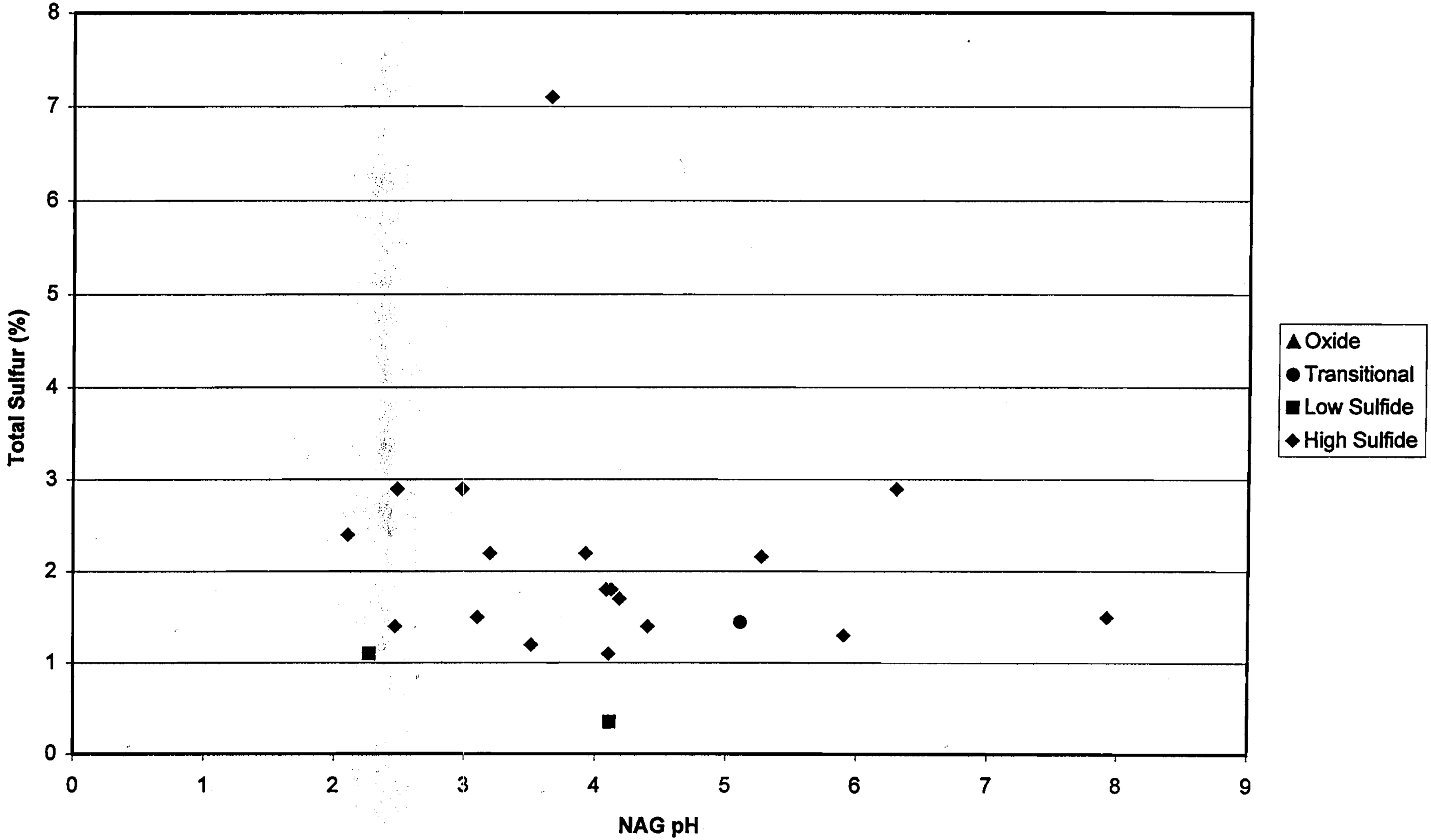

Figure A.6.3 - NAG pH vs. Total Sulfur

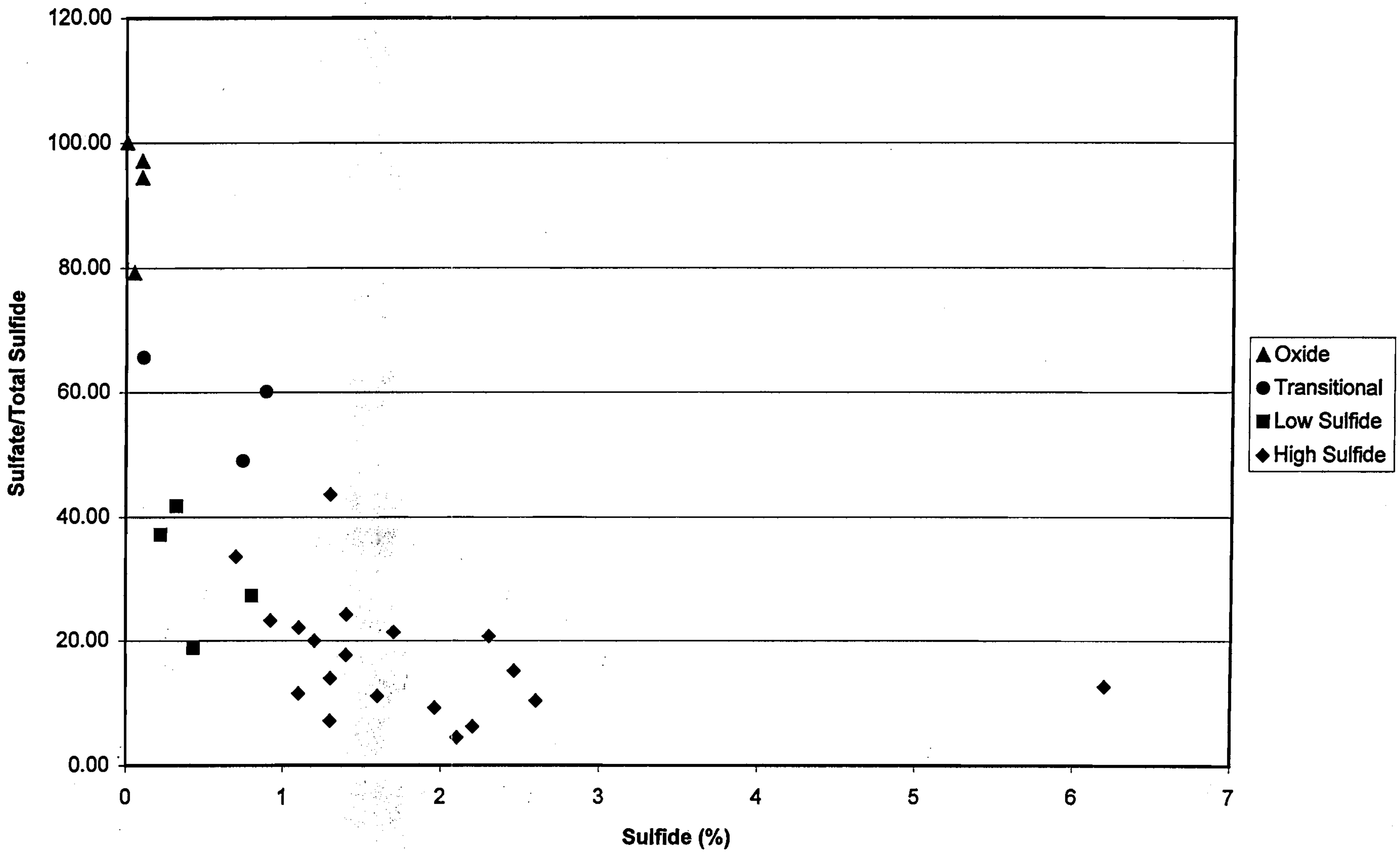

Figure A.6.4 - Sulfate/Total Sulfur vs. Sulfide

Table A.1.1
Numbers of samples analysed in the Waste Rock Characterization Program

Test	Number of Samples Analyzed		
	Phase I EIS	Phase II WMP	Total
Paste pH/Conductivity	19	93	112
Total Metals (ICP)	2	0	2
Acid Base Accounting (ABA)	19	28	47
Net Acid Generating (NAG)	0	59	59
EPA 1312	1	0	1
Kinetic Testing	5	0	5
Physical Tests*	1	0	1

EIS = Environmental Impact Statement
WMP = Waste Management Plan
* Gradation, Modified Proctor, Hydraulic Conductivity

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EPA 1312	1	0	1
Kinetic Testing	5	0	5
Physical Tests*	1	0	1

EIS = Environmental Impact Statement
WMP = Waste Management Plan
* Gradation, Modified Proctor, Hydraulic Conductivity

Table A.1.2
Number of Tests on Samples of Each Rock Type

	Rock Type					Total
	Quartz Monzonite	Quartz Breccia	Biotite Breccia	Andesite	Quartz Vein	
Number of Samples	91	8	24	2	6	131
Paste pH/Conductivity	91	8	24	1	6	130
Total Metals (ICP)	2	--	--	--	--	2
Acid Base Accounting (ABA)	31	2	10	1	2	46
Net Acid Generating (NAG)	33	6	17	--	3	59
EPA 1312	1	--	--	--	--	1
Kinetic Testing	5	--	--	--	--	5
Physical Tests*	1	--	--	--	--	1

EIS = Environmental Impact Statement
WMP = Waste Management Plan
* Gradation, Modified Proctor, Hydraulic Conductivity

Table A.3.1
Total Metals Concentrations in Waste Rock

Parameters (ppm)	Sample Number	
	WD-1	PW-3
Aluminum	1890	2950
Antimony	< 0.10	<0.10
Arsenic	0.4	1.9
Barium	10	24
Boron	<2	<2
Cadmium	<0.5	<0.5
Calcium	700	700
Chromium	<1	<1
Cobalt	11	9
Copper	186	226
Iron	41600	40800
Lead	2	4
Magnesium	200	800
Manganese	8	39
Mercury	<0.02	<0.02
Molybdenum	7	57
Nickel	<2	3
Phosphorus (%)	0.01	0.04
Potassium	1200	1300
Selenium	3.9	9.0
Silver	<1	<1
Sodium	200	200
Vanadium	1	5
Zinc	7	14

Table A.3.2
Extractable Metals Concentrations in Waste Rock

Parameters (mg/L)	WD-1
pH	3
Conductivity (mmhos/cm)	5.6
Sulfate	3050
Acidity (as $CaCO_3$)	1050
Alkalinity (as $CaCO_3$)	0
Aluminum	151
Antimony	N/A
Arsenic	< 0.1
Barium	0.09
Boron	0.10
Cadmium	0.019
Calcium	314
Chloride	6
Chromium	0.03
Cobalt	0.29
Copper	13.6
Fluoride	1.2
Iron	102
Lead	< 0.021
Magnesium	23
Manganese	3.35
Mercury	< 0.0002
Molybdenum	<0.01
Nickel	0.11
Potassium	4
Selenium	< 0.1
Silver	< 0.01
Sodium	13
Vanadium	< 0.01
Zinc	0.87

Table A.3.3
Results of ABA Testing of Column Samples

Sample Number	SW-1	PW-2	LGSSP-2	C10-190-199-2	IDC-24-222-241
Rock Type	qm	qb	qm	qm	qm
Classification	oxidized	transitional	oxidized	unoxidized	unoxidized
Total Sulfur (%)	1.36	0.37	0.61	3.59	1.74
Sulfate (%)	0.01	0.01	0.01	0.07	0.01
Sulfide (%)	1.36	0.37	0.61	3.52	1.74
AP	42	11	19	110	54
NP	36	11	39	44	31
NNP	-6	0	20	-66	-23
NP:AP	0.86	1.00	2.05	0.40	0.57

Table A.3.4
Results of Kinetic Test Work

Sample Number	SW-1	PW-2	LGSSP-2	C10-190-199-2	IDC-24-222-241
Total Sulfur (%)	1.36	0.37	0.61	3.59	1.74
Sulfate (%)	0.01	0.01	0.01	0.07	0.01
Sulfide (%)	1.36	0.37	0.61	3.52	1.74
AP	42	11	19	110	54
NP	36	11	39	44	31
NNP	-6	0	20	-66	-23
NP:AP	0.86	1.00	2.05	0.40	0.57
Estimated Time to Depletion (years)					
NP (from stoichiometry)	286	220	126	253	389
AP (from sulfate)	1262	382	263	1051	2842
Pseudo Steady State Release Rate kg CaCO3 eq./tonne/week					

Table A.4.1

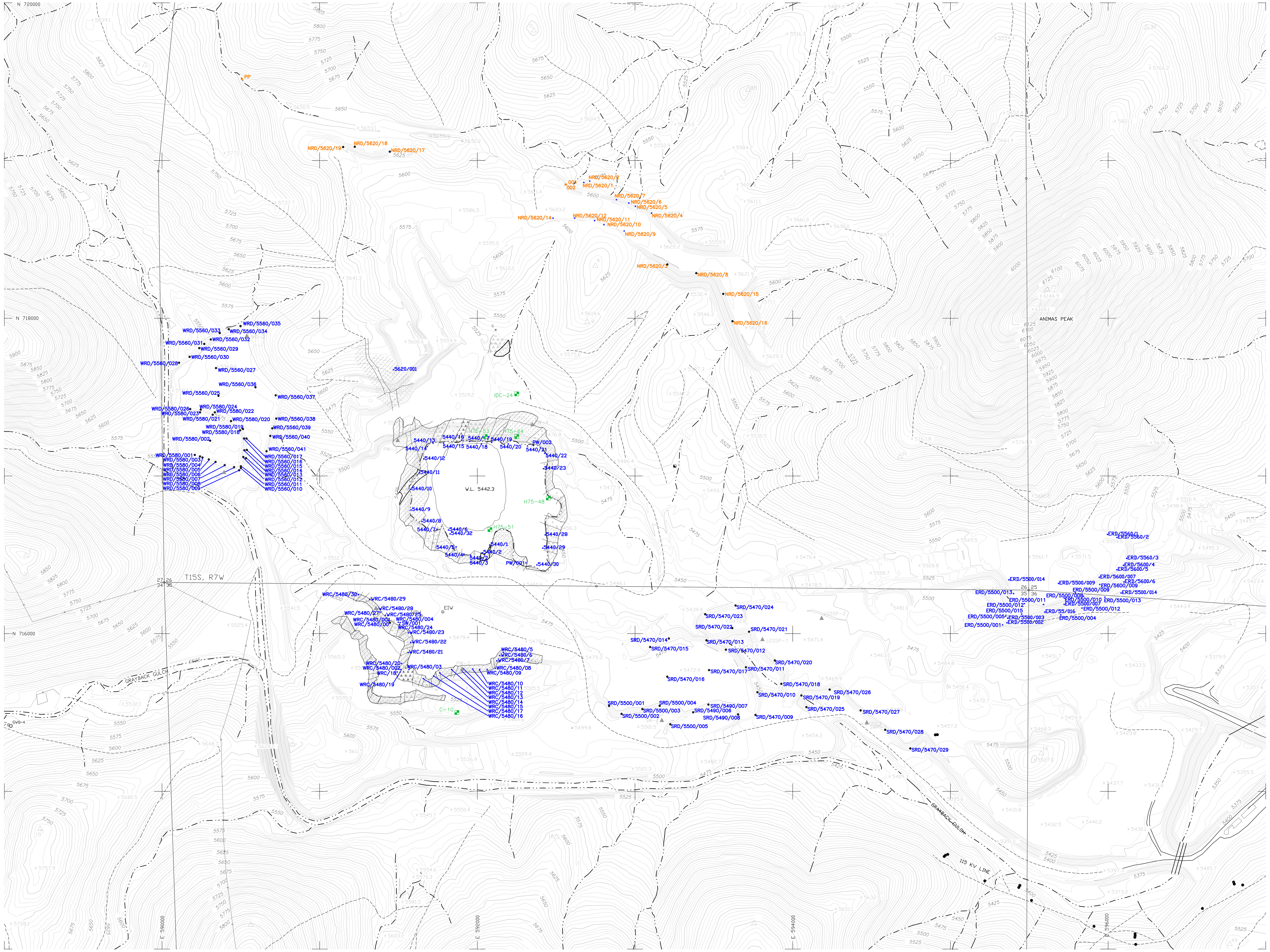
Chemistry of West Dump Seep (August, 1997)

Parameter	W-Waste All in mg/l unless otherwise stated
pH (std. units)	3.03
Alkalinity (mg/l $CaCO_3$ equiv.)	0.
Bicarbonate	0.
Carbonate	0.
Sulfate	22,100.
Total Dissolved Solids	25,440.
Chloride	16.
Fluoride	0.31
Nitrate_N	4.7
Iron	310.
Copper	1,800.
Arsenic	0.14
Aluminium	2,100.
Barium	<0.05
Beryllium	0.49
Boron	0.21
Calcium	410.
Cadmium	0.82
Cobalt	9.9
Nickel	1.3
Thallium	0.02
Manganese	170.
Zinc	38.
Molybdenum	0.28
Selenium	0.11
Magnesium	580.
Sodium	20.
Potassium	<1

Table A.6.1
Copper Flat Project
Waste Rock Classification System

Waste Rock Type	Criteria No. 1 Visual	Criteria No. 2 Paste pH (s.u.)	Criteria No. 3 Paste Conductivity (uS)	Criteria No. 4 AP (T/KT)	Criteria No. 4 NAG	Required Criteria
Oxidized	No visible sulfides, loss of texture, strong oxide staining	>5.0	<500	<1.6	0	(1, 2 and 3) or (1 and 4)
Transition	Visible sulfides, loss of texture, strong oxide staining	<5.0	>500	>1.6	>0	1
Unoxidized	Visible sulfides, fresh appearance, minor feox staining	>5.0	<500	>10	>0	1,2 and 3
Low sulfide	Few visible sulfides, fresh appearance	>5.0	<500	<10	0	1 through 4

Notes:
(1) AP criteria for identification of oxidized and transition waste based on a total or sulfide sulfur content of 0.05 percent
(2) NP of unoxidized waste is typically greater than 30 T/KT, therefore AP criteria for low sulfur waste is for an NP:AP ratio near 3:1 and sulfur content of 0.32 percent
(3) Acid producing potential (AP) by syulfur analysis and NAG are alternatives for criteria No. 4



N

LEGEND

- H75-51 ▪ SAMPLED DRILL HOLE COLLAR LOCATION (APPROXIMATE)
- PW-1 ▲ SURFACE GRAB SAMPLE LOCATION
- • SAMPLE LOCATION

300 150 0 300 600

SCALE IN FEET

ENGINEER	No.	DESCRIPTION	BY	DATE

REVISIONS

PREPARED FOR: ALTA GOLD COMPANY

PREPARED BY: SRK Consulting Engineers and Scientists

TITLE: WASTE ROCK SAMPLE LOCATION MAP

SCALE: AS SHOWN

DRAWING No.: FIGURE A.1.2

REVISION: A

PROJECT No.: 68606

REFERENCE

DESIGNED	10/98
DRAWN	10/98
CHECKED	10/98
APPROVED	10/98
APPROVED	

APPENDIX A.1

TESTING PROTOCOLS

Paste pH and TDS

Acid Base Accounting

Modified EPA 1312 test

Humidity Columns

Net Acid Generation (NAG) Test

FIELD PASTE pH and CONDUCTIVITY

Objectives

- To determine the pH and conductivity of the pore water resulting from dissolution of secondary mineral phases on the surfaces of oxidized rock particles.
- To indicate whether oxidation, and accumulation of contaminants in the form of secondary mineral phases, has occurred in the waste rock prior to collection of the sample.

Principles of Test

Water is added to the sample to form a paste or slurry thus mobilizing secondary mineral phases and providing a medium accessible to the pH and conductivity or TDS probe. The probe is placed in the paste or slurry and the pH or conductivity value is read directly from the meter.

Equipment

1. pH meter equipped with a combination pH electrode.
2. Conductivity or TDS meter (in this case a Hanna Instruments field combined pH/ORP/temperature meter).
3. 50 mL beakers, or equivalent (disposable paper cups are recommended).
4. Spatula or stirring rod (eg. plastic coffee stirrers).
5. Litmus paper strips.

Reagents

1. Standard buffer solution, pH 4.00 and pH 7.00.
2. Standard electrolyte solutions (for calibration of conductivity meter).
3. Distilled (or deionized) water.

Procedure

1. Calibrate pH and conductivity or TDS meters using the standard solutions and following the instructions provided with the meters.

2. Obtain approximately 25 g of fines (particles smaller than 1 mm if possible) from the rock sample to be tested, and place in a fresh or decontaminated beaker or testing vessel.

3. Add approximately 25 ml of distilled water to sample. (More water may be required if the sample is very dry or extremely fine.)

4. Stir sample with fresh or cleaned spatula to form a paste or slurry. Paste should slide off spatula easily.

5. Tip the testing container to one side to allow a pool of water or slurry to collect in the corner. Dip each of the probes into the slurry, and allow the meter readings to stabilize. The conductivity reading should, however, be done first, as electrolyte from the combination pH probe may affect the conductivity of the solution.

6. Decontaminate probes and containers using distilled or de-ionized water.

7. Record the measurements in your field notebook along with a description of the rock type tested, and the general appearance of the sample.

Alternatives

For a coarser rock mixture, wet the surface of the rock with distilled water, and mix water with any surface coatings or fines. Place a piece of litmus paper over the wetted area. Compare the color of the litmus with the pH color-coded scale and record pH.

Calculations

Paste TDS is assessed by measuring Electrical Conductivity (EC) and then converting conductivity values to TDS using the equation (Hem, 1985):

$$0.59\left[EC, FScm^{-1}\right] = \left[TDS, mg/l\right]$$

Interpretation

High conductivity (or TDS) levels indicate there is a considerable store of contaminant salts. These are usually sulfates, but can be other metal salts. When a sample is collected over depth, it is not always clear whether the stored salts are due to oxidation at that point in the sediment profile, or if the salts were generated somewhere higher in the profile and moved downwards to the sample location. Look for stains along the flow path that may indicate if this is the case.

Low pH readings indicate oxidation and acid generation has occurred, usually at the location from which the sample was collected. Readings taken on uncrushed samples in the field or lab usually provide a much better indication of the extent of oxidation than crushed samples. This is because crushing can liberate neutralizing minerals thereby increasing the available neutralizing capacity of the sample.

References

Sobek, A.A., Schuller, W.A. Freeman, J.R. and Smith, R.M., 1978, Field and Laboratory Methods Applicable to Overburden and Minesoils, EPA 600/2-78-054, 203pp.

British Columbia AMD Task Force, 1989, Draft Acid Rock Drainage Technical Guide, Vol I, Crown Publications, Victoria, B.C.

MODIFIED ACID BASE ACCOUNTING (ABA)

Objectives

- To determine the balance between acid producing and acid consuming components of mine waste.

Principles of Test

The fundamental principals of acid base accounting comprise two distinct measurements:

1. Determination of the neutralization potential (NP) of a sample.

2. Calculation of the acid potential (AP) of the sample.

The difference between the two values, the net neutralization potential (Net NP), and the ratio (NP:AP) allow classification of the sample as potentially acid consuming or producing. To facilitate comparison of values, NP, AP, and Net NP are all expressed in units of tons $CaCO_3$ equivalent per kiloton.

In the original Sobek method of acid base accounting, the neutralization potential is determined by heating the sample and mixing for two hours. In the modified method, the neutralization potential is determined by treating a sample with excess standardized hydrochloric acid at ambient, or slightly above (25 - 30°C) ambient, temperatures for 24 hours. A fizz test is employed to provide a guide to the amount of acid to be initially added to the test. Acid is added as required during the acid-treatment stage to maintain sufficient acidity for reaction. After treatment, the unconsumed acid is titrated with standardized base to pH 8.3 to allow calculation of the calcium carbonate equivalent for the acid consumed.

For the calculation of the acid potential, the sample is analyzed for total and sulfate sulfur. Sulfide sulfur content is also measured or is calculated by the difference between the other two sulfur numbers. AP is determined from sulfide sulfur number, assuming: 1) total conversion of sulfide to sulfate; and, 2) production of 4 moles H^+ per mole of sulfide oxidized, assuming that all the sulfide is present as pyrite. In some cases, difficulties associated with the analytical procedures for sulfide analysis may influence the estimation of the acid generation potential. For example, sulfate associated with the mineral barite is not readily distinguished from sulfide in a typical sulfate analysis, but does not contribute to the acid potential.

Equipment

1. Aluminum foil.
2. 250 mL Erlenmeyer flask.
3. Reciprocating shaking apparatus or other suitable agitation device.
4. Burette, 50 or 100 mL, one for each of the acid and the base solutions.
5. pH meter, equipped with a combination pH electrode.

Reagents

1. Distilled (or deionized) water, preferably CO2-free (store in container equipped with an ascarite tube)
2. Certified grade, 0.1 N hydrochloric acid, for standardization of bases
3. Approximately 0.1 N sodium hydroxide, standardized.
4. Approximately 0.5 N sodium hydroxide, standardized.
5. Approximately 0.1 N hydrochloric acid, standardized.
6. Approximately 0.5 N hydrochloric acid, standardized.
7. Approximately 25 percent strength hydrochloric acid, for fizz test.
8. Buffer solutions (pH 4.00 and 7.00) for calibration of pH meter.

Procedure

1. Crush and pulverize the sample to a target size of 80 percent minus 60 mesh (Tyler). Tailings samples should be tested at the received particle size.
2. Submit a sample of the test material for total sulfur and sulfate sulfur analyses.

3. Use certified 0.1 N hydrochloric acid to standardize the 0.1 N and 0.5 N sodium hydroxide solutions to standardize the 0.1 N and 0.5 N hydrochloric acid solutions.

4. Place approximately 0.5 g of pulverized sample on a piece of aluminum foil in a small shallow dish. Add one or two drops of 25 percent HCl to the sample. The presence of carbonate will be indicated by a bubbling or an audible "fizz". Rate the "fizz" as indicated in Table 1.

Volume and Normality of HCl for Use in NP

Determination on Basis of Fizz Rating (2g Sample)

Fizz Rating	HCl (mL, Normality)	
None	20	0.1
Slight	40	0.1
Moderate	40	0.5
Strong	80	0.5

5. Weigh 2.00 g of the sample (minus 60 mesh) into a 250 mL Erlenmeyer flask and, as a first approximation, add the volume and normality of HCl as indicated by the "fizz" rating shown above.

6. Agitate the contents of the flask for 24 hours by placing on a shaking apparatus. At least once in the treatment period, and preferably after approximately 6 hours of reaction, check the pH of the pulp. If the pH is above 2.0, add an appropriate volume of hydrochloric acid of the same strength originally added (generally between 1.5 to 2.0 ml). Record the amount added for back titration.

7. At the end of the shaking period, check the pulp pH. If the total volume and strength of acid was appropriate, the end pH will be in the range 1.5 - 2.0. If the pH is above this range, the amount of acid added is judged to be insufficient for reaction. If the pH is below the range, the amount of acid added is judged to be

too high, causing over reaction. In either case, repeat the test using the next higher or lower volume or strength of HCl as appropriate.

8 Titrate the contents of the flask using 0.1 N or 0.5 N NaOH (corresponding to the normality of HCl used in step 4) to pH 8.3. Titrate with NaOH until a constant reading of 8.3 remains for at least 30 seconds.

Calculations

1. The neutralization potential, NP, of the sample is given by:

$$NP = \frac{50a\left[x-(b/a)y\right]}{c}$$

where *NP* = neutralization potential in tonnes $CaC0_3$ equivalent per 1000 tonnes of material

a = normality of HCl

b = normality of Na0H

c = sample weight in grams

x = volume of HCl added in mL

y = volume of Na0H added to pH 7.0 in mL

2. The acid potential, AP, of the sample in kg CaC03 equivalent per ton, is given by:

$$AP = \text{Percent sulphide sulfur x } 31.25$$

where,

sulphide sulfur = total sulfur - sulfate sulfur

3. The net neutralization potential, Net NP, in kg CaC03 equivalent per ton of material is given by:

$$Net\ NP = NP - AP$$

Reporting of Results

The results of the test should be tabulated to provide the following information:

Sample description, paste pH, total sulfur analysis (% S_T), sulfate sulfur analysis (% $S(SO_4)$, NP (kg $CaC0_3$ equivalent per ton), AP (kg $CaC0_3$ equivalent per ton), Net NP (kg $CaC0_3$ equivalent per ton).

References

Lawrence, R.W., Poling, G.P. and Marchant, P.B., 1989. Investigation of predictive techniques for acid mine drainage. Report on DSS Contract No. 23440-7-9178/01-SQ, Energy Mines and Resources, Canada, MEND Report 1.16.1 (a).

Sobek, A.A., Schuller, W.A. Freeman, J.R. and Smith, R.M., 1978, Field and Laboratory Methods Applicable to Overburden and Minesoils, EPA 600/2-78-054, 203pp.

STATIC NET ACID GENERATION (NAG) TEST PROCEDURE

Objectives

- To determine the net acid remaining, if any, after complete oxidation of the materials with hydrogen peroxide and allowing complete reaction of the acid formed with the neutralizing components of the material. The NAG test provides a direct assessment of the potential for a material to produce acid after a period of exposure and weathering and is used to refine the results of the theoretical ABA predictions.

Principles of the Tests

After neutralization is completed, by reaction with hydrogen peroxide, the remaining H_2SO_4, if any, is titrated with sodium hydroxide. The amount of NaOH needed is equivalent to the NAG of the material (expressed in kg H_2SO_4/tonne material).

Sample Preparation

Tailings samples can be tested ‘as received’.

Reagents

1. H2O2 - BDH ‘Analar’ Analytical Reagent 30% w/v (100 V), or equivalent, diluted 1:1 with deionized H2O to 15% a.

2. NaOH - 0.50M Standardized Solution.

3. NaOH - 0.10M Standardized Solution.

Procedure:

Add 250 mL of reagent 1 (15% H_2O_2) to 2.5 g of tailings (pulverized sample if testing waste rock) sample in a 500 mL wide mouth conical flask, or equivalent. Cover with a watch glass, and place in a fumehood or well-ventilated area [b]. The H_2O_2 should be at room temperature before commencing test.

Allow sample to react until ‘boiling’ or effervescing ceases. Heat sample on hot plate and gently boil until effervescence stops or for a minimum of 2 hours. Do not allow sample to boil dry - add deionized water if necessary.

Allow solution to cool to room temperature then record final pH (NAGpH).

Rinse the sample that has adhered to the sides of the flask down into the solution with deionized water. Add deionized water to give a final volume of 250 mL.

Titrate solution to pH 4.5 while stirring with appropriate NaOH concentration based on final NAG solution pH as follows:

NAG Solution pH	Reagent	NaOH Concentration
>2	3	0.10 M
≤2	2	0.50 M

[a] The pH of the H_2O_2 used in the NAG test should be checked to ensure it is between pH 4 and 7. If the pH is less than 4 then add dilute NaOH (use a solution made up by adding 1 g NaOH to 100 mL deionized H_2O) until the pH is greater than 4 (aim for a pH between 4 and 6). The pH is adjusted to greater than pH 4 to ensure that the phosphoric acid, used to stabilize H_2O_2 in some brands, is neutralized. The pH of the 15% H_2O_2 should always be checked to ensure that any stabilizing acid is neutralized, otherwise, false positive results may be obtained.

[b] The NAG reaction can be vigorous and sample solutions can 'boil' at temperatures of up to 120^{o}C. Great care must be taken to place samples in a well-ventilated area or fume cupboard.

Calculations

The NAG capacity is determined by titration of the sample to determine the net amount of acid generated by peroxide oxidation.

Net Acid Generation:

$$NAG = \frac{49 \times V \times M}{W}$$

Where:

NAG	= net acid generation (kg H_2SO_4/tonne)
V	= volume of base NaOH titrated (mL)
M	= molarity of base NaOH (moles/L)
W	= weight of sample reacted (g)

NOTE: If NAG value exceeds 25 kg H_2SO_4 per tonne, repeat using a 1.00 g sample.

Interpretations

The NAG capacity is an independent measure of the acid generating potential of a sample. Materials should be classified based on the table given below.

SAMPLE CATEGORY	FINAL NAGpH	NAG VALUE kg H_2SO_4/t	NNP kg/ton $CaCO_3$
POTENTIALLY ACID FORMING			
Higher capacity	<4	>10	positive
Lower capacity	<4	≤10	negative
UNCERTAIN [1]	≥4	0	positive
NON-ACID FORMING [2]	≥4	0	positive

[1] Further evaluation including sulfur forms and mineralogy

[2] Acid consuming materials are identified by NNP values less than approximately -100

References

Miller, S., Robertson, A., and Donohue, T. (1997). Advances in Acid Drainage Prediction Using the Net Acid Generation (NAG) Test. In: *Proceedings of the Fourth International Conference on Acid Rock Drainage, Vancouver, B.C., Canada, 1997*, vol II, pp. 535-547.

Lewis, H.S., Susteyo, W., Miller, S.D., and Jeffery, J.J. (1997). Waste Rock Management Planning and Implementation at P.T. Freeport Indonesia Company's Mining Operations in Irian Jaya. In: *Proceedings of the Fourth International Conference on Acid Rock Drainage, Vancouver, B.C., Canada, 1997*, vol III, pp. 1361-1376.

EPA 1312 Leach Extraction Test

Objectives

- To characterize and quantify the soluble contaminant content of waste rock samples.

Principles of Test

The sample is mixed with distilled water, and is agitated in a flask to allow dissolution of the contained, soluble secondary mineral phases. The solution is collected at the end of the test, filtered, and analysed for immediate parameters (pH, alkalinity, acidity, sulfate, and conductivity) and for contained metals.

This test method is modified from the EPA method 1312 by using a ratio of water to solids of 2:1 or 3:1 rather than 20:1. The less dilution reduces the possibility of metal concentrations below detection.

Equipment

1. Erlenmeyer Flask (500 mL to 1 L, depending on sample size).
2. pH and conductivity meters.
3. Water filtering apparatus and filters.
4. Reciprocating shaking apparatus or other suitable agitation device.

Reagents

1. Distilled Water.
2. Calibration standards for pH and conductivity.

Procedure

1. Split a representative sample of approximately 200 to 500 g from the field sample, and determine exact weight. Place in Erlenmeyer Flask. The amount of sample is at the discretion of the technician, but should be increased if the particle sizes are large or the variation between the different particles is high.
2. Add distilled (or de-ionized) water to the sample to obtain a water to solids ratio of exactly 2:1 by weight. Cap the Erlenmeyer flask and place in agitation device.
3. Agitate the slurry for a total period of 23 hours. Terminate the agitation process and allow suspended solids to settle for one hour prior to termination of the test.

4. Remove the clear decant and filter the solution immediately, using a standard 0.45 µm millepore filter. Remove a small portion of the filtrate and determine the conductivity and pH.

5. Solution samples are submitted for analysis of immediate parameters (pH, alkalinity, acidity Eh, and conductivity) and for constituent concentrations (ICP metal scan and sulfate).

Note:Analytical procedures for radionuclide analyses generally require larger eluate concentrations. Therefore, a larger volume of solid will be required.

Interpretation

Soluble salt and radionuclide contents are calculated from the eluate constituent concentration and volume, and are reported per unit mass of waste rock.

Solubility controls on the solution concentrations should be checked by assessing saturation indices for the contaminants of concern. This may be done rapidly by using a geochemical equilibrium model such as MINTEQA2 or equivalent. Where saturation conditions are indicated, consecutive extraction tests should be performed to determine the total soluble component loading from the cumulative constituent release by the waste rock sample.

References

The field extraction test is modified from a number of different sources, including the EPA series of extraction tests.

Humidity Column Testing

Objectives

The intent of humidity column testing procedures is to simulate as many of the field conditions as is practical. These conditions include:

- representative particle size distributions for the fine fraction (less than 4") within the mine rock; and
- flushing rates encountered under normal circumstances in mine rock piles at the site;
- contact time between the leachate and the rock, usually the flowpath length.

To accomplish this, a large volume of rock is used for the testing, approximately 5 - 8 kg. The rock is graded to represent the 4-inch minus fraction of the rock contained in the rock piles. The site precipitation levels are evaluated on a surface area basis. The diameter of the column is adjusted (within a reasonable limit) to provide enough leachate for the analysis. The flow path (column length) should be approximately 1.5 times greater than the diameter of the column. During the column operation, water is trickled over the rock for 2 days. Air that is humidified by bubbling it through water at a temperature slightly above room temperature, is introduced at the bottom of the column for 5 days of each cycle. Usually the test is carried out for 20 weeks, with weekly analysis of key parameters (pH, alkalinity, acidity, conductivity, Eh, sulfate). Metals are typically measured on a weekly basis until "steady state" conditions have been achieved. After 10 weeks of testing, the frequency of metals analysis can be reduced to every other week, or less, depending on the test results to that time. A typical humidity column is shown in the figure below.

Procedure

1. Examine site precipitation records over a typical yearly period. If there is a seasonal rainy period, determine the average weekly precipitation during that period. Look at the pattern of this rainfall, i.e. is it a steady drizzle over a few days, or heavy rain over a few hours. The water addition rate to the column should follow this pattern as closely as is possible.

2. Calculate the rate of water addition to the column. Start with a minimum column diameter of 30 cm.

eg. rainfall = 10 mm/week over the rainy season
column = 30 cm diameter (0.152 metres radius)
SA column = pr2 = 3.14 (0.152)2 = 0.073
irrigation volume = 0.010 m/wk x 0.073 m2 = 0.00073 m3/wk = 0.73 L/wk

If this volume seems reasonable, use the 30 cm column. If it is not sufficient to satisfy the sample volume requirements for the weekly analyses, the column diameter should be increased until this is satisfied.

3. Once the column diameter has been determined, the rock sample height is obtained by multiplying the diameter by 1.5. The equipment should provide some freeboard above the rock column height (approximately 5 to 10 cm).

   The columns can be constructed out of almost any "inert" plastic cylinder. ABS or PVC pipe provides good strength and durability at a reasonable cost. Plexiglass also works well, but is usually expensive, especially for the large diameter columns.

   As illustrated in Figure D.5.1, the column must have a raised screen constructed about an 2 cm from the bottom, and a solid base through which the leachate is collected. All joints are sealed with a high quality flexible plumbing sealing. (There are supports in the void between the perforated base and the base plate). Humidified air is added through an additional port at the base of the column (not shown). Several layers of Teflon mesh areplaced above the perforated plate to prevent washing of fines from the sample into the collection zone. During the column operation, a clear plexiglass cover is placed over the column to prevent excessive evaporation losses.

4. Water addition

   Water is applied to the column using a peristaltic pump. This can be automated with a timer that pulses water, in a fine spray, over the surface of the rock. Water can also be applied as a continuous drip over one area of the column. Dispersal of water can be achieved in a number of ways, eg. glass rods, plastic tubing, or possibly plastic pellets. (Our experience is that glass wool provides a significant source of alkalinity, and should not be used.)

5. At the start of the test, the dry rock will absorb a considerable amount of water. For the first week, humidified air should be added continuously to the column, to

wet the surfaces of the rock and initiate the oxidation process. Once good water recovery (80%) has been achieved, the regular weekly cycle should commence. A typical cycle is described below.

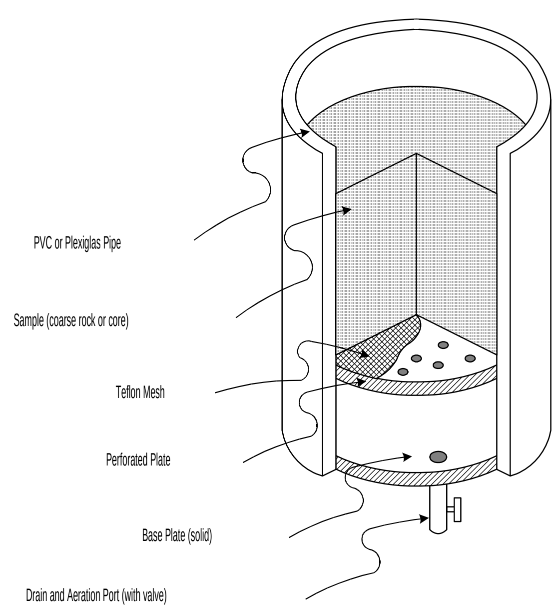
a) Humid Aeration Cycle - for five days, humidified air is added at the base of the columns;

b) Flush Cycle - de-ionized water is added to the column over a two day period. Water is added via a continuous drip dissipated over the top surface of the rock column.

c) Leachate Collection - the column is allowed to drain for 4 hours after the flush cycle is terminated. At the end of the drain cycle the leachate is collected and analyzed.

The test should be run for at least 20 weeks. Test results should be evaluated periodically. After 20 weeks, if the results are inconclusive, the program may need to be extended.

6. Solution samples are submitted for analysis of immediate parameters (pH, alkalinity, acidity Eh, and conductivity) and for constituent concentrations (ICP metal scan and sulfate) on a weekly basis.



Humidity Column Design

APPENDIX A.2

PASTE pH AND CONDUCTIVITY DATA

ACID BASE ACCOUNTING DATA

and

NET ACID GENERATION DATA

1997 Surface Sample Analyses

Sample	Type	Lithology	Visible sulfide %	EC	Paste pH	NAG kg/T H_2SO_4	NAG pH	Sulfate %	Sulfide %	Sulfur Total %	SO_4/S %	AGP (m/g $CaCO_3$)	NP (m/g $CaCO_3$)	NNP	NP:AP
ERD 5500 001	T	QM	1	3140	3.63	29.60	5.11	0.71	0.74	1.45	48.97	45.3	18.9	-26.4	0.42
ERD 5500 002	HS	QB	4	19	7.94	15.48	2.48	0.44	2.46	2.9	15.17	53.1	62.5	9.4	1.18
ERD 5500 004	LS	QM	1	430	5.31										
ERD 5500 005	LS	QM	1	595	3.31										
ERD 5500 006	LS	QM	1.5	891	5.72										
ERD 5500 009	HS	BB	10	4000	2.71	80.75	6.30	0.6	2.3	2.9	20.69	91	9.1	-81.9	0.10
ERD 5500 010	LS	QM	1.5	471	4.55	19.99	3.92								
ERD 5500 012	HS	QM	2	1928	2.71										
ERD 5500 014	HS	QM	2	4370	2.73										
ERD 5510 002	LS	QM	1.5	257	4.71										
ERD 5560 001	O	AN			9.14			0.01	0.005	0.01	100.00	0.3	23.2	22.9	77.33
ERD 5560 002	HS	QM	8	467	6.76			0.3	2.6	2.9	10.34	90	23.7	-66.3	0.26
ERD 5560 006	HS	QB	2	1305	3.38										
ERD 5560 008	HS	QV	5	330	4.08			0.47	1.7	2.2	21.36	68	2	-66	0.03
ERD 5560 010	LS	QM	1.5	708	4.55	23.62	3.87								
ERD 5560 011	HS	QB	3	1565	4.54	22.05	4.07								
ERD 5600 001	LS	QM	1	450	4.44			0.1	0.43	0.53	18.87	17	0.1	-16.9	0.01
ERD 5600 003	HS	QB	3	4230	2.9	33.81	3.19	0.96	1.3	2.2	43.64	69	0.1	-68.9	0.00
ERD 5600 005	T	QB	0.5	2700	3.23	27.05	4.34								
ERD 5600 007	T	QM	0.5	174	6.88	14.31	2.68								
ERD 5600 009	T	QM	0.5	657	4.73										
ERD 5600 011	T	QM	0.5	847	5.43										
ERD 5600 012	T	QM	0.5	254	6.82										
ERD 5600 013	HS	QM	2	321	5.17										
ERD 5600 014	HS	BB	2	2080	3.55										
ERD 5600 070	HS	BB	4	227	4.92	11.27	2.45								
NRD 5620 001	HS	BB	4	41	5.05	10.68	3.41								
NRD 5620 001	HS	QB	5	1193	2.91	19.80	2.45								
NRD 5620 002	HS	QB	6	1717	2.68	77.62	2.98	0.3	2.6	2.9	10.34	90	23.7	-66.3	0.26
NRD 5620 003	HS	QM	4	1111	3.56	57.33	4.12	0.2	1.6	1.8	11.11	55	0.1	-54.9	0.00
NRD 5620 004	O	QM			4.75			0.17	0.1	0.18	94.44	5.6	0.1	-5.5	0.02
NRD 5620 005	T	QV	1	2170	2.81	9.60	4.81								
NRD 5620 006	HS	QM	2	260	3.68										
NRD 5620 007	HS	QM	2	1009	2.98										
NRD 5620 008	HS	QM	3	235	4.13	42.63	5.90	0.15	1.1	1.3	11.54	40	0.8	-39.2	0.02
NRD 5620 009	HS	QM	2	663	3.28										
NRD 5620 010	HS	QM	2	128	3.86										
NRD 5620 011	HS	QM	2	1219	2.68	39.69	3.51	0.28	0.92	1.2	23.33	36	0.1	-35.9	0.00
NRD 5620 012	HS	QB	4	997	2.75	58.80	4.08	0.2	1.6	1.8	11.11	57	0.1	-56.9	0.00
NRD 5620 013	HS	QM	2	2240	2.62										
NRD 5620 014	HS	QB	20	4860	2.5	223.44	3.65	0.9	6.2	7.1	12.68	220	0.1	-219.9	0.00
NRD 5620 015	HS	QB	2	1075	3.71										
NRD 5620 016	HS	QM	2	3390	2.51										

1997 Surface Sample Analyses

Sample	Type	Lithology	Visible sulfide %	EC	Paste pH	NAG kg/T H_2SO_4	NAG pH	Sulfate %	Sulfide %	Sulfur Total %	SO_4/S %	AGP	NP	NNP	NP:AP
												m/g $CaCO_3$			
NRD 5650 017	LS	QM	1	41.4	6.09	23.72	4.11	0.13	0.22	0.35	37.14	11	0.1	-10.9	0.01
NRD 5650 018	HS	QM	2	89	4.82										
NRD 5650 019	HS	QM	2	3620	2.79	46.35	4.40	0.1	1.3	1.4	7.14	45	0.1	-44.9	0.00
SRD 5470 006	HS	QM	2	63	5.94										
SRD 5470 010	LS	QM	1	196	7.05	8.72	2.51								
SRD 5470 011	HS	QV	5	2200	2.54	43.51	3.10	0.21	1.3	1.5	14.00	47	6.7	-40.3	0.14
SRD 5470 012	HS	QB	6	182	7.63			0.46	1.4	1.9	24.21	59	38.9	-20.1	0.66
SRD 5470 013	HS	QM	3	821	4.4										
SRD 5470 014	HS	QB	4	62.9	5.26	5.88	2.29								
SRD 5470 015	HS	QM	3	118.5	5.55										
SRD 5470 016	HS	QM	4	89.6	7.06										
SRD 5470 016	HS	QV	5	6570	2.66										
SRD 5470 017	HS	QB	4	27	5.02	21.56	2.27								
SRD 5470 018	HS	QB	5	1703	3.08										
SRD 5470 019	HS	QV	5	229	4.55										
SRD 5470 020	HS	QM	3	162	7.83	12.74	2.47	0.31	1.1	1.4	22.14	44	36.4	-7.6	0.83
SRD 5470 021	HS	QB	4	321	4.32										
SRD 5470 022	HS	QM	2	386	6.03										
SRD 5470 023	HS	QM	4	27	5.51										
SRD 5470 024	HS	QM	5	3970	2.52										
SRD 5470 025	HS	QM	3	172.2	5.21										
SRD 5470 027	HS	QM	2	3520	2.72	15.78	2.52								
SRD 5490 007	O	QM		42	8.76	19.70	3.32								
SRD 5500 001	HS	QM	2	831	5.31	8.23	4.10	0.37	0.7	1.1	33.64	33	34.2	1.2	1.04
SRD 5500 002	HS	BB	4	33	7.38	22.05	4.63								
SRD 5500 003	O	BB		58.7	4.75										
SRD 5500 004	HS	QB	4	231	5.5										
SRD 5500 005	HS	QV	5	292	6.05	19.01	3.96								
WRC 5440 30	HS	QM	2	227	4.1	15.88									
WRC 5440 31A	LS	QM	0.5		7.91			0.23	0.32	0.55	41.82	33	34.2	1.2	1.04
WRC 5440 31B	T	QM	0.5		8.35			0.21	0.11	0.32	65.63	10	10.1	0.1	1.01
WRC 5440 32	O	QM		347	6.55			0.19	0.05	0.24	79.17	7.5	9.6	2.1	1.28
WRC 5480 006	HS	QB	5	3680	3.7	31.46									
WRC 5480 007	HS	QB	5	1643	3.18	33.52									
WRC 5480 007	HS	QV	5	550	3.41	32.73									
WRC 5480 008	HS	QM	2	785	3.67	15.09									
WRC 5480 009	HS	BB	3	764	3.73	32.54									
WRC 5480 010	HS	BB	4	1338	3.76	28.71									
WRC 5480 012	LS	QB	1	589	4.01	33.81									
WRC 5480 013	LS	QM	1	297	6.95	15.19									
WRC 5480 014	T	QB	0.5	801	4.12	20.19		1.25	0.89	2.08	60.10	65	47.6	-17.4	0.73
WRC 5480 015	HS	QM	2	826	3.42										
WRC 5480 016	LS	QM	1	470	6.26										
WRC 5480 018	HS	QM	2	4840	3.02										

1997 Surface Sample Analyses

Sample	Type	Lithology	Visible sulfide %	EC	Paste pH	NAG kg/T H_2SO_4	NAG pH	Sulfate %	Sulfide %	Sulfur Total %	SO_4/S %	AGP	NP	NNP	NP:AP
												m/g $CaCO_3$			
WRC 5480 019	HS	QM	2	3020	2.66										
WRC 5480 020	HS	QM	2	878	3.96										
WRC 5480 021	HS	QM	2	1009	4.38										
WRC 5480 022	HS	QM	2	1850	2.97										
WRC 5480 023	HS	QM	2	1880	2.64										
WRC 5480 024	HS	QM	1.5	1190	2.71										
WRC 5480 025	LS	QM	1	637	8.6										
WRC 5480 026	LS	QM	1	129	9.65										
WRC 5480 027	HS	QM	2	1580	2.12										
WRC 5480 028	HS	QM	2	964	4.89										
WRC 5480 029	HS	QM	2	580	3.59										
WRC 5480 030	HS	QM	2	258	5.85										
WRC 5580 005	T	QV(Sternberg)pw2	2	19000	3.79										
WRD 4480 010	LS	QM	1	50	6.06										
WRD 5560 020	LS	QM	1	64	6.72										
WRD 5560 027	HS	QM	2	3990	2.56										
WRD 5560 028	HS	QM	2	730	2.95										
WRD 5560 029	HS	QM	2	1552	2.53										
WRD 5560 030	HS	QM	2	321	4.64										
WRD 5560 031	HS	QM	2	282	4.4										
WRD 5560 032	HS	QM	2	620	2.99										
WRD 5560 034	HS	QM	2	201	3.95										
WRD 5560 035	HS	QM	2	833	4.35										
WRD 5560 036	HS	QM	2	171	3.79										
WRD 5560 037	HS	QM	2	164	7.8										
WRD 5560 038	HS	QM	5	54	6.59	18.33	7.92	0.3	1.2	1.5	20.00	47	30.2	-16.8	0.64
WRD 5560 039	HS	QB	6	1848	2.81	72.13	3.92	0.1	2.1	2.2	4.55	70	0.1	-69.9	0.00
WRD 5560 040	HS	QB	3	456	3.97	36.46	2.98								
WRD 5560 041	HS	QB	4	2190	3.31	50.57	4.18	0.3	1.4	1.7	17.65	53	7.6	-45.4	0.14
WRD 5580 001	LS	QM	1	133	4	21.56	2.27	0.3	0.8	1.1	27.27	33	17.8	-15.2	0.54
WRD 5580 002	HS	QM	3	1422	2.77	34.01	6.00								
WRD 5580 004	O	QB			4.82			0.33	0.1	0.34	97.06	11	0.1	-10.9	0.01
WRD 5580 005	LS	QM	2	93	6.72	29.40	5.01								
WRD 5580 006	T	QM	0.5	212	3.2	30.77	5.06								
WRD 5580 007	HS	QB	2	345	3.02	31.07	4.87								
WRD 5580 008	HS	QB	2	230	5.55	29.01	5.15								
WRD 5580 009	HS	QM	2	325	3.14	28.62	5.01								
WRD 5580 011	HS	QM	2	8	5.6	28.03	5.29								
WRD 5580 012	HS	QM	2	305	5.4	29.11	5.1								
WRD 5580 013	HS	BB	7	2860	2.45	47.14	2.09								
WRD 5580 014	HS	BB	4	21	5	31.85	5.27	0.2	1.96	2.16	9.26	73.8	43.7	-30.1	0.59
WRD 5580 015	HS	QB	4	156	4.45	31.16	3.05								
WRD 5580 016	HS	QM	2	45.6	5.72	22.74	4.06								
WRD 5580 017	HS	QM	2	41	5.54	30.48	5.04								

1997 Surface Sample Analyses

Sample	Type	Lithology	Visible sulfide %	EC	Paste pH	NAG kg/T H_2SO_4	NAG pH	Sulfate %	Sulfide %	Sulfur Total %	SO_4/S %	AGP	NP	NNP	NP:AP
												m/g $CaCO_3$			
WRD 5580 018	HS	QM	2	112	6.4	32.93	5.55								
WRD 5580 019	HS	QM	2	42	6.14	19.60	3.91								
WRD 5580 021	HS	QM	2	65	5.87	19.89	3.98								
WRD 5580 022	HS	QM	2	170	5.61	39.79	3.00								
WRD 5580 023	HS	QM	2	103	7.67	21.17	4.63								
WRD 5580 024	HS	QM	1.5	183	5.39	21.56	4.07								
WRD 5580 025	HS	QM	1.5	42	5.74	15.78	2.52								
WRD 5580 026	HS	QM	2	84	6.1	34.79	6.42								
WRD 5580 033	HS	QM	1.5	237	3.82	38.71	7.74								
WRD 5580 042	HS	QB	5	1080	2.35	76.93	2.10	0.15	2.2	2.4	6.25	74	0.1	-73.9	0.00

KEY

Lithology QM= Quartz Monzonite QB= Quartz Breccia BB= Biotite Breccia QV = Quartz Vein AN = Andesite

Visible sulfide (%) = Observed pyrite/sulfide content in hand specimen

Type HS=High Sulfide (>2% visible sulfide) LS= Low Sulfide (<2% visible sulfide) T=Transitional (trace sulfide & acidic paste pH) O=Oxide (no observed sulfide)

NAG (eqkg H2SO4/T)= <u>49xVolume of NaOH titrated x molality of NaOH (0.1M)</u>
weight of sample (5g)

Copper Flat Project
Static Test on Wall Rock and Drill Core from the Pit Area
1994 Sampling

Sample	Paste PH	Total	Sulfide	Sulfate	NP	AP	NNP	NP/AP
PW-1 SW pitwall transition	6.1	3.61	3.47	0.14	32	108.44	-76.44	0.3
PW-2 Oxidized pitwall	--	0.37	0.365	0.005	11	11.41	-0.41	0.96
PW-3 NW pitwall	2.6	2.2	2.195	0.005	0.1	68.59	-68.49	--
PW-4 NE pitwall	3.9	1.89	1.885	0.005	16	58.91	-42.91	0.27
IDC24-222-241, QM – core	--	1.74	1.735	0.005	31	54.22	-23.22	0.57
CF10-177-190, andesite – core	--	2.86	2.8	0.06	52	87.5	-35.5	0.59
CF10-190-199 QM—core	--	3.59	3.52	0.07	44	110	-66	0.4
CF10-214-220, QM – core	--	3.92	3.915	0.005	65	122.34	-57.34	0.53
H75-53-42, QM - reverse circ.	8.2	1.77	1.765	0.005	36	55.16	-19.16	0.65
H75-64-44, QM - reverse circ.	7.2	1.69	1.685	0.005	39	52.66	-13.66	0.74
H75-51-34, QM - reverse circ.	8.6	2.02	2.015	0.005	49	62.97	-13.97	0.78
H75-48-58, QM - reverse circ.	7.2	1.18	1.175	0.005	16	36.72	-20.72	0.44
H75-48-44, QM - reverse circ.	7.4	1.06	1.055	0.005	9	32.97	-23.97	0.27

SOURCE: *Copper Flat Mine - Compliation of Pit Lake Studies (SRK 1997)*

APPENDIX A.3

HUMIDITY COLUMN TEST DATA

Parameter	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5	Cycle 6	Cycle 7	Cycle 8	Cycle 9	Cycle 10	Cycle 11	Cycle 12	Cycle 13	Cycle 14	Cycle 15
Ag ug/l	1.	4.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
Al mg/l	0.03	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
As ug/l	30.	30.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.
B ug/l	50.	50.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.
Ba ug/l	75.	60.	30.	15.	35.	45.	35.	40.	40.	45.	40.	45.	35.	35.	15.
Be ug/l	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
Bi ug/l	6.	26.	2.	2.	2.	2.	2.	2.	2.	2.	2.	6.	2.	2.	2.
Ca mg/l	30.48	23.76	18.11	12.95	18.44	15.01	13.24	13.16	13.42	15.01	13.19	15.92	13.85	11.87	5.47
Cd ug/l	1.	2.	1.	1.	3.	1.	1.	3.	1.	1.	1.	1.	1.	1.	1.
Co ug/l	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
Cr ug/l	5.	20.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
Cu ug/l	14.	16.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
Fe mg/l	0.04	0.06	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
K mg/l	1.56	1.47	0.65	0.13	0.47	0.61	0.12	0.79	0.9	0.22	0.68	0.94	0.34	0.75	0.18
Li ug/l	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.
Mg mg/l	1.26	1.04	0.59	0.36	0.58	0.42	0.39	0.39	0.37	0.34	0.52	0.65	0.48	0.48	0.18
Mn mg/l	0.07	0.03	0.02	0.02	0.035	0.03	0.025	0.025	0.025	0.02	0.015	0.02	0.015	0.01	0.005
Mo ug/l	6.	4.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	4.
Na mg/l	5.24	4.63	2.19	1.26	2.38	1.79	1.65	1.82	1.27	1.57	2.34	2.98	2.05	2.12	0.52
Ni ug/l	10.	15.	10.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	10.
P ug/l	40.	110.	10.	10.	10.	10.	30.	10.	10.	10.	10.	10.	10.	30.	10.
Pb ug/l	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	8.	10.	2.	2.	2.
Sb ug/l	10.	34.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	4.	2.
Se ug/l	85.	150.	5.	5.	5.	5.	50.	25.	15.	15.	30.	40.	5.	30.	15.
Si mg/l	0.87	0.6	0.53	0.3	0.6	0.39	0.51	0.52	0.5	0.53	0.56	0.73	0.48	0.57	0.28
Sn ug/l	100.	174.	2.	2.	2.	2.	2.	2.	6.	22.	46.	2.	2.	80.	2.
Sr ug/l	124.	104.	50.	28.	44.	32.	32.	34.	34.	32.	34.	46.	36.	34.	18.
Ti ug/l	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
V ug/l	2.	5.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
Zn ug/l	28.	25.	12.	3.	9.	20.	11.	16.	1.	1.	2.	6.	8.	5.	9.
pH	7.73	7.8	7.55	7.4	7.85	7.64	7.52	7.53	7.54	7.59	7.61	7.63	7.72	7.51	7.16
Redox (mV)	300.	289.	307.	321.	295.	311.	318.	321.	341.	287.	272.	264.	265.	265.	296.
Conductivity (uS/cm)	132.	104.	70.	45.	69.	53.	45.	42.	41.	46.	50.	63.	49.	44.	19.
Alkalinity (mg $CaCO_3$/l)	43.	31.	24.	17.	26.	18.	16.	17.	17.	20.	19.	26.	19.	16.	10.
Acidity (pH 4.5)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Acidity (pH 8.3)	1.	2.	2.	2.	1.	1.	2.	1.	1.	2.	1.	2.9	2.	2.	3.
Cum Acidity (pH 8.3)	0.1	0.1	0.2	0.3	0.3	0.4	0.5	0.5	0.6	0.7	0.7	0.9	1.	1.1	1.2
Sulphate (mg/l)	9.	9.	5.	6.	8.	6.	5.	4.	4.	4.	5.	4.	3.	4.	2.
Cum Sulphate (mg/kg)	0.5	0.8	1.	1.2	1.6	1.9	2.2	2.4	2.6	2.8	3.	3.2	3.4	3.6	3.7
Water added (L)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
pH of water added	5.45	6.26	5.98	5.59	6.15	6.03	5.83	5.98	6.15	6.05	5.96	6.04	6.06	6.56	6.23
Leachate collected (L)	0.214	0.144	0.184	0.148	0.188	0.218	0.169	0.23	0.188	0.231	0.189	0.191	0.212	0.21	0.194
Cumulative Iron	0.04	0.1	0.11	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.19	0.2	0.21	0.22	0.23
Cumulative Copper	14.	30.	32.	34.	36.	38.	40.	42.	44.	46.	48.	50.	52.	54.	56.

Parameter	Cycle 16	Cycle 17	Cycle 18	Cycle 19	Cycle 20	Cycle 21	Cycle 22	Cycle 23	Cycle 24	Cycle 25	Cycle 26	Cycle 27	Cycle 28	Cycle 29
Ag ug/l	<0.015	<0.015	<0.015	<0.015	<0.015								<0.015	<0.015
Al mg/l	<0.20	<0.20	<0.20	<0.20	<0.20								<0.20	<0.20
As ug/l	<0.20	<0.20	<0.20	<0.20	<0.20								<0.20	<0.20
B ug/l	<0.10	<0.10	<0.10	<0.10	<0.10								<0.10	<0.10
Ba ug/l	0.014	0.022	0.018	0.046	0.033								0.061	0.057
Be ug/l	<0.005	<0.005	<0.005	<0.005	<0.005								<0.005	<0.005
Bi ug/l	<0.10	<0.1	<0.1	<0.1	<0.1								<0.1	<0.1
Ca mg/l	1.5	2.75	2.2	4.49	2.7								6.21	8.
Cd ug/l	<0.010	<0.010	<0.010	<0.010	<0.010								<0.010	<0.010
Co ug/l	<0.015	<0.015	<0.015	<0.015	<0.015								<0.015	<0.015
Cr ug/l	<0.015	<0.015	<0.015	<0.015	<0.015								<0.015	<0.015
Cu ug/l	<0.010	<0.010	<0.010	<0.010	<0.010								<0.010	<0.010
Fe mg/l	<0.030	<0.030	<0.030	<0.030	<0.030								<0.030	<0.030
K mg/l	<2.0	<2.0	<2.0	<2.0	<2.0								<2.0	<2.0
Li ug/l	<0.015	<0.015	<0.015	<0.015	<0.015								<0.015	<0.015
Mg mg/l	0.091	0.12	0.12	0.323	0.16								0.453	0.621
Mn mg/l	0.008	0.005	0.005	0.007	<0.005								0.016	0.012
Mo ug/l	<0.030	<0.030	<0.030	<0.030	<0.030								<0.030	<0.030
Na mg/l	<2.0	<2.0	<2.0	<2.0	<2.0								<2.0	<2.0
Ni ug/l	<0.020	<0.020	<0.020	<0.020	<0.020								<0.020	<0.020
P ug/l	<0.30	<0.30	<0.30	<0.30	<0.30								<0.30	<0.30
Pb ug/l	<0.050	<0.050	<0.050	<0.050	<0.050								<0.050	<0.050
Sb ug/l	<0.20	<0.20	<0.20	<0.20	<0.20								<0.20	<0.20
Se ug/l	<0.20	<0.20	<0.20	<0.20	<0.20								<0.20	<0.20
Si mg/l	0.143	0.207	0.171	0.377	0.231								0.432	0.596
Sn ug/l	<0.30	<0.30	<0.30	<0.30	<0.30								<0.30	<0.30
Sr ug/l	0.011	0.016	0.015	0.03	0.022								0.04	0.053
Ti ug/l	<0.010	<0.010	<0.010	<0.010	<0.010								<0.010	<0.010
V ug/l	<0.030	<0.030	<0.030	<0.030	<0.030								<0.030	<0.030
Zn ug/l	0.01	0.006	0.009	0.012	0.015								0.022	0.024
pH	7.08	7.29	7.23	7.4	6.64								7.59	7.69
Redox (mV)	304.	284.	295.	288.	281.								291.	293.
Conductivity (uS/cm)	10.	16.	15.	32.	19.								45.	58.
Alkalinity (mg $CaCO_3$/l)	6.	10.	7.	12.	8.								16.	20.
Acidity (pH 4.5)	0.	0.	0.	0.	0.								0.	0.
Acidity (pH 8.3)	5.	5.	6.	3.	6.								5.9	6.9
Cum Acidity (pH 8.3)	1.4	1.6	1.9	2.1	2.4								2.6	3.
Sulphate (mg/l)	2.	2.	2.	4.	3.								4.	4.
Cum Sulphate (mg/kg)	3.8	3.9	3.9	4.1	4.3								4.5	4.7
Water added (L)	0.2	0.2	0.2	0.2	0.2								0.2	0.2
pH of water added	5.92	5.57	5.66	6.09	5.23								5.93	5.7
Leachate collected (L)	0.151	0.175	0.198	0.181	0.205								0.185	0.216
Cumulative Iron	0.23	0.23	0.23	0.23	0.23								0.23	0.23
Cumulative Copper	56.	56.	56.	56.	56.								56.	56.

Laboratory Equipment Failure
Weeks 21-27
No Samples Collected

LGSSP-2 - Kinetic Test Data

Parameter	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5	Cycle 6	Cycle 7	Cycle 8	Cycle 9	Cycle 10	Cycle 11	Cycle 12	Cycle 13	Cycle 14	Cycle 15
Ag ug/l	7.	6.	1.	1.	1.	1.	1.	1.	1.	1.	2.	1.	1.	1.	1.
Al mg/l	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
As ug/l	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.
B ug/l	60.	70.	40.	30.	10.	10.	30.	10.	10.	10.	10.	10.	10.	10.	10.
Ba ug/l	200.	105.	60.	55.	60.	40.	70.	75.	50.	90.	80.	60.	60.	75.	45.
Be ug/l	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
Bi ug/l	6.	26.	2.	2.	2.	2.	2.	2.	2.	2.	8.	2.	2.	2.	2.
Ca mg/l	155.59	115.41	85.41	76.19	55.92	41.91	51.46	44.1	38.78	54.5	52.94	37.69	45.46	51.56	32.69
Cd ug/l	18.	13.	5.	1.	5.	1.	3.	5.	1.	1.	6.	1.	7.	1.	1.
Co ug/l	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
Cr ug/l	20.	25.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
Cu ug/l	82.	54.	28.	26.	16.	18.	34.	16.	14.	12.	10.	6.	10.	10.	6.
Fe mg/l	0.41	0.28	0.04	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.08	0.01	0.01	0.01	0.01
K mg/l	7.07	7.1	7.65	7.2	4.99	4.56	5.84	4.95	4.58	4.64	5.79	4.85	5.52	6.79	4.62
Li ug/l	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.
Mg mg/l	16.36	11.17	8.56	7.12	4.48	2.92	4.14	3.22	2.68	4.25	4.34	2.58	3.58	4.32	2.2
Mn mg/l	0.04	0.035	0.02	0.01	0.03	0.015	0.01	0.015	0.005	0.01	0.015	0.01	0.005	0.005	0.005
Mo ug/l	242.	308.	288.	282.	176.	122.	140.	96.	74.	126.	126.	60.	90.	98.	66.
Na mg/l	7.5	7.94	7.2	6.55	3.88	2.91	3.15	2.04	1.79	2.48	2.69	1.54	2.31	2.5	1.63
Ni ug/l	5.	15.	10.	5.	5.	5.	5.	5.	5.	5.	10.	5.	5.	5.	5.
P ug/l	230.	270.	300.	340.	220.	200.	240.	190.	120.	200.	220.	180.	200.	270.	150.
Pb ug/l	32.	20.	2.	2.	2.	2.	2.	2.	2.	2.	2.	6.	12.	2.	2.
Sb ug/l	18.	22.	2.	2.	2.	2.	2.	2.	2.	2.	10.	2.	2.	2.	2.
Se ug/l	530.	405.	285.	245.	125.	30.	210.	145.	160.	225.	170.	110.	125.	115.	70.
Si mg/l	5.53	6.71	7.61	8.57	6.18	7.08	7.17	5.79	6.24	5.6	5.38	4.81	5.66	5.39	5.
Sn ug/l	574.	508.	2.	2.	2.	2.	26.	92.	60.	64.	90.	44.	44.	52.	2.
Sr ug/l	1,018.	680.	492.	418.	270.	178.	252.	204.	168.	262.	234.	142.	216.	224.	126.
Ti ug/l	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
V ug/l	11.	10.	5.	4.	2.	1.	4.	1.	1.	1.	6.	3.	2.	2.	2.
Zn ug/l	28.	14.	12.	13.	6.	17.	13.	14.	1.	1.	1.	1.	9.	1.	3.
pH	8.07	8.1	8.09	8.16	8.11	8.13	8.13	8.05	8.21	8.03	8.04	8.01	8.07	7.96	8.02
Redox (mV)	325.	306.	318.	330.	310.	322.	335.	337.	344.	294.	281.	271.	268.	269.	296.
Conductivity (uS/cm)	979.	690.	533.	448.	308.	196.	261.	204.	170.	264.	279.	170.	226.	267.	151.
Alkalinity (mg $CaCO_3$/l)	53.	54.	58.	64.	54.	53.	58.	49.	54.	50.	51.	41.	54.	48.	49.
Acidity (pH 4.5)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Acidity (pH 8.3)	1.	1.	1.	1.	1.	1.	1.	1.	0.5	1.	1.	1.	1.	1.	1.
Cum Acidity (pH 8.3)	0.	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.5	0.5
Sulphate (mg/l)	432.	243.	155.	141.	82.	29.	64.	49.	21.	69.	69.	30.	48.	72.	16.
Cum Sulphate (mg/kg)	10.4	17.5	22.6	25.9	28.7	29.6	32.	33.6	34.2	36.8	39.5	40.5	42.3	45.7	46.2
Water added (L)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
pH of water added	5.45	6.26	5.98	5.59	6.15	6.03	5.83	5.98	6.15	6.05	5.96	6.04	6.06	6.56	6.23
Leachate collected (L)	0.102	0.122	0.139	0.101	0.144	0.119	0.162	0.138	0.112	0.158	0.165	0.153	0.158	0.198	0.127
Cumulative Iron	0.41	0.69	0.73	0.74	0.75	0.76	0.77	0.78	0.79	0.8	0.88	0.89	0.9	0.91	0.92
Cumulative Copper	82.	136.	164.	190.	206.	224.	258.	274.	288.	300.	310.	316.	326.	336.	342.

LGSSP-2 - Kinetic Test Data

Parameter	Cycle 16	Cycle 17	Cycle 18	Cycle 19	Cycle 20	Cycle 21	Cycle 22	Cycle 23	Cycle 24	Cycle 25	Cycle 26	Cycle 27	Cycle 28	Cycle 29
Ag ug/l	<0.015	<0.015	<0.015	<0.015	<0.015								<0.015	<0.015
Al mg/l	<0.20	<0.20	<0.20	<0.20	<0.20								<0.20	<0.20
As ug/l	<0.20	<0.20	<0.20	<0.20	<0.20								<0.20	<0.20
B ug/l	<0.10	<0.10	<0.10	<0.10	<0.10								<0.10	<0.10
Ba ug/l	0.058	0.048	0.037	0.038	0.044								0.101	0.084
Be ug/l	<0.005	<0.005	<0.005	<0.005	<0.005								<0.005	<0.005
Bi ug/l	<0.10	<0.10	<0.10	<0.10	<0.10								<0.10	<0.10
Ca mg/l	27.3	22.4	16.4	17.	14.6								66.2	65.3
Cd ug/l	<0.010	<0.010	<0.010	<0.010	<0.010								<0.010	<0.010
Co ug/l	<0.015	<0.015	<0.015	<0.015	<0.015								<0.015	<0.015
Cr ug/l	<0.015	<0.015	<0.015	<0.015	<0.015								<0.015	<0.015
Cu ug/l	0.019	0.016	0.011	0.011	<0.010								0.014	0.018
Fe mg/l	<0.030	<0.030	<0.030	<0.030	<0.030								<0.030	<0.030
K mg/l	4.	3.4	2.2	2.8	<2.0								4.4	4.2
Li ug/l	<0.015	<0.015	<0.015	<0.015	<0.015								<0.015	<0.015
Mg mg/l	2.7	2.11	1.49	1.55	1.29								6.2	6.19
Mn mg/l	<0.005	<0.005	<0.005	<0.005	<0.005								<0.005	<0.005
Mo ug/l	0.066	0.041	<0.030	0.03	<0.030								0.065	0.093
Na mg/l	<2.0	<2.0	<2.0	<2.0	<2.0								<2.0	<2.0
Ni ug/l	<0.020	<0.020	<0.020	<0.020	<0.020								<0.020	<0.020
P ug/l	<0.30	<0.30	<0.30	<0.30	<0.30								<0.30	<0.30
Pb ug/l	<0.050	<0.050	<0.050	<0.050	<0.050								<0.050	<0.050
Sb ug/l	<0.20	<0.20	<0.20	<0.20	<0.20								<0.20	<0.20
Se ug/l	<0.20	<0.20	<0.20	<0.20	<0.20								<0.20	<0.20
Si mg/l	5.55	4.58	3.18	3.22	2.26								4.12	5.03
Sn ug/l	<0.30	<0.30	<0.30	<0.30	<0.30								<0.30	<0.30
Sr ug/l	0.179	0.14	0.104	0.108	0.093								0.409	0.393
Ti ug/l	<0.010	<0.010	<0.010	<0.010	<0.010								<0.010	<0.010
V ug/l	<0.030	<0.030	<0.030	<0.030	<0.030								<0.030	<0.030
Zn ug/l	0.005	0.009	<0.005	<0.005	<0.005								0.008	0.005
pH	8.12	8.09	8.01	7.92	7.22								7.9	7.96
Redox (mV)	288.	298.	294.	290.	280.								313.	296.
Conductivity (uS/cm)	177.	138.	104.	109.	93.								402.	384.
Alkalinity (mg $CaCO_3$/l)	57.	48.	34.	38.	30.								36.	49.
Acidity (pH 4.5)	0.	0.	0.	0.	0.								0.	0.
Acidity (pH 8.3)	1.	1.	2.	2.	3.								3.	2.
Cum Acidity (pH 8.3)	0.5	0.5	0.6	0.7	0.8								1.	1.
Sulphate (mg/l)	20.	10.	11.	11.	8.								139.	124.
Cum Sulphate (mg/kg)	46.8	47.1	47.5	47.9	48.3								54.4	59.3
Water added (L)	0.2	0.2	0.2	0.2	0.2								0.2	0.2
pH of water added	5.92	5.57	5.66	6.09	5.23								5.93	5.7
Leachate collected (L)	0.127	0.131	0.16	0.158	0.203								0.183	0.67
Cumulative Iron	0.92	0.92	0.92	0.92	0.92								0.92	0.92
Cumulative Copper	342.	342.	342.	342.	342.								342.	342.

Laboratory Equipment Failure
Weeks 21-27
No Samples Collected

C10-190-199-2 - Kinetic Test Data

Parameter	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5	Cycle 6	Cycle 7	Cycle 8	Cycle 9	Cycle 10	Cycle 11	Cycle 12	Cycle 13	Cycle 14	Cycle 15
Ag ug/l	5.	5.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
Al mg/l	0.01	0.04	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
As ug/l	10.	30.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.
B ug/l	50.	30.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.
Ba ug/l	50.	30.	45.	35.	15.	25.	15.	15.	15.	25.	20.	35.	35.	15.	30.
Be ug/l	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
Bi ug/l	6.	16.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	8.
Ca mg/l	48.27	40.54	43.47	34.16	32.33	30.47	23.86	25.61	19.7	22.26	20.91	23.92	22.28	18.03	22.24
Cd ug/l	3.	8.	2.	1.	1.	3.	3.	3.	1.	1.	1.	1.	4.	4.	3.
Co ug/l	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
Cr ug/l	10.	15.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
Cu ug/l	52.	34.	24.	20.	14.	10.	8.	8.	6.	4.	2.	2.	4.	4.	2.
Fe mg/l	0.05	0.11	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
K mg/l	3.95	3.56	4.39	2.98	2.07	1.51	2.13	2.16	1.36	0.77	1.5	1.78	1.35	1.31	2.1
Li ug/l	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.
Mg mg/l	4.25	3.86	4.68	3.49	3.06	2.59	2.22	2.35	1.47	1.79	1.83	2.5	2.3	2.04	2.4
Mn mg/l	0.11	0.065	0.05	0.035	0.045	0.04	0.035	0.035	0.025	0.025	0.025	0.025	0.025	0.02	0.03
Mo ug/l	10.	12.	6.	4.	6.	2.	2.	2.	2.	2.	2.	4.	2.	4.	4.
Na mg/l	3.83	4.18	4.35	3.16	2.22	2.01	1.98	1.78	1.24	1.01	1.09	1.82	1.61	1.66	1.87
Ni ug/l	5.	10.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
P ug/l	60.	100.	10.	30.	10.	10.	10.	30.	10.	10.	10.	10.	10.	10.	20.
Pb ug/l	6.	22.	2.	2.	2.	2.	2.	2.	2.	2.	6.	2.	2.	2.	4.
Sb ug/l	14.	22.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
Se ug/l	205.	200.	80.	75.	40.	5.	50.	95.	95.	75.	15.	70.	10.	35.	60.
Si mg/l	0.85	0.7	1.02	0.82	0.71	0.78	0.9	0.81	0.57	0.53	0.5	0.66	0.3	0.41	0.74
Sn ug/l	66.	316.	2.	2.	148.	2.	18.	66.	24.	50.	2.	2.	8.	58.	2.
Sr ug/l	372.	320.	324.	244.	194.	184.	136.	150.	100.	110.	94.	132.	120.	80.	140.
Tl ug/l	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
V ug/l	5.	6.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	2.
Zn ug/l	31.	29.	21.	16.	13.	13.	14.	8.	1.	1.	10.	30.	19.	17.	36.
pH	8.07	7.91	7.9	7.37	7.75	7.8	7.66	7.4	7.78	7.57	7.55	7.45	7.03	7.04	7.45
Redox (mV)	306.	297.	315.	327.	303.	320.	326.	329.	346.	292.	279.	276.	277.	281.	304.
Conductivity (uS/cm)	259.	225.	253.	181.	165.	142.	112.	114.	77.	89.	90.	114.	103.	86.	107.
Alkalinity (mg $CaCO_3$/l)	43.	30.	32.	22.	19.	25.	20.	21.	19.	17.	15.	15.	11.	10.	16.
Acidity (pH 4.5)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Acidity (pH 8.3)	1.	1.	1.	2.	1.	1.	2.	2.	0.5	2.	1.	2.	2.	2.	2.
Cum Acidity (pH 8.3)	0.	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.6	0.7	0.8	0.9	0.9
Sulphate (mg/l)	65.	58.	70.	57.	51.	33.	25.	26.	12.	17.	20.	30.	27.	20.	22.
Cum Sulphate (mg/kg)	3.2	5.5	7.8	9.5	12.	13.4	14.2	15.4	15.9	16.7	17.6	19.	20.3	21.2	22.1
Water added (L)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
pH of water added	5.45	6.26	5.98	5.59	6.15	6.03	5.83	5.98	6.15	6.05	5.96	6.04	6.06	6.56	6.23
Leachate collected (L)	0.228	0.175	0.149	0.139	0.224	0.19	0.158	0.198	0.195	0.219	0.215	0.208	0.219	0.206	0.194
Cumulative Iron	0.05	0.16	0.17	0.18	0.19	0.2	0.21	0.22	0.23	0.24	0.25	0.26	0.27	0.28	0.29
Cumulative Copper	52.	86.	110.	130.	144.	154.	162.	170.	176.	180.	182.	184.	188.	192.	194.

C10-190-199-2 - Kinetic Test Data

Parameter	Cycle 16	Cycle 17	Cycle 18	Cycle 19	Cycle 20	Cycle 21	Cycle 22	Cycle 23	Cycle 24	Cycle 25	Cycle 26	Cycle 27	Cycle 28	Cycle 29
Ag ug/l	<0.015	<0.015	<0.015	<0.015	<0.015								<0.015	<0.015
Al mg/l	<0.20	<0.20	<0.20	<0.20	<0.20								<0.20	<0.20
As ug/l	<0.20	<0.20	<0.20	<0.20	<0.20								<0.20	<0.20
B ug/l	<0.10	<0.10	<0.10	<0.10	<0.10								<0.10	<0.10
Ba ug/l	0.026	0.022	0.013	0.011	0.023								0.096	0.066
Be ug/l	<0.005	<0.005	<0.005	<0.005	<0.005								<0.005	<0.005
Bi ug/l	<0.10	<0.10	<0.10	<0.10	<0.10								<0.10	<0.10
Ca mg/l	11.8	10.8	4.76	3.15	14.3								45.3	50.7
Cd ug/l	<0.010	<0.010	<0.010	<0.010	<0.010								<0.010	<0.010
Co ug/l	<0.015	<0.015	<0.015	<0.015	<0.015								<0.015	<0.015
Cr ug/l	<0.015	<0.015	<0.015	<0.015	<0.015								<0.015	<0.015
Cu ug/l	0.017	0.015	0.012	0.015	0.016								0.036	0.034
Fe mg/l	<0.030	<0.030	<0.030	<0.030	<0.030								<0.030	<0.030
K mg/l	<2.0	<2.0	<2.0	<2.0	<2.0								<2.0	<2.0
Li ug/l	<0.015	<0.015	<0.015	<0.015	<0.015								<0.015	<0.015
Mg mg/l	2.05	1.75	0.749	0.456	1.48								6.05	7.52
Mn mg/l	0.032	0.029	0.013	0.012	0.035								0.083	0.089
Mo ug/l	<0.030	<0.030	<0.030	<0.030	<0.030								<0.030	<0.030
Na mg/l	<2.0	<2.0	<2.0	<2.0	<2.0								<2.0	<2.0
Ni ug/l	<0.020	<0.020	<0.020	<0.020	<0.020								<0.020	<0.020
P ug/l	<0.30	<0.30	<0.30	<0.30	<0.30								<0.30	<0.30
Pb ug/l	<0.050	<0.050	<0.050	<0.050	<0.050								<0.050	<0.050
Sb ug/l	<0.20	<0.20	<0.20	<0.20	<0.20								<0.20	<0.20
Se ug/l	<0.20	<0.20	<0.20	<0.20	<0.20								<0.20	<0.20
Si mg/l	0.541	0.547	0.275	0.169	0.346								0.614	0.679
Sn ug/l	<0.30	<0.30	<0.30	<0.30	<0.30								<0.30	<0.30
Sr ug/l	0.131	0.108	0.047	0.03	0.112								0.393	0.427
Ti ug/l	<0.010	<0.010	<0.010	<0.010	<0.010								<0.010	<0.010
V ug/l	<0.030	<0.030	<0.030	<0.030	<0.030								<0.030	<0.030
Zn ug/l	0.02	0.02	0.016	0.015	0.041								0.078	0.058
pH	7.52	7.64	7.27	6.87	6.66								7.49	7.41
Redox (mV)	309.	290.	301.	297.	290.								320.	307.
Conductivity (uS/cm)	95.	80.	37.	28.	104.								309.	335.
Alkalinity (mg $CaCO_3$/l)	15.	15.	8.	5.	8.								14.	15.
Acidity (pH 4.5)	0.	0.	0.	0.	0.								0.	0.
Acidity (pH 8.3)	3.	6.	2.	4.	4.								6.9	8.9
Cum Acidity (pH 8.3)	1.1	1.3	1.4	1.6	1.8								2.1	2.5
Sulphate (mg/l)	19.	14.	7.	6.	28.								118.	124.
Cum Sulphate (mg/kg)	22.9	23.5	23.8	24.1	25.3								30.2	35.5
Water added (L)	0.2	0.2	0.2	0.2	0.2								0.2	0.2
pH of water added	5.92	5.57	5.66	6.09	5.23								5.93	5.7
Leachate collected (L)	0.177	0.205	0.194	0.219	0.197								0.188	0.198
Cumulative Iron	0.29	0.29	0.29	0.29	0.29								0.29	0.29
Cumulative Copper	194.	194.	194.	194.	194.								194.	194.

Laboratory Equipment Failure
Weeks 21-27
No Samples Collected

Sample SW-1 - Kinetic Test Data

Parameter	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5	Cycle 6	Cycle 7	Cycle 8	Cycle 9	Cycle 10	Cycle 11	Cycle 12	Cycle 13	Cycle 14	Cycle 15
Ag ug/l	2.	4.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
Al mg/l	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
As ug/l	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.
B ug/l	20.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.
Ba ug/l	50.	30.	20.	20.	10.	10.	20.	25.	25.	15.	20.	25.	15.	20.	15.
Be ug/l	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
Bi ug/l	6.	6.	2.	2.	2.	2.	2.	2.	2.	2.	8.	2.	2.	2.	2.
Ca mg/l	53.15	45.51	34.83	36.28	31.01	23.67	23.36	24.87	30.06	23.22	23.31	30.56	20.57	22.22	17.45
Cd ug/l	2.	2.	1.	1.	1.	1.	7.	1.	1.	1.	4.	5.	1.	1.	5.
Co ug/l	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
Cr ug/l	15.	15.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
Cu ug/l	26.	16.	10.	12.	6.	2.	2.	2.	6.	2.	2.	2.	2.	2.	2.
Fe mg/l	0.08	0.08	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
K mg/l	2.98	2.71	2.19	2.94	2.35	1.69	1.41	1.07	2.17	0.15	1.7	2.14	1.98	1.47	1.28
Li ug/l	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.
Mg mg/l	4.46	3.72	2.5	2.78	2.19	1.24	1.38	1.49	2.02	1.32	1.42	2.38	1.26	1.37	1.02
Mn mg/l	0.04	0.015	0.01	0.015	0.01	0.005	0.005	0.005	0.015	0.005	0.005	0.005	0.005	0.005	0.005
Mo ug/l	102.	84.	50.	62.	44.	26.	22.	32.	32.	14.	32.	32.	10.	26.	20.
Na mg/l	1.57	1.17	0.82	1.01	0.79	0.28	0.47	0.43	0.66	0.36	0.43	0.7	0.41	0.52	0.34
Ni ug/l	10.	10.	5.	10.	5.	5.	5.	5.	5.	5.	5.	15.	5.	5.	5.
P ug/l	120.	140.	40.	150.	100.	90.	180.	140.	130.	100.	140.	180.	50.	140.	80.
Pb ug/l	4.	8.	2.	2.	2.	2.	2.	2.	2.	2.	6.	2.	4.	2.	12.
Sb ug/l	14.	20.	2.	2.	2.	2.	2.	2.	2.	2.	6.	2.	2.	60.	2.
Se ug/l	210.	155.	65.	110.	25.	5.	80.	45.	80.	40.	70.	85.	20.	2.06	35.
Si mg/l	3.69	3.95	3.56	4.88	4.05	1.99	2.6	1.99	3.74	2.51	2.31	2.82	1.93	2.	1.98
Sn ug/l	300.	376.	2.	2.	2.	2.	80.	2.	44.	12.	2.	8.	50.	60.	2.
Sr ug/l	194.	166.	104.	110.	82.	56.	62.	68.	88.	56.	60.	78.	48.	2.	38.
Ti ug/l	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
V ug/l	5.	6.	1.	1.	1.	1.	1.	1.	1.	1.	2.	1.	1.	1.	1.
Zn ug/l	27.	9.	7.	7.	4.	8.	4.	9.	1.	1.	7.	3.	11.	1.	4.
pH	7.65	7.73	7.87	7.91	8.04	7.65	7.69	7.66	8.	7.78	7.85	7.75	7.62	7.74	7.54
Redox (mV)	287.	265.	280.	305.	296.	302.	320.	317.	309.	260.	251.	241.	233.	233.	278.
Conductivity (uS/cm)	266.	231.	167.	174.	144.	95.	92.	105.	125.	84.	94.	138.	78.	84.	65.
Alkalinity (mg $CaCO_3$/l)	34.	29.	27.	37.	35.	21.	23.	18.	34.	26.	26.	26.	20.	22.	14.
Acidity (pH 4.5)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Acidity (pH 8.3)	0.5	2.	1.	2.	1.	0.5	2.	1.	1.	1.	1.	2.	2.	2.	4.
Cum Acidity (pH 8.3)	0.	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.6	0.6	0.7	0.9
Sulphate (mg/l)	77.	60.	32.	30.	24.	12.	11.	20.	14.	8.	11.	25.	8.	9.	6.
Cum Sulphate (mg/kg)	3.9	6.7	8.2	8.2	8.2	8.8	9.3	10.3	10.7	11.1	11.6	12.9	13.2	13.6	13.9
Water added (L)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
pH of water added	5.45	6.26	5.98	5.59	6.15	6.03	5.83	5.98	6.15	6.05	5.96	6.04	6.06	6.56	6.23
Leachate collected (L)	0.166	0.207	0.157	0.128	0.181	0.168	0.188	0.194	0.162	0.209	0.198	0.206	0.179	0.186	0.206
Cumulative Iron	0.08	0.16	0.17	0.18	0.19	0.2	0.21	0.22	0.23	0.24	0.25	0.26	0.27	0.28	0.29
Cumulative Copper	26.	42.	52.	64.	70.	72.	74.	76.	82.	84.	86.	88.	90.	92.	94.

Sample SW-1 - Kinetic Test Data

Parameter	Cycle 16	Cycle 17	Cycle 18	Cycle 19	Cycle 20	Cycle 21	Cycle 22	Cycle 23	Cycle 24	Cycle 25	Cycle 26	Cycle 27	Cycle 28	Cycle 29
Ag ug/l	<0.015	<0.015	<0.015	<0.015	<0.015								<0.015	<0.015
Al mg/l	<0.20	<0.20	<0.20	<0.20	<0.20								<0.20	<0.20
As ug/l	<0.20	<0.20	<0.20	<0.20	<0.20								<0.20	<0.20
B ug/l	<0.10	<0.10	<0.10	<0.10	<0.10								<0.10	<0.10
Ba ug/l	0.018	0.014	<0.010	0.012	0.013								0.021	0.021
Be ug/l	<0.005	<0.005	<0.005	<0.005	<0.005								<0.005	<0.005
Bi ug/l	<0.10	<0.10	<0.10	<0.10	<0.10								<0.10	<0.10
Ca mg/l	10.9	8.36	6.44	7.72	4.2								7.65	7.26
Cd ug/l	<0.010	<0.010	<0.010	<0.010	<0.010								<0.010	<0.010
Co ug/l	<0.015	<0.015	<0.015	<0.015	<0.015								<0.015	<0.015
Cr ug/l	<0.015	<0.015	<0.015	<0.015	<0.015								<0.015	<0.015
Cu ug/l	0.011	<0.010	<0.010	0.01	<0.010								0.011	0.012
Fe mg/l	<0.030	<0.031	<0.032	<0.033	<0.034								<0.035	<0.036
K mg/l	<2.0	<2.1	<2.2	<2.3	<2.4								<2.5	<2.6
Li ug/l	<0.015	<0.016	<0.017	<0.018	<0.019								<0.020	<0.021
Mg mg/l	1.14	0.766	0.636	0.782	0.414								0.851	0.775
Mn mg/l	<0.005	<0.005	0.005	0.006	0.007								0.022	0.013
Mo ug/l	<0.030	<0.031	<0.032	<0.033	<0.034								<0.035	<0.036
Na mg/l	<2.0	<2.1	<2.2	<2.3	<2.4								<2.5	<2.6
Ni ug/l	<0.020	<0.020	<0.020	<0.020	<0.020								<0.020	<0.020
P ug/l	<0.30	<0.30	<0.30	<0.30	<0.30								<0.30	<0.30
Pb ug/l	<0.050	<0.050	<0.050	<0.050	<0.050								<0.050	<0.050
Sb ug/l	<0.20	<0.20	<0.20	<0.20	<0.20								<0.20	<0.20
Se ug/l	<0.20	<0.20	<0.20	<0.20	<0.20								<0.20	<0.20
Si mg/l	1.99	1.33	1.25	1.38	0.705								0.581	0.928
Sn ug/l	<0.30	<0.31	<0.32	<0.33	<0.34								<0.35	<0.36
Sr ug/l	0.055	0.044	0.034	0.039	0.026								0.037	0.035
Ti ug/l	<0.010	<0.010	<0.010	<0.010	<0.010								<0.010	<0.010
V ug/l	<0.030	<0.030	<0.030	<0.030	<0.030								<0.030	<0.030
Zn ug/l	0.006	0.005	0.007	0.008	0.011								0.026	0.014
pH	7.79	7.64	7.55	7.44	6.54								7.2	7.32
Redox (mV)	261.	280.	283.	274.	260.								298.	277.
Conductivity (uS/cm)	73.	53.	40.	51.	27.								55.	49.
Alkalinity (mg $CaCO_3$/l)	13.	13.	16.	15.	9.								4.	4.
Acidity (pH 4.5)	0.													
Acidity (pH 8.3)	3.	3.	5.	5.	5.								10.9	11.9
Cum Acidity (pH 8.3)	1.	1.2	1.4	1.6	1.9								2.3	3.
Sulphate (mg/l)	5.	4.	4.	6.	4.								11.	6.
Cum Sulphate (mg/kg)	14.1	14.3	14.5	14.7	14.9								15.4	15.7
Water added (L)	0.2	0.2	0.2	0.2	0.2								0.2	0.2
pH of water added	5.92	5.57	5.66	6.09	5.23								5.93	5.7
Leachate collected (L)	0.171	0.178	0.188	0.177	0.211								0.175	0.22
Cumulative Iron	0.29	0.29	0.29	0.29	0.29								0.29	0.29
Cumulative Copper	94.	94.	94.	94.	94.								94.	94.

Laboratory Equipment Failure
Weeks 21-27
No Samples Collected

Sample PW-2 - Kinetic Test Data

Parameter	Cycle 1	Cycle 2	Cycle 3	Cycle 4	Cycle 5	Cycle 6	Cycle 7	Cycle 8	Cycle 9	Cycle 10	Cycle 11	Cycle 12	Cycle 13	Cycle 14	Cycle 15
Ag ug/l	36.	3.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
Al mg/l	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
As ug/l	30.	20.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.
B ug/l	10.	20.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.
Ba ug/l	110.	75.	25.	45.	15.	60.	25.	25.	25.	30.	35.	60.	30.	35.	35.
Be ug/l	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
Bi ug/l	26.	42.	2.	2.	2.	2.	2.	2.	2.	2.	8.	8.	2.	2.	16.
Ca mg/l	30.55	33.63	9.45	11.3	3.49	12.99	4.86	4.17	3.87	4.01	5.17	5.19	4.91	4.48	7.33
Cd ug/l	26.	25.	12.	1.	1.	8.	7.	7.	1.	1.	4.	1.	4.	1.	1.
Co ug/l	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
Cr ug/l	5.	10.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
Cu ug/l	302.2	280.	67.4	63.4	23.6	83.8	31.4	28.	42.4	43.6	62.6	81.8	59.8	69.	102.2
Fe mg/l	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
K mg/l	5.11	5.88	1.53	2.22	0.3	2.22	0.58	0.62	0.01	0.4	1.42	1.26	1.61	1.46	1.51
Li ug/l	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.	10.
Mg mg/l	1.6	2.03	0.44	0.52	0.11	0.58	0.18	0.15	0.13	0.13	0.27	0.26	0.19	0.22	0.37
Mn mg/l	0.1	0.145	0.045	0.055	0.02	0.07	0.03	0.02	0.025	0.03	0.035	0.04	0.035	0.035	0.065
Mo ug/l	24.	14.	8.	10.	2.	6.	2.	2.	2.	2.	6.	4.	2.	4.	6.
Na mg/l	1.29	1.64	0.38	0.55	0.06	0.56	0.18	0.16	0.12	0.13	0.23	0.2	0.2	0.39	0.33
Ni ug/l	5.	10.	5.	5.	5.	5.	5.	5.	5.	5.	5.	10.	5.	5.	5.
P ug/l	70.	80.	10.	10.	30.	30.	20.	30.	10.	10.	40.	10.	10.	10.	70.
Pb ug/l	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	28.	8.	2.	2.	2.
Sb ug/l	2.	16.	2.	2.	2.	2.	2.	2.	2.	2.	8.	2.	2.	2.	2.
Se ug/l	120.	125.	5.	5.	5.	5.	5.	5.	25.	10.	45.	5.	5.	10.	5.
Si mg/l	7.32	9.68	2.54	4.08	1.	4.73	1.54	1.42	1.4	1.46	1.76	1.79	1.28	1.41	1.71
Sn ug/l	2.	328.	88.	2.	2.	2.	2.	2.	58.	50.	2.	2.	34.	12.	2.
Sr ug/l	98.	114.	18.	20.	2.	30.	8.	10.	8.	6.	14.	12.	8.	10.	14.
Ti ug/l	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
V ug/l	1.	3.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
Zn ug/l	473.	492.	114.	126.	43.	176.	58.	51.	3.	1.	66.	96.	68.	64.	145.
pH	6.52	5.87	5.99	5.9	6.42	6.1	6.03	6.26	6.43	6.31	6.14	6.1	6.14	6.13	5.95
Redox (mV)	367.	332.	306.	321.	281.	335.	310.	316.	362.	297.	315.	307.	312.	315.	352.
Conductivity (uS/cm)	169.	193.	51.	57.	19.	63.	23.	17.	20.	21.	28.	29.	25.	27.	39.
Alkalinity (mg $CaCO_3$/l)	7.	3.	2.	3.	3.	2.	3.	2.	3.	3.	2.	2.	2.	2.	3.
Acidity (pH 4.5)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Acidity (pH 8.3)	8.	9.	4.	4.	3.	3.	2.	2.	2.	2.9	2.9	2.9	3.	3.	4.
Cum Acidity (pH 8.3)	0.4	0.9	1.	1.2	1.3	1.5	1.6	1.7	1.7	1.9	2.1	2.2	2.4	2.5	2.7
Sulphate (mg/l)	59.	66.	13.	15.	7.	15.	6.	5.	5.	5.	7.	7.	4.	6.	10.
Cum Sulphate (mg/kg)	2.6	6.3	6.9	7.4	7.7	8.4	8.7	9.	9.2	9.5	9.9	10.3	10.4	10.7	11.3
Water added (L)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
pH of water added	5.45	6.26	5.98	5.59	6.15	6.03	5.83	5.98	6.15	6.05	5.96	6.04	6.06	6.56	6.23
Leachate collected (L)	0.166	0.207	0.157	0.128	0.181	0.168	0.188	0.194	0.162	0.209	0.198	0.206	0.179	0.186	0.206
Cumulative Iron	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.1	0.11	0.12	0.13	0.14	0.15
Cumulative Copper	302.2	582.2	649.6	713.	736.6	820.4	851.8	879.8	922.2	965.8	1,028.4	1,110.2	1,170.	1,239.	1,341.2

Sample PW-2 - Kinetic Test Data

Parameter	Cycle 16	Cycle 17	Cycle 18	Cycle 19	Cycle 20	Cycle 21	Cycle 22	Cycle 23	Cycle 24	Cycle 25	Cycle 26	Cycle 27	Cycle 28	Cycle 29
Ag ug/l	<0.015	<0.015	<0.015	<0.015	<0.015								<0.015	<0.015
Al mg/l	<0.20	<0.20	<0.20	<0.20	<0.20								<0.20	<0.20
As ug/l	<0.20	<0.20	<0.20	<0.20	<0.20								<0.20	<0.20
B ug/l	<0.10	<0.10	<0.10	<0.10	<0.10								<0.10	<0.10
Ba ug/l	0.014	0.015	0.011	0.012	0.015								0.025	0.035
Be ug/l	<0.005	<0.005	<0.005	<0.005	<0.005								<0.005	<0.005
Bi ug/l	<0.10	<0.10	<0.10	<0.10	<0.10								<0.10	<0.10
Ca mg/l	1.06	1.09	0.51	0.548	0.761								1.02	2.02
Cd ug/l	<0.010	<0.010	<0.010	<0.010	<0.010								<0.010	<0.010
Co ug/l	<0.015	<0.015	<0.015	<0.015	<0.015								<0.015	<0.015
Cr ug/l	<0.015	<0.015	<0.015	<0.015	<0.015								<0.015	<0.015
Cu ug/l	28.1	24.4	16.5	16.4	17.								22.	32.
Fe mg/l	<0.030	<0.030	<0.030	<0.030	<0.030								<0.030	<0.030
K mg/l	<2.0	<2.0	<2.0	<2.0	<2.0								<2.0	<2.0
Li ug/l	<0.015	<0.015	<0.015	<0.015	<0.015								<0.015	<0.015
Mg mg/l	0.097	0.101	0.054	<0.050	0.093								0.086	0.188
Mn mg/l	0.02	0.021	0.013	0.017	0.019								0.03	0.044
Mo ug/l	<0.030	<0.030	<0.030	<0.030	<0.030								<0.030	<0.030
Na mg/l	<2.0	<2.0	<2.0	<2.0	<2.0								<2.0	<2.0
Ni ug/l	<0.020	<0.020	<0.020	<0.020	<0.020								<0.020	<0.020
P ug/l	<0.30	<0.30	<0.30	<0.30	<0.30								<0.30	<0.30
Pb ug/l	<0.050	<0.050	<0.050	<0.050	<0.050								<0.050	<0.050
Sb ug/l	<0.20	<0.20	<0.20	<0.20	<0.20								<0.20	<0.20
Se ug/l	<0.20	<0.20	<0.20	<0.20	<0.20								<0.20	<0.20
Si mg/l	0.685	0.991	0.377	0.458	0.567								0.364	0.686
Sn ug/l	<0.30	<0.30	<0.30	<0.30	<0.30								<0.30	<0.30
Sr ug/l	0.008	0.009	0.006	<0.001	0.011								0.007	0.013
Tl ug/l	<0.010	<0.010	<0.010	<0.010	<0.010								<0.010	<0.010
V ug/l	<0.030	<0.030	<0.030	<0.030	<0.030								<0.030	<0.030
Zn ug/l	0.038	0.04	0.023	0.027	0.04								0.058	0.077
pH	6.23	6.4	6.17	6.19	5.35								6.31	6.03
Redox (mV)	327.	326.	316.	308.	294.								340.	332.
Conductivity (uS/cm)	32.	12.	6.	6.	8.								11.	19.
Alkalinity (mg $CaCO_3$/l)	3.	3.	3.	2.	1.								2.	2.
Acidity (pH 4.5)	0.	0.	0.	0.	0.								0.	0.
Acidity (pH 8.3)	2.	2.	3.	4.	6.								11.9	11.9
Cum Acidity (pH 8.3)	2.9	3.	3.1	3.3	3.7								4.3	5.
Sulphate (mg/l)	3.	3.	3.	4.	4.								3.	4.
Cum Sulphate (mg/kg)	11.5	11.6	11.8	12.	12.2								12.4	12.6
Water added (L)	0.2	0.2	0.2	0.2	0.2								0.2	0.2
pH of water added	5.92	5.57	5.66	6.09	5.23								5.93	5.7
Leachate collected (L)	0.171	0.178	0.188	0.177	0.211								0.175	0.22
Cumulative Iron	0.15	0.15	0.15	0.15	0.15								0.15	0.15
Cumulative Copper	1,369.3	1,393.7	1,410.2	1,426.6	1,443.6								1,465.6	1,497.6

Laboratory Equipment Failure
Weeks 21-27
No Samples Collected

Appendix B

Tailings Characterization

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LIST OF TABLES

APPENDIX B

GEOCHEMICAL CHARACTERIZATION OF TAILINGS

1.0 TESTING PROGRAM

Tailings from previous mining operations at the Copper Flat project were sampled on two occasions. In conjunction with piezometer installation, two tailings samples were recovered with a split spoon sample in 1994 (T-10-12 and T-5-7). In 1996, five test pits were excavated in the existing impoundment and an additional 11 samples were obtained.

Tailings samples were analyzed for paste pH and conductivity values, and by Acid Base Accounting tests. Results are listed in Table 1.1. The tailings collected in 1996 are grouped according to their appearance in hand specimen. Yellow tailings are assumed to be derived from oxidized or transition materials and are given the label TTLS (transition tailings) while fresh gray tailings that are assumed to have been derived from unoxidized quartz monzonite are labeled UTLS (unoxidized tailings). Black tailings (BTLS) are assumed to be derived from biotite breccia.

The tailings samples are not currently generating acid. Paste pH values for all samples were all above 6.1. Paste conductivity was low and ranged from 298 to 686 μS/cm. On the basis of the paste results, the current reactivity of the existing tailings is low.

Based on ABA results, sulfide sulfur contents averaged 0.72 for the transition tailings and 0.95 for the unoxidized tailings collected in 1996. Based on sulfide sulfur content, five of the samples had NP:AP ratios below 1, indicating that these samples have moderate potential to produce acidity. All other samples show a weak acid producing potential.

The decrease in acid generating potential relative to waste rock samples (i.e. higher NP:AP ratios) is likely a result of sulfide removal during the concentration process. The tailings show no increase in neutralization potential relative to the waste rock samples, indicating that lime added during processing has little impact on the chemistry of the tailings.

Sample T-10-12 was analyzed for total metals concentrations using the EPA 3051 digestion and analysis by ICP. Results, listed in Table 1.2, indicate the sample had high concentrations of aluminum (2,700 ppm), copper (1,600 ppm), iron (19,000), magnesium (1,800 ppm), potassium (1.400 ppm), and zinc (418 ppm). However, results of a modified EPA method 1312 leach indicated that these metals are not easily leached. These results confirm the limited oxidation that has occurred in the tailings, as indicated by the low paste conductivity. Therefore, the color of the tailings exhibited in drill hole and test pit samples is believed to be a result of the source of the materials. The designation of “transition” or “unoxidized” refers only to the nature of the ore from which the tailings were produced.

2.0 CHARACTERISTICS AND BEHAVIOR OF FUTURE TAILINGS

The majority of future ore will be unoxidized quartz monzonite, biotite breccia, and quartz breccia. Future tailings are anticipated to have geochemical properties similar to the UTLS tailings samples shown in Table 1.1. While a potential for acid generation is indicated, no evidence of acid generation was observed following 14 years of weathering under field conditions. Future tailings are anticipated to be equally slow in generating acid and releasing metals.

Table B.1.1
Tailings Geochemical Analysis - 1994 and 1996 Samples

Sample ID	pH (S.U.)	Paste Conductivity (µS/cm)	Sulfur Total (%)	Sulfur Sulfate (%)	Sulfur Sulfide (%)	Sulfur Pyrite (%)	Neutralization Potential (T/KT)	AP (sulfide) (T/KT)	NNP (sulfide) (T/KT)	NP/AP (sulfide)	AP (pyrite) (T/KT)	NNP (pyrite) (T/KT)	NP/AP (pyrite)
Transition Tailings													
P1-TTLS	6.6	466	1.12	0.47	0.65	0.58	36.00	20.31	15.69	1.77	18.13	17.88	1.99
P2-TTLS	7.1	483											
P3-TTLS	7.3	628	1.16	0.52	0.64	0.31	17.00	20.00	-3.00	0.85	9.69	7.31	1.75
P4-TTLS	7.3	651	1.31	0.45	0.86	0.54	27.00	26.88	0.12	1.00	16.88	10.13	1.60
P5-TTLS	7.5	547											
Mean	7.2	555	1.20	0.48	0.72	0.48	26.67	22.40	4.27	1.21	14.90	11.77	1.78
Unoxidized Tailings													
P1-TLS@12"	6.2	486	0.79	0.13	0.66	0.45	26.00	20.63	5.38	1.26	14.06	11.94	1.85
P1-UTLS	6.8	686	1.3	0.25	1.05	0.6	25.00	32.81	-7.81	0.76	18.75	6.25	1.33
P2-UTLS	7.7	643	1.15	0.19	0.96	0.75	25.00	30.00	-5.00	0.83	23.44	1.56	1.07
P3-UTLS	7.6	352											
P4-UTLS	7.2	357											
P5-UTLS	7.6	455	1.19	0.08	1.11	0.72	31.00	34.69	-3.69	0.89	22.50	8.50	1.38
Mean	7.2	497	1.11	0.16	0.95	0.63	26.75	29.53	-2.78	0.94	19.69	7.06	1.41
Black Tailings													
P5-BTLS	7.8	298	0.92	0.27	0.65	0.3	35.00	20.31	14.69	1.72	9.38	25.63	3.73
1994 Tailings Samples													
T-10-12	7.8		1.26	0.03	1.23	0.68	24	38.44	-14.44	0.62	21.25	2.75	1.13
T-5-7	7.5		1.1	0.18	0.92	0.53	31	28.75	2.25	1.08	16.56	14.44	1.87
Mean	7.7		1.18	0.11	1.08	0.61	27.50	33.59	-6.09	0.85	18.91	8.59	1.50

Notes:
Sulfide sulfur equals total sulfur minus sulfate sulfur
NNP equals net neutralization potential (NP-AP)

Table B.1.2
Total and Extractable Metals Concentrations in Tailings

Parameters	Total Metals in Solids ICP ppm	Extractable Metals EPA 1312 (mg/L)
Aluminum	2700	< 0.05
Antimony	< 0.5	N/A
Arsenic	1.3	< 0.1
Barium	52	0.10
Boron	< 2	0.07
Cadmium	1.8	< 0.005
Calcium	8500	300
Chloride	N/A	6
Chromium	5	< 0.01
Cobalt	13	< 0.02
Copper	1600	0.03
Fluoride	N/A	1.4
Iron	19000	< 0.02
Lead	15	< 0.021
Magnesium	1800	22
Manganese	251	1.50
Mercury	< 0.02	< 0.0002
Molybdenum	34	0.19
Nickel	3	< 0.02
Potassium	1400	44
Selenium	< 0.03	< 0.1
Silver	< 1	< 0.01
Sodium	200	44
Sulfate	N/A	940
Vanadium	7	< 0.01
Zinc	418	0.42

Appendix 7-C

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

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TECHNICAL MEMORANDUM

TO: Steve Raugust, New Mexico Copper Corporation

COPY TO: Ann Carpenter, Remote Energy Solutions

FROM: Rob Bowell, Ruth Warrender, Amy Prestia **DATE:** 06 December 2010

SUBJECT: **Copper Flat Static Testwork Summary and Kinetic Test Recommendations**

1. INTRODUCTION

SRK Consulting has undertaken a geochemical characterization study to assess the Acid Rock Drainage and Metal Leaching (ARDML) potential of the Copper Flat deposit, New Mexico. This memorandum details the results of the initial characterization of the collected materials and includes recommendations for additional kinetic testwork.

A total of 74 representative grab and core samples were collected by SRK during a site visit in April 2010. A sample matrix summarising the main material types (as defined by rock and alteration type) is provided in Table 1. The collected samples were subject to a number of static geochemical tests in order to characterize the nature of materials on site and to determine their potential for ARDML generation. This included Multi Element Analysis, Acid Base Accounting (ABA), Net Acid Generation (NAG) testing and an assessment of the potential short-term metal mobility (MWMP testing). A summary of the methods used and the results of this testwork are provided below. In addition, the complete geochemical database detailing the results of the ARDML assessment has been included as an attachment to this memorandum.

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Asia
Australia
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South America
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Table 1: Details of samples collected for the ARDML assessment

Lithology	Alteration	ABA/NAG/Multi-Element			MWMP		
		Drillcore	Grab	Total	Drillcore	Grab	Total
Dolerite	Propylitic		2	**2**		2	**2**
Andesite	Propylitic		4	**4**		2	**2**
Quartz Monzonite	Argillic	6	2	**8**	3	2	**5**
	Biotite	3	1	**4**	1	1	**2**
	Leach Cap	5	4	**9**	2	2	**4**
	Potassic	6		**6**	3		**3**
	Propylitic	3		**3**	1		**1**
	Quartz Sericite	5	4	**9**	2	2	**4**
Quartz Monzonite Breccia	Argillic	5	1	**6**	2	1	**3**
	Biotite	6		**6**	2		**2**
	Leach Cap	2	1	**3**	1	1	**2**
	Potassic	2	1	**3**	2	1	**3**
	Propylitic	4		**4**	3		**3**
	Quartz	3		**3**	2		**2**
Tailings	-		4	**4**		2	**2**
Total		**50**	**24**	**74**	**24**	**16**	**40**

2. MULTI-ELEMENT ANALYSIS

Multi-element analysis was carried out to allow comprehensive geochemical characterisation of the 74 samples. The analysis was carried out by ALS Chemex, Reno, Nevada and involved a strong multi-acid digestion followed by Inductively Coupled Plasma Mass Spectrometry (ICP-MS) analysis. This included determination of major elements (e.g. aluminium, calcium, magnesium, sodium, potassium, iron, sulfur) and trace elements (e.g. zinc, copper, cadmium, lead).

The data were analyzed using the Geochemical Abundance Index (GAI) (INAP, 2002), which compares the concentration of an element in a given sample to its average crustal abundance. GAI values are particularly useful in determining the relative enrichment of elements based on lithology and may be used to identify elements enriched above average crustal concentrations (‘ECA elements’). GAI values were calculated as follows:

$$GAI = \log_2 [C/(1.5*S)]$$

Where C is the concentration of an element as determined from the WRA and S is the average crustal abundance of the element of interest (Mason, 1966). Materials are then assigned a GAI value between zero and six based on the degree of enrichment (Table 2). According to the INAP (2002) protocol, a GAI value greater than three indicates significant enrichment.

Table 2: Interpretation of GAI values for WRA data

GAI Value	Interpretation
0	<3 times average crustal concentration
1	3 to 6 times average crustal concentration
2	6 to 12 times average crustal concentration
3	12 to 24 times average crustal concentration
4	24 to 48 times average crustal concentration
5	48 to 96 times average crustal concentration
6	>96 times average crustal concentration

The results of the multi-element analysis are provided in full in the attached database and are summarized in Table 3. The results show that all material types are characterized by elevated concentrations of silver, cadmium, copper, molybdenum, rhenium, sulfur, selenium, tellurium and tungsten, with GAI values between 1 and 6 representing up to 96 times enrichment of average crustal concentrations. Copper concentrations were elevated up to 1 wt% in the samples and sulfur concentrations reached 3.34 wt%, with particular enrichment occurring in the Argillic Breccia and the Breccia-Leach Cap materials. These elevated concentrations are associated with the sulfide mineralization, whilst the elevated concentrations of molybdenum, silver, rhenium, arsenic and zinc in the materials can be explained by the common association of these elements with porphyry copper deposits (Rose, Hawkes and Webb, 1979). The leachability of ECA elements from the material types will be examined from metal mobility (MWMP) tests, which will account for site-specific factors affecting mineral solubility.

Table 3: Summary of Multi Element Analysis Results

	#	Multi Element Anlysis - average concentrations per lithology/alteration type (mg/kg)																			
		Ag	As	Bi	Ca	Cd	Cs	Cu	Mo	Pb	Rb	Re	S	Sb	Se	Te	Th	Tl	U	W	Zn
Average crustal abundance (mg/kg)		*0.07*	*1.8*	*0.2*	*36,300*	*0.2*	*3*	*55*	*1.5*	*13*	*90*	*0.001*	*260*	*0.2*	*0.05*	*0.01*	*7.2*	*0.5*	*1.8*	*1.5*	*70*
Andesite - Propylitic	4	0.3	0.9	0.6	39,650	0.6	6.4	217	5.4	8.7	138	0.005	925	0.4	2.0	0.2	6.4	1.3	2.1	2.2	60
Breccia - Argillic	6	3.8	10.9	1.8	10,400	1.0	7.4	3,882	197	127.6	225	0.287	17,267	0.6	4.3	0.8	22.3	1.7	5.8	9.5	134
Breccia - Biotite	6	2.3	6.5	1.3	10,700	1.0	10.2	2,701	38	39.2	222	0.061	16,950	0.4	3.3	0.6	26.3	1.7	8.4	7.1	133
Breccia - Leach Cap	3	4.3	18.7	1.6	4,533	2.9	12.2	4,000	88	90.8	211	0.145	23,333	2.7	4.0	0.8	29.2	2.1	6.7	6.5	316
Breccia - Potassic	3	1.9	28.3	0.8	15,333	0.9	7.4	2,549	162	25.5	216	0.241	16,567	0.8	4.3	0.2	20.1	2.0	6.7	9.8	108
Breccia - Propylitic	4	5.2	3.6	9.2	12,725	2.5	16.3	4,796	308	46.9	245	0.269	17,250	0.4	5.0	1.3	38.0	1.9	4.3	8.6	337
Breccia - Quartz	3	4.0	24.7	1.3	11,967	1.0	7.7	4,580	114	69.9	245	0.096	14,000	0.8	4.0	0.4	26.4	1.7	10.1	8.7	127
Dolerite - Propylitic	2	0.2	0.4	0.0	58,550	2.3	6.5	1,664	4.4	6.1	62	0.028	1,350	0.2	2.5	0.1	4.7	0.3	4.9	1.0	213
Quartz Monzonite - Argillic	8	2.4	1.6	1.1	13,563	1.1	9.8	2,480	54	72.4	242	0.050	9,213	0.4	3.1	0.3	21.2	1.8	5.0	11.9	146
Quartz Monzonite - Biotite	4	1.0	1.1	0.5	4,900	0.8	7.8	1,734	109	43.7	270	0.133	6,225	0.2	2.0	0.1	31.8	1.9	8.6	8.4	119
Quartz Monzonite - Leach Cap	9	3.0	1.9	2.1	11,811	1.6	8.7	3,784	47	63.8	264	0.055	9,267	0.5	3.6	0.7	23.6	1.8	6.2	12.2	181
Quartz Monzonite - Potassic	6	1.3	1.3	1.0	14,467	0.6	8.5	1,788	52	38.1	227	0.065	8,700	0.3	2.5	0.2	21.7	1.4	5.7	9.2	96
Quartz Monzonite - Propylitic	3	0.7	1.4	0.5	21,100	1.3	13.0	856	20	29.5	216	0.017	5,167	0.3	1.0	0.1	11.5	1.2	3.6	5.6	186
Quartz Monzonite - Quartz Sericite	9	1.1	1.2	0.8	11,278	0.2	6.9	1,407	143	31.6	250	0.072	14,311	0.3	3.0	0.2	17.6	1.6	5.1	9.1	47
Tailings-North Dam	2	1.3	5.1	1.6	16,400	0.4	8.9	1,175	44	28.9	286	0.062	13,100	0.4	3.5	0.4	25.4	2.1	7.5	9.7	69
Tailings - South Dam	2	0.1	6.0	0.3	168,500	0.1	5.7	53	1	12.3	73	0.002	400	0.4	1.5	0.1	6.5	0.6	4.1	1.6	53
Average (all lithologies)	74	2.2	5.6	1.6	18,980	1.1	8.9	2,489	92	51.4	226	0.099	11,458	0.5	3.2	0.4	21.6	1.6	5.9	8.6	140

# = number of samples representing material type
GAI = 0 represents < 3 times average crustal concentrations
GAI = 1 represents 3 to 6 times average crustal concentrations
GAI = 2 represents 6 to 12 times average crustal concentrations
GAI = 3 represents 12 to 24 times average crustal concentrations
GAI = 4 represents 24 to 48 times average crustal concentrations
GAI = 5 represents 48 to 96 times average crustal concentrations
GAI = 6 represents greater than 86 times average crustal concentrations

3. ACID BASE ACCOUNTING

Acid Base Accounting (ABA) testwork was carried out by SVL laboratories using a modified Sobek method. The testwork was carried out in order to evaluate the acid generating (AP) based on speciated sulfur analysis and neutralizing potential (NP) of the samples was determined by using the modified Sobek protocol that includes a digestion to expel any CO_2 followed by a back titration with NaOH to a pH of 8.3 s.u.

The balance between the acid generating mineral phases and acid neutralizing mineral phases is referred to as the net neutralization potential (NNP), which is equal to the difference between NP and AP. The NNP allows classification of the samples as potentially acid consuming or acid producing. A positive value of NNP indicates the sample neutralizes more acid than is produced during oxidation. A negative NNP value indicates there are more acid producing constituents than acid neutralizing constituents. Material that would be considered to have a high potential for acid neutralization produce a net neutralizing potential of greater than 20 eq. kg $CaCO_3$/ton. Acid Base Accounting data is also described using the neutralization potential ratio, which is calculated by dividing the NP by the AP (i.e., NP:AP).

Acid Base Accounting results are typically compared to criteria provided by the BLM (2004) in order to determine the potential for the waste rock material to generate acid. The Nevada BLM Water Resource Data and Analysis Guide for Mining Activities (BLM 2004) establishes the following guidelines for the evaluation of ABA test results:

- NP:AP values greater than 3 and NNP values greater than 20 eq. kg CaCO3/ton are not acid generating and do not require further testing; and
- NP:AP values less than 3 and/or NNP values less than 20 eq. kg CaCO3/ton have uncertain potential and require further evaluation using kinetic test methods.

The criteria used for the assessment of acid generation for Copper Flat materials are outlined in Table 4.

Table 4: Interpretation of Copper Flat ABA data

	NNP (kg $CaCO_3$ eq/t)	NPR
Potentially Acid Forming (PAF)	NNP < -20	NPR < 1
Non Acid Forming (NAF)	NNP > +20	NPR > 3
Area of Uncertainty	NNP between -20 and +20	NPR between 1 and 3

The ABA testwork results for the Copper Flat samples are provided in full in the attached database and are summarized in Table 5. The samples were found to have an average acid generating potential of 27.7 kg $CaCO_3$ eq/t and an average neutralizing potential of 24 kg $CaCO_3$ eq/t, indicating a slight surplus of acidity in the samples. This is supported by Figure 1, which shows the samples generally tend towards net acid generating rather than net neutralising. A scatter plot comparing the acid generating and neutralizing potential of the samples as a function of material type is given in Figure 2. This demonstrates that the samples are variable in terms of their acid generating potential. Fifty-four percent of samples exhibited potentially acid forming (PAF) characteristics based on NPR values less than 1 (Figure 2). This included all samples of Biotite Breccia, Breccia-Leach Cap, Argillic Breccia, Quartz Breccia, Quartz Monzonite–Leach Cap and Quartz Monzonite–Biotite materials. In contrast, the propylitically altered materials (Andesite – Propylitic, Breccia – Propylitic, Dolerite – Propylitic and Quartz Monzonite – Propylitic) generally exhibited non-acid forming (NAF) characteristics based on NPR values greater than 3.

Figure 3 shows that the net neutralizing capacity of the Copper Flat samples is largely dependent on the sulfide sulfur content of the materials. Samples with a high sulfide sulfur content (up to 2.52 wt%) are generally characterized by a lower net neutralizing potential.

Table 5: Summary of Acid Base Accounting results

Lithology	Alteration	#	Sulfide sulfur (wt%)	AP ($CaCO_3$ eq/t)		NP ($CaCO_3$ eq/t)		NNP ($CaCO_3$ eq/t)		NPR	
				Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Andesite	Propylitic	4	0.08	2.50	4.40	23.8	1.58	21.5	6.04	61.9	39.7
Breccia	Argillic	6	1.39	43.4	19.3	23.7	12.3	-19.7	12.7	0.54	0.22
Breccia	Biotite	6	1.35	42.3	19.2	24.6	7.11	-17.7	26.2	0.76	0.50
Breccia	Leach cap	3	1.84	57.4	21.8	14.7	4.66	-42.7	26.0	0.31	0.25
Breccia	Potassic	3	1.17	36.6	9.89	35.0	13.4	-1.57	23.2	1.09	0.76
Breccia	Propylitic	4	1.46	45.6	23.7	34.8	5.80	-10.8	27.1	1.01	0.65
Breccia	Quartz	3	1.00	31.3	4.15	28.6	1.55	-2.73	3.88	0.92	0.10
Dolerite	Propylitic	2	0.02	0.60	0.42	44.4	49.1	43.9	49.8	137	179
Quartz monzonite	Argillic	8	0.66	20.6	13.9	19.9	10.21	-0.74	16.6	1.41	1.09
Quartz monzonite	Biotite	4	0.43	13.3	3.54	5.88	1.79	-7.40	2.93	0.45	0.13
Quartz monzonite	Leach cap	9	0.63	19.8	10.9	19.8	22.4	-0.01	21.8	3.93	8.95
Quartz monzonite	Potassic	6	0.62	19.5	7.30	26.4	13.9	6.97	18.6	1.77	1.52
Quartz monzonite	Propylitic	3	0.45	14.1	1.25	41.5	3.77	27.4	3.16	2.96	0.22
Quartz monzonite	Quartz sericite	9	1.07	33.3	22.0	21.0	19.1	-12.4	37.5	1.07	1.06
All lithologies		**74**	**0.86**	**27.7**	**19.8**	**24.0**	**62.9**	**6.92**	**70.4**	**43.3**	**217**

Number of samples representing material type
Potentially acid forming (PAF)
Potentially acid forming (lower capacity)
Non Acid Forming (NAF)

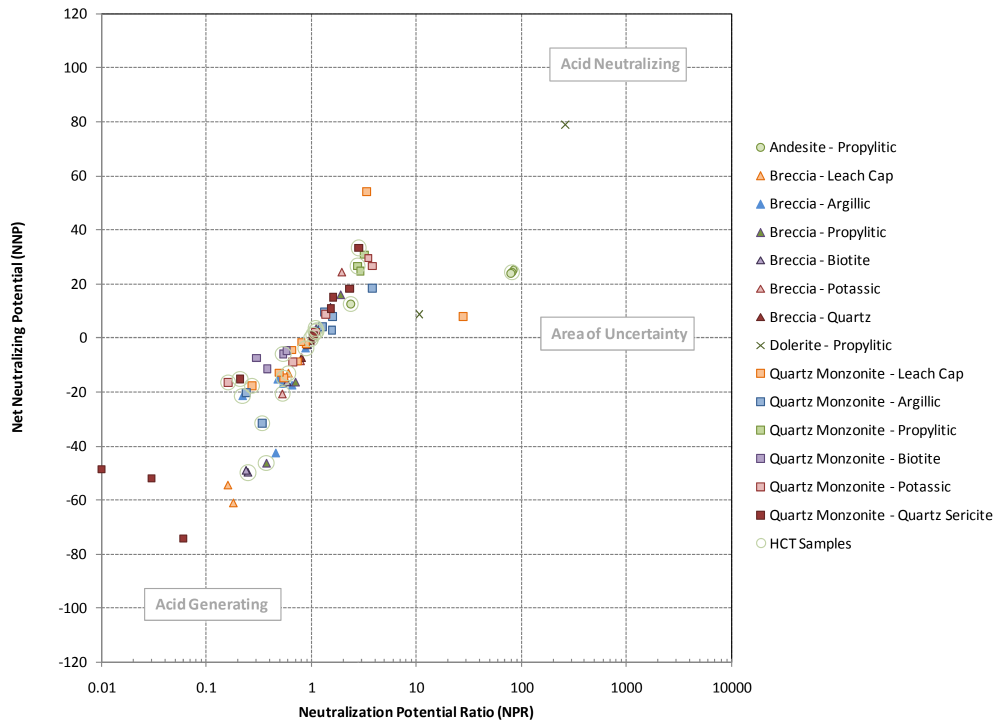

Figure 1: Neutralization Potential Ratio (NPR) vs. Net Neutralizing Potential (NNP)

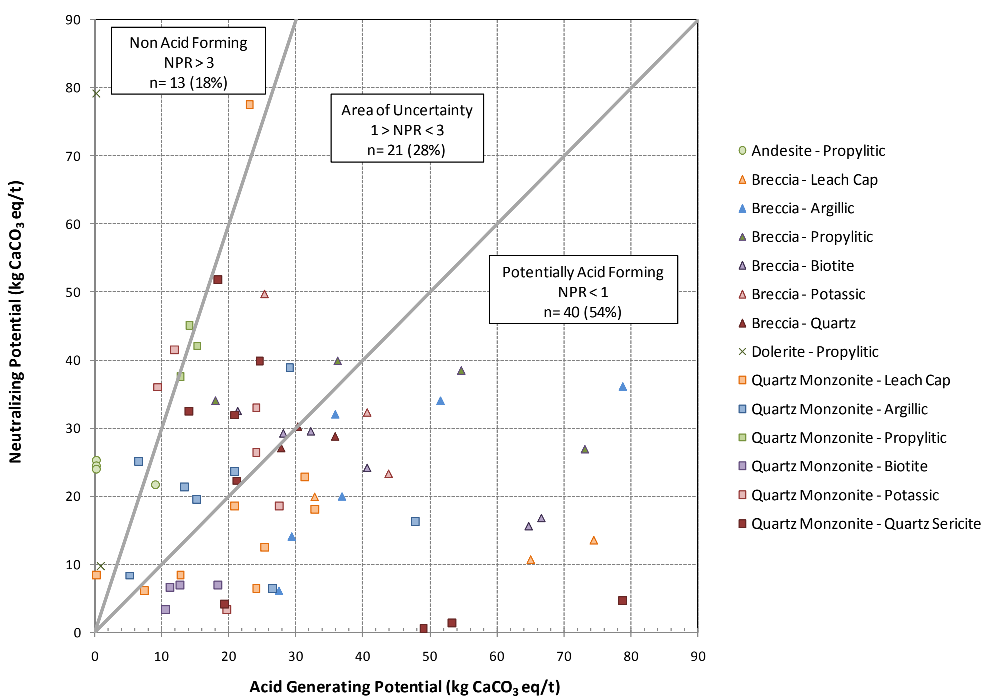

Figure 2: Scatter Plot of Acid Generating Potential vs. Neutralizing Potential

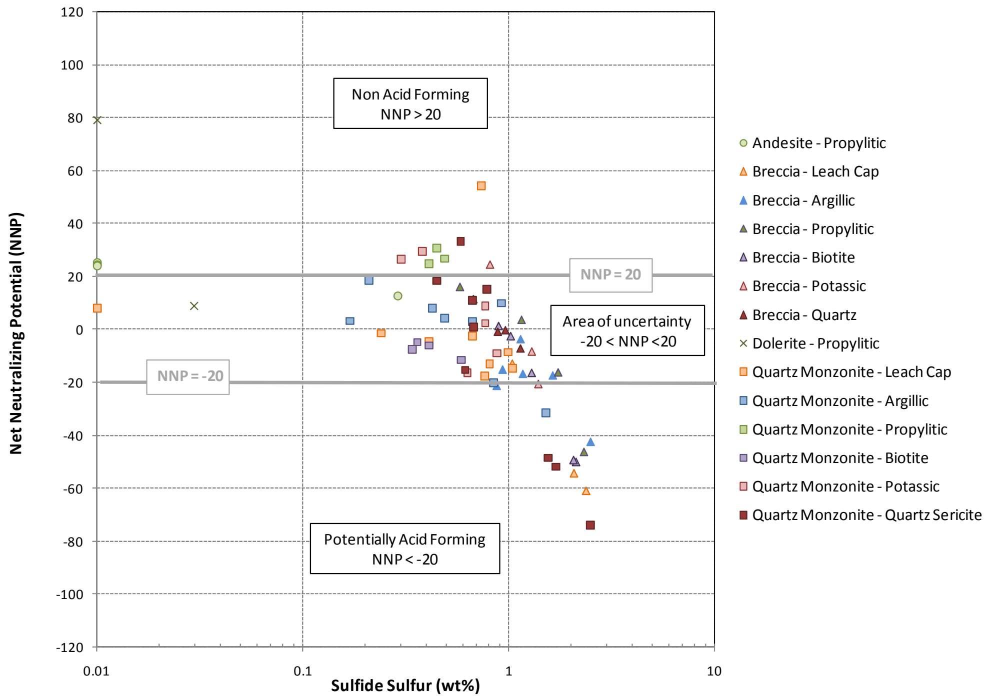

Figure 3: Scatter Plot of Sulfide Sulfur vs. Net Neutralizing Potential (NNP)

4. STATIC NAG TESTING

Static Net Acid Generation (NAG) testwork was carried out in order to determine the maximum potential for acid generation from the Copper Flat samples. The static NAG test differs from the ABA test in that it provides a direct empirical estimate of the overall sample reactivity, including any acid generated by semi-soluble sulfate minerals (i.e., jarosite) as well as other potentially acid-generating sulfate and sulfide minerals. As such, the NAG test often provides a better estimate of field acid generation than the more widely-used ABA method, which defines acid potential based solely on sulfide content.

NAG testing was carried out by SVL laboratories in accordance with the method described by Miller et al. (1997). The method essentially involved intensive oxidation of the sample using hydrogen peroxide (H_2O_2), which accelerates the dissolution of sulfide minerals and has the net result that acid production and neutralisation can be measured directly.

The leachate was then titrated with sodium hydroxide in two stages (to pH 4.5 and to pH 7) to determine the NAG value, which was calculated as follows:

$$NAG = (V_{Init} / X) (49 * V_{NaOH} * M) / W$$

Where:
NAG = net acid generation (kg H2SO4/tonne);
V_{Init} = volume of initial hydrogen peroxide solution (mL);
X = volume used to determine NAG by titration (mL);
V_{NaOH} = volume of NaOH used in titration (mL);
M = concentration of NaOH used in titration (moles/litre); and
W = weight of sample reacted (g).

In general a NAG pH less than 4.5 and a NAG value greater than 5 kg H_2SO_4 per tonne are indicative of a potentially acid forming material.

The static NAG data for the Copper Flat samples are provided in full in the attached database and are summarized in Table 6. A scatter plot comparing NAG pH with net acid generation (in kg H_2SO_4 equivalents per ton) according to material type is given in Figure 4. Most material types were found to be characterized by a NAG pH greater than 4.5 and a NAG value of zero, indicating that they are unlikely to be problematic in terms of long-term acid generation. However, several material types were characterized by lower NAG pH values (2.26 – 3.76 s.u.) and indicated the potential to generate up to 44 kg H_2SO_4 per ton. In particular the Breccia-Leach Cap and the Quartz Monzonite-Quartz Sericite materials can be classified as higher capacity PAF materials based on static NAG values generally greater than 20 kg H_2SO_4 eq/t. In addition, two samples of Biotite Breccia material and two samples of Argillic Breccia material exhibited higher capacity PAF characteristics based on a NAG pH between 2.98 and 3.77 s.u. and static NAG values up to 20.5 kg H_2SO_4 eq/t. The Quartz Monzonite-Biotite material exhibited lower capacity PAF characteristics based on NAG values between 5 and 10 kg H_2SO_4 eq/t.

Comparison of ABA and static NAG testwork results suggests that sulfide sulfur content is not the sole control on the acid generating potential of the Copper Flat materials; the net neutralizing potential (NNP) of the materials was also found to influence the long-term potential for acid generation (see Figure 5 and Figure 6). Samples with a high sulfide sulfur content and high NNP were generally found to be non-acid forming based on NAG testwork results, whereas samples with a low NNP were generally found to show a greater potential for acid formation (Figure 5).

Table 6: Summary of Static NAG results

Lithology	Alteration	#	NAG pH		NAG value (kg H_2SO_4 eq/t)	
			Mean	S.D.	Mean	S.D.
Andesite	Propylitic	4	6.50	2.23	1.23	2.45
Breccia	Argillic	6	6.60	2.52	4.74	7.62
Breccia	Biotite	6	6.61	2.71	6.29	9.79
Breccia	Leach cap	3	2.98	0.20	19.5	9.27
Breccia	Potassic	3	7.50	2.14	0	0
Breccia	Propylitic	4	7.53	2.22	0	0
Breccia	Quartz	3	8.62	0.59	0	0
Dolerite	Propylitic	2	8.69	1.94	0	0
Quartz monzonite	Argillic	8	7.70	2.57	1.13	3.19
Quartz monzonite	Biotite	4	4.88	2.38	4.07	2.73
Quartz monzonite	Leach cap	9	6.69	2.01	0.75	2.25
Quartz monzonite	Potassic	6	8.01	2.17	0	0
Quartz monzonite	Propylitic	3	8.37	0.20	0	0
Quartz monzonite	Quartz sericite	9	5.84	3.19	14.2	19.3
Tailings - North Dam	-	2	8.78	0.33	0	0
Tailings - South Dam	-	2	10.32	0.87	0	0
All lithologies		**74**	**6.96**	**2.50**	**3.91**	**9.33**

#	Number of samples representing material type
(pink)	Potentially Acid Forming (PAF)
(yellow)	Potentially Acid Forming Lower Capacity

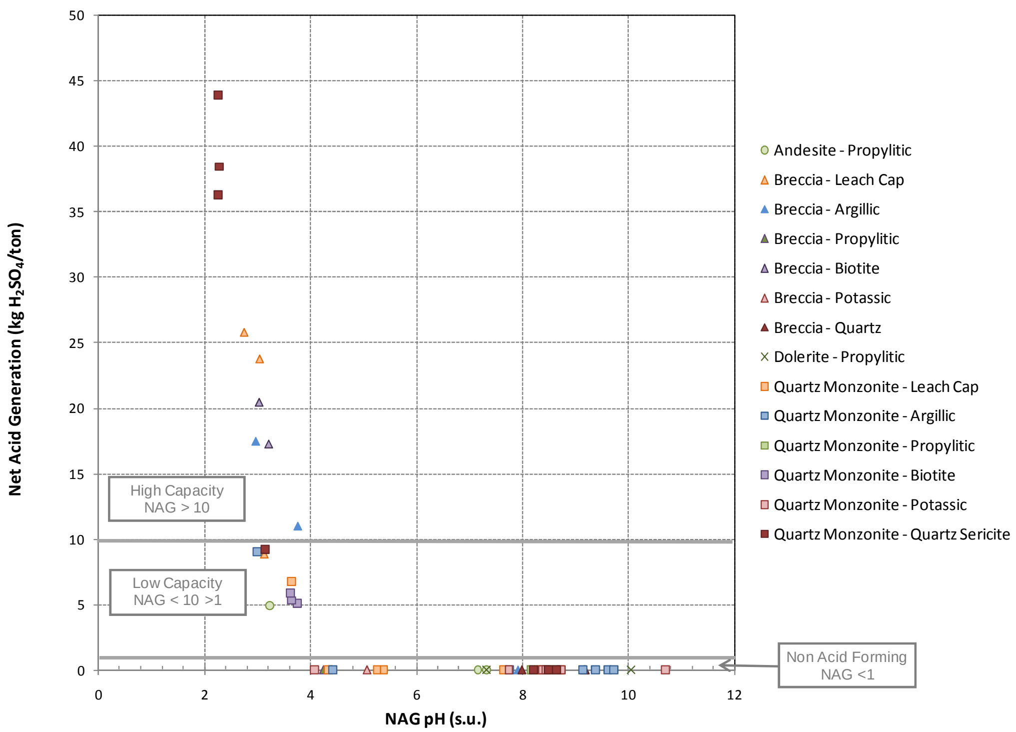

Figure 4: Scatter Plot of NAG pH vs. Net Acid Generation Potential

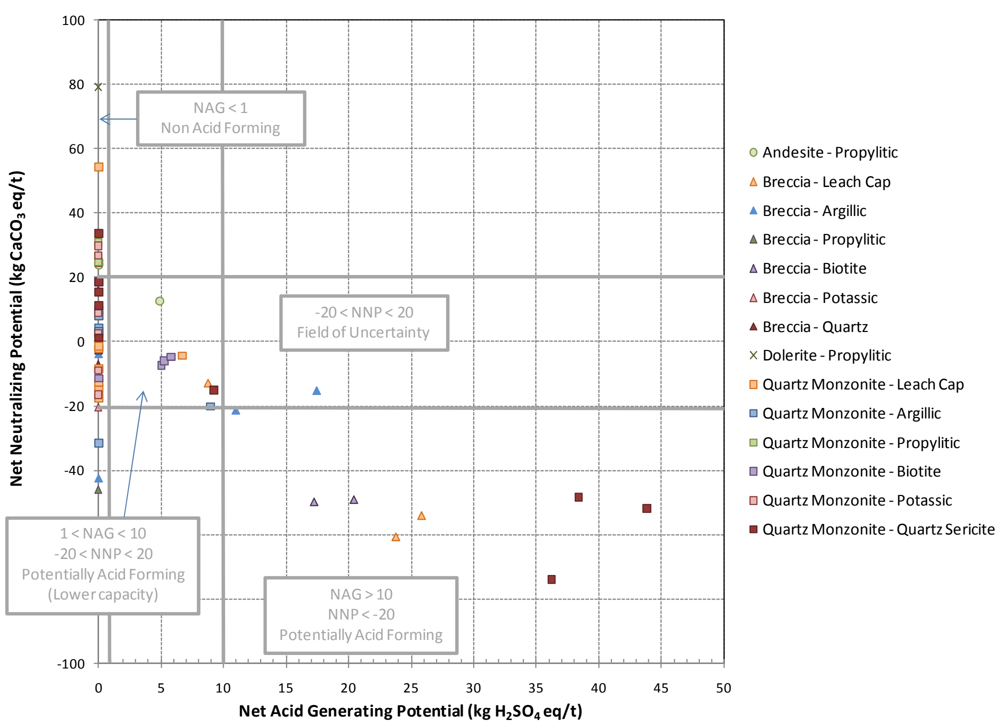

Figure 5: Scatter Plot of Net Acid Generation Potential vs. Net Neutralizing Potential

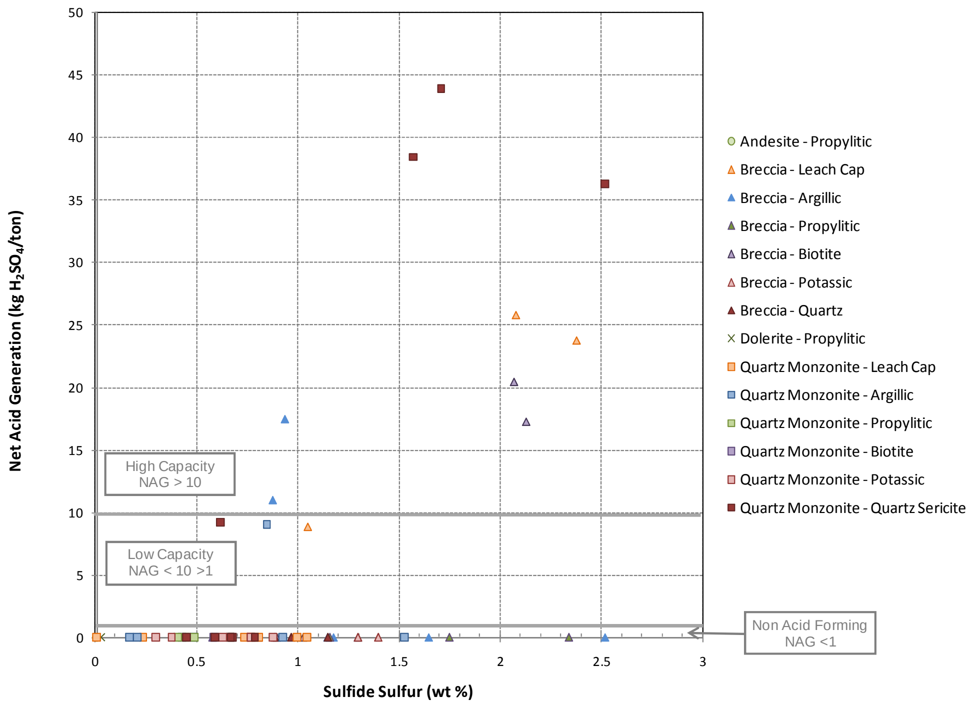

Figure 6: Scatter Plot of Sulfide Sulfur vs. Net Acid Generation Potential

5. SHORT-TERM METAL LEACHING (MWMP)

Meteoric Water Mobility Procedure (MWMP) testing was carried out by ALS Chemex, Reno, Nevada to give an indication of short-term metal mobility from the Copper Flat materials. In particular the release of ECA elements (elements identified as being present at concentrations above average crustal abundance) was studied. The MWMP test was developed to simulate the leaching of weather mine waste materials with meteoric water during precipitation events. The results of the MWMP test can be used to identify the presence of leachable metals and readily soluble salts stored in the material as well as provide an indication of their availability for dissolution and transport in response to a precipitation event. A total of 40 representative samples were selected for MWMP testing (Table 1) based on the results of ABA and NAG testwork.

The results of the MWMP testing are provided in full in the attached database and the main findings are summarized below. In general, metal mobility and metal leaching from the Copper Flat materials was found to be low, with ECA elements generally being released at concentrations below analytical detection limits in the MWMP leachates. Furthermore, the leachates were generally characterized by circum-neutral to moderately alkaline pH (pH 6.9 – 8.8 s.u.).

Scatter plots of Ficklin metal release as a function of leachate pH and sulfide sulfur content are given in Figure 7 and Figure 8, respectively. The Ficklin plot in Figure 7 demonstrates that most leachates can be classified as ‘near-neutral, low metal’ solutions based on an MWMP pH between 6.9 and 8.8 s.u. However, 20% of leachates can be classified as acid with moderate to high metal concentrations based on a leachate pH between 3.02 and 5.5 and total Ficklin metal concentrations up to 292 mg/L (cadmium + cobalt + copper + nickel + lead + zinc). Further analysis of the static data demonstrated that the samples which showed higher levels of metal and acidity release were grab samples collected from the waste rock dumps (rather than core material). Furthermore, the majority of the metal load from the grab samples was found to be made up of copper (Figure 9), thus suggesting that the elevated metal release was related to the flushing of soluble copper salts from the surface of the waste rock materials rather than the oxidation of sulfide minerals. This hypothesis is further supported by the poor correlation between Ficklin metal release and the sulfide sulfur content of the materials (Figure 8).

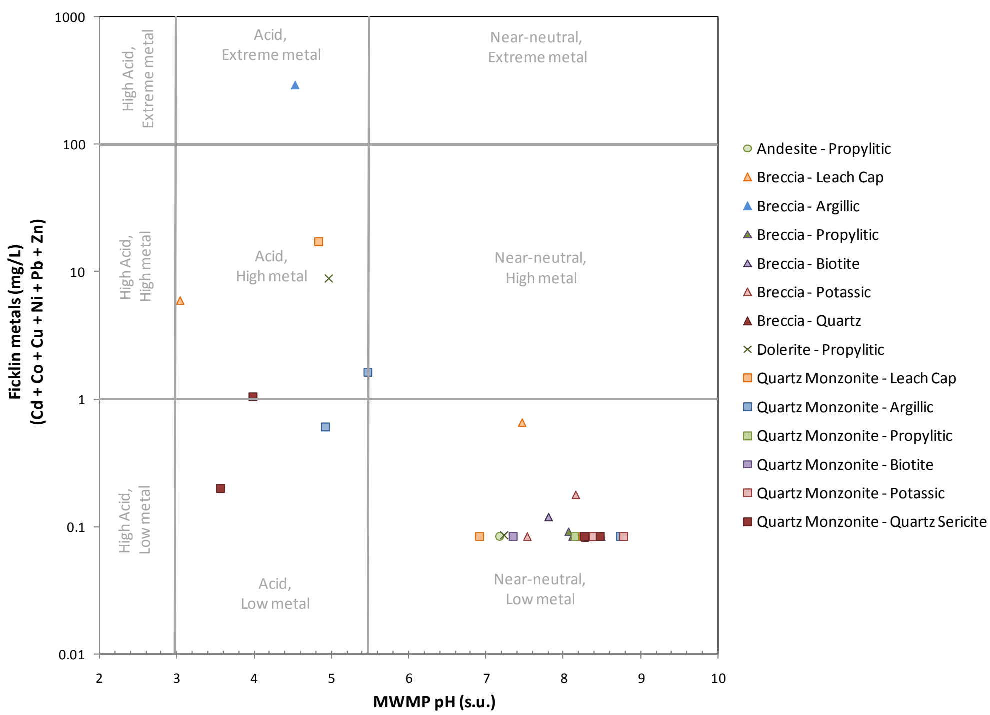

Figure 7: Scatter Plot of MWMP pH vs. Ficklin Metal Release

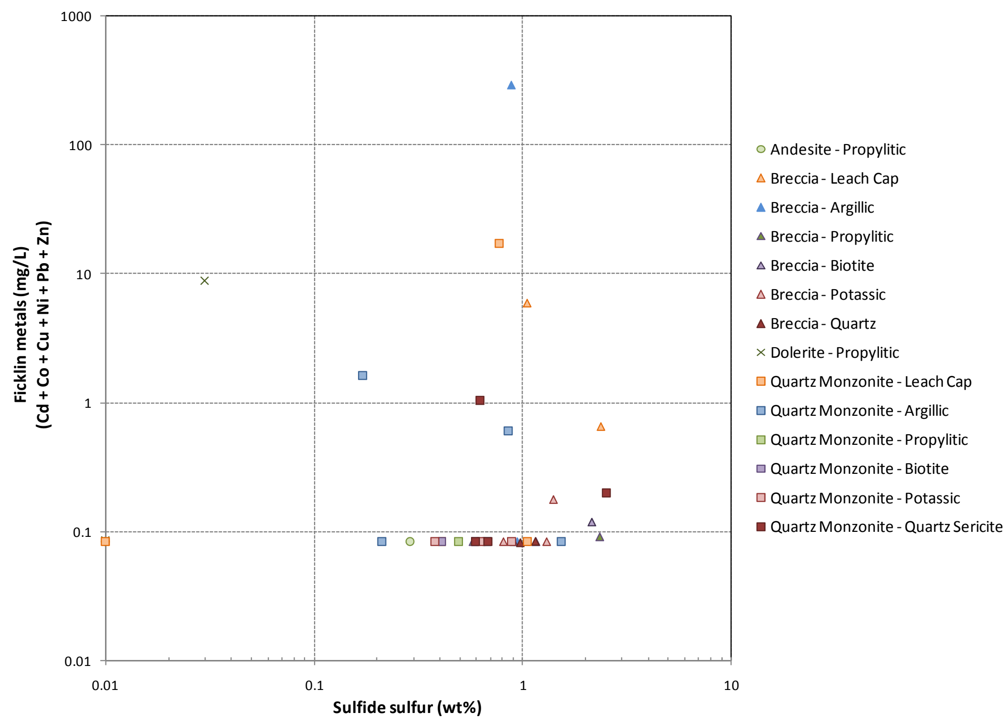

Figure 8: Scatter Plot of Sulfide Sulfur vs. MWMP Ficklin Metal Release

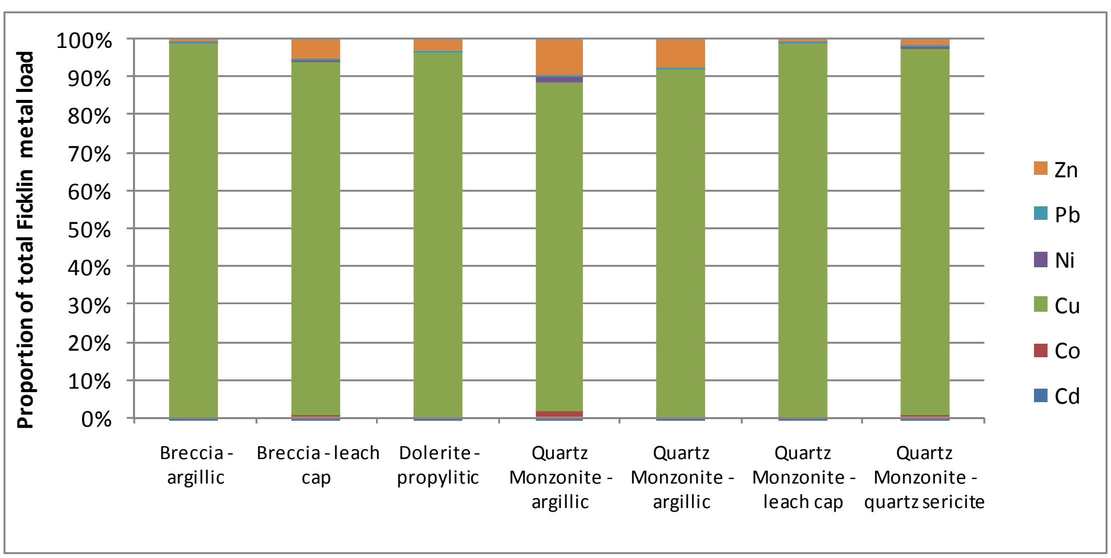

Figure 9: Histogram of Percentage Contribution of Parameters to Total Ficklin Metal Release in MWMP test (Grab Samples)

6. REMAINING TESTWORK

The objective of the static testing was to allow rapid assessment of the acid generating and metal leaching characteristics of the main lithological units that will be exposed on site at Copper Flat. However, these static tests do not consider the temporal variations that may occur in leachate chemistry as a result of long-term changes in oxidation, dissolution and desorption reaction rates. Because chemical weathering kinetics is known to strongly affect solute release over time, the results of these static tests ideally need to be confirmed using kinetic methods. Kinetic tests (e.g. laboratory humidity cell tests) evaluate temporal changes in leachate chemistry, through the sequential leaching of the rock weathered in a regular cycle of exposure to dry and wet air in a controlled laboratory environment. These cycles simulate and accelerate the chemical weathering rates observed under field conditions, using test conditions that are specifically designed to target oxidation of sulfide minerals. The goal of kinetic testing is to provide reaction rate data to support prediction of the leachate chemistry that would likely develop during meteoric rinsing of waste rock storage area facilities. Kinetic test data can also be used to predict concentrations of constituents that would be released from pit wall rock in response to meteoric rinsing and to develop a prediction of future pit lake water quality.

A sub-set of samples from the Copper Flat static test database have been selected for kinetic testing. The samples selected for HCT testing are summarized in Table 7 below along with the prediction of acid and metal release from the static test data (i.e., ABA, NAG and MWMP tests). These samples represent the range of predicted geochemistry for the waste rock and pit wall rock types for Copper Flat.

As discussed above, the BLM only considers waste rock to be non-acid generating without kinetic testing if there is 300 percent excess neutralizing capacity (i.e., NP:AP> 3) and the NNP is greater than 20 eq. kg $CaCO_3$/ton. According to the BLM guidance (2004) samples that do not meet these criteria require kinetic testing to define the acid generating potential. The majority of the Copper Flat samples demonstrate an uncertain potential for acid generation with NP:AP values less than 3 and NNP values less than 20 eq. kg $CaCO_3$/ton.

Kinetic testing proposed for this project is the standard humidity cell test procedure designed to simulate water-rock interactions (ASTM D-5744-96). This test runs for a minimum of 20 weeks and follows a seven-day cycle until steady state conditions are achieved. During the seven-day cycle, water is trickled over the rock for two days. Air that is humidified slightly above room temperature is introduced at the bottom of the column for two days of each cycle followed by two days of dry air. On the seventh day, the sample is rinsed with distilled water and the extracted solution is collected for analysis. Key parameters including; pH, alkalinity, acidity, electrical conductivity, iron and sulfate are measured on a weekly basis. Metals are typically measured on a weekly basis for the first 4 weeks of testing. After this, the frequency of metals analysis can be reduced to every fourth week.

Table 7: Samples selected for kinetic testing

Lithology	Alteration	Sample ID	Type	Pyritic Sulfur	NNP	NPR	NAG pH	Total NAG	MWMP pH	Metals Release
Andesite	Propylitic	SRK 0864	Grab	0.01	24.4	81.3	8.29	0	7.18	Low
		SRK 0866	Grab	0.29	12.5	2.37	3.23	4.9	6.92	Low
Breccia	Argillic	604811	Core	1.15	-3.9	0.89	8.42	0	8.24	Low
		SRK 0854	Grab	0.88	-21.5	0.22	3.77	10.98	4.54	High
	Biotite	604767	Core	2.13	-49.9	0.25	3.21	17.26	7.8	Low
		605033	Core	0.9	1.1	1.04	8.3	0	8.37	Low
	Leach Cap	SRK 0872	Grab	1.05	-13.0	0.60	3.14	8.82	3.05	Moderate
	Propylitic	604862	Core	1.16	3.5	1.10	8.28	0	8.11	Low
		604867	Core	2.34	-46.2	0.37	4.24	0	8.06	Low
	Quartz	604787	Core	0.97	-0.2	0.99	8	0	8.28	Low
	Potassic	604854	Core	1.4	-20.6	0.53	5.08	0	8.16	Low
Quartz Monzonite	Argillic	604562	Core	1.53	-31.6	0.34	7.75	0	8.28	Low
		604606	Core	0.67	2.7	1.13	9.6	0	8.31	Low
	Biotite	604673	Core	0.41	-5.9	0.54	3.66	5.29	8.33	Low
	Leach Cap	604569	Core	1.05	-14.8	0.55	8.33	0	8.25	Low
		SRK 0867	Grab	0.77	-17.7	0.27	4.35	0	4.84	Moderate
	Potassic	604669	Core	0.63	-16.5	0.16	4.08	0	8.39	Low
		604653	Core	0.77	2.3	1.10	8.38	0	--	--
	Propylitic	605153	Core	0.49	26.7	2.75	8.56	0	8.15	Low
	Quartz Sericite	SRK 0858	Grab	0.62	-15.3	0.21	3.15	9.22	3.99	Moderate
		604656	Core	0.59	33.4	2.82	8.2	0	8.27	Low

HCTs are run until steady state effluent chemistry is observed. At which time the tests will be terminated. Steady state is reached once constituent concentrations remain constant for more than four consecutive weeks following evidence of sulfide leaching in previous leaching cycles. After the leaching reactions have been adequately characterized in the HCT, the cell will be rested for two weeks and rinsed again to determine if significant salt accumulation has occurred during the resting period. SRK will also conduct pre-leach and post-leach, ABA, multi-element analysis, and mineralogy on all samples selected for kinetic tests. This further defines the mineralogical processes that occur as the materials are exposed to oxygen and water.

7. LABORATORY COSTS AND SCHEDULE

A total of 21 samples have been selected from the Copper Flat database for kinetic testing. These samples have already been prepared and are being stored at McClelland Laboratories awaiting further instruction. The estimated laboratory costs for the HCTs are summarized in Table 8 below.

Table 8: Estimated kinetic test laboratory costs

Kinetic Test Cost Estimate	Lab	# of samples	Cost Per Sample	Total Cost
Pre-Leach Mineralogy	SRK UK	21	$150	$3,150
Humidity Cell Test Set-up	McClelland	21	$130	$2,730
Humidity Cell Test [1]	McClelland	21	$2,200	$46,200
Profile II for HCT Extracts [1]	WetLAB	21	$3,200	$67,200
Termination Testing (4-Acid Digest, ABA, Min)	SVL	21	$285	$5,985
Reporting	McClelland	21	$750	$15,750
			Total	$141,015

[1] Assumes the HCT will be run for 20 weeks and that samples will be collected for Weeks 0, 1, 2, 3, 4, 8, 12, 16, 20 and final rinse for Profile II testing (10 Profile II tests per sample @ $320/test).

The HCTs will be run until the data indicate that the reactions have stabilized. This can take a minimum of 20 weeks but can take longer depending upon the results. For the purposes of this cost estimate we are assuming that the data we need should be available in 20 weeks. Once the cells have reached a steady-state, the cells will be rested for two weeks and rinsed again to determine if significant salt accumulation has occurred during the resting period. Following the final rinse, a split of the post-leach sample material will be collected for mineralogy, ABA and multi-element analysis. The cost estimate also assumes mineralogy testing will be conducted on the pre-leach samples.

While the kinetic tests are being performed, SRK will continue with the data compilation from the static tests and the analysis of those data. After the final data are available, it will take about six to eight weeks to finalize the analysis of the characterization results and complete the draft report.

8. REFERENCES

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Appendix 7-D

Copper Flat Geochemical Characterization Program
(SRK Feb 2011)

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Memorandum

To:	Steve Raugust, NMCC	**Date:**	February 7, 2011
	Cynthia Ardito, INTERA Incorporated	**From:**	Amy Prestia, Rob Bowell, Ruth Warrender
Subject:	Copper Flat Geochemical Characterization Program	**Project #:**	191000.03

This memorandum has been prepared by SRK Consulting (SRK) to provide New Mexico Copper Corporation (NMCC) with a description of the objectives, approach and test methods applied during the Copper Flat geochemical characterization study. This information is needed to address comments from NMED and MMD on the SAP that are relevant to the Abatement Plan. A summary of the preliminary results of the characterization program is also provided below. The preliminary results are described in greater detail in a separate memo submitted to NMCC in December 2010.

The primary purpose of the geochemical characterization program is to provide an understanding of the geochemical characteristics of materials specific to the Copper Flat deposit and define the potential for waste rock, pit walls and tailings material to generate acid or leach deleterious constituents. In order to accomplish the objectives of the study, samples representative of waste rock, pit walls and tailings material were collected and characterized following guidelines set forth in the *Bureau of Land Management Instruction Memorandum NV-2010-014, Nevada Bureau of Land Management Rock Characterization Resources and Water Analysis Guidance for Mining Activities (BLM, January 8, 2010).*

The following activities were completed as part of the geochemical characterization program:

- Review of site geology and identification of the primary material types for the project;
- Collection of drill core samples representative of waste rock;
- Collection of surface samples from existing waste rock dump, pit wall and tailings impoundment surfaces; and
- Static and kinetic laboratory testing of representative samples.

The two main considerations of this baseline geochemical characterization are:

- Acid generation due to oxidation of sulfide minerals, which can potentially lead to development of Acid Rock Drainage (ARD); and
- Potential for leaching of metals (e.g., copper) and salts (e.g., sulfate).

The processes of acid generation and metal leaching can operate independently, although the development of acidic conditions enhances the solubility of many metals.

At the time this memorandum was prepared, the geochemical testing program was not complete. Consequently, the conclusions concerning acid generation potential presented herein are preliminary and are based upon the results of the static testwork only. These conclusions may change pending the final characterization results upon completion of the kinetic humidity cell program. Upon completion of the data collection and evaluation, the final waste rock characterization results will be submitted in a comprehensive report.

1 Copper Flat Material Types

Waste rock is typically classified and tested according to material type and the number of samples selected for geochemical testing is based on the relative percentage of each material type predicted to be mined from the geologic block model. At this time a block model is not available for the Copper Flat project. Therefore, material types for the Copper Flat project were delineated from a review of data available from the recent exploration drilling program including the drillhole database, drill logs, assay data and bulk element geochemistry (limited to copper, molybdenum, gold silver).

The term ‘rock type’ refers to the basic lithological description of the rock, ‘alteration type’ refers to the type of mineral assemblage that has been formed as a result of hydrothermal alteration and ‘oxidation state’ refers to the degree of oxidation of the rock. The term ‘material type’ denotes a unique combination of rock type, alteration type and oxidation state.

The main rock types for the Copper Flat project include:

1. Alluvium/Overburden
2. Andesite
3. Quartz Monzonite Breccia
4. Quartz Monzonite
5. Dolerite

Alteration type is determined by visual identification of characteristic secondary mineralogy. The four alteration types for the Copper Flat deposit include:

1. Leach Cap
2. Propylitic
3. Argillic
4. Silicification

Oxidation can be determined from color and a visual estimate of sulfide mineral content and oxidation state can be broken into three categories including:

1. Oxide: material has been mostly oxidized and there are no remaining sulfide minerals.
2. Mixed: material has been partially oxidized and some sulfide minerals are still remaining.
3. Non-Oxide: sulfide minerals are not oxidized and there is no evidence of oxidation.

For the purposes of the material characterization and testing, SRK have identified a total of fourteen material types for the Copper Flat project as summarized in Table 1 below. Sample intervals in the exploration database were not coded with information on oxidation of the material. Therefore, the material type delineations are based on rock type and alteration only and do not account for oxidation state.

Table 1: Copper Flat Material Types

<table>
<tr><th>Material Type</th><th>Rock Type</th><th>Alteration</th></tr>
<tr><td>1</td><td>Andesite</td><td>Propylitic</td></tr>
<tr><td>2</td><td rowspan="6">Breccia</td><td>Argillic</td></tr>
<tr><td>3</td><td>Biotite</td></tr>
<tr><td>4</td><td>Leach cap</td></tr>
<tr><td>5</td><td>Potassic</td></tr>
<tr><td>6</td><td>Propylitic</td></tr>
<tr><td>7</td><td>Quartz</td></tr>
<tr><td>8</td><td>Dolerite</td><td>Propylitic</td></tr>
<tr><td>9</td><td rowspan="6">Quartz Monzonite</td><td>Argillic</td></tr>
<tr><td>10</td><td>Biotite</td></tr>
<tr><td>11</td><td>Leach cap</td></tr>
<tr><td>12</td><td>Potassic</td></tr>
<tr><td>13</td><td>Propylitic</td></tr>
<tr><td>14</td><td>Quartz sericite</td></tr>
</table>

2 Geochemistry Sample Selection

During the April 2010 site visit, two types of samples were collected including:

1. Drill hole samples collected at depth from recent exploration core holes.
2. Bulk surface grab samples from pit wall exposures, existing waste rock dumps and the tailings impoundment.

A description of the sample collection approach and methodology for each of the sample sources for the current investigation is provided in the following sections. The location of the recent exploration drill holes are shown in Figure 1 along with the recent geochemistry samples collected from the surface of the waste rock dumps, pit walls and tailings impoundment . Figure 1 also shows locations of samples collected in the late 1990s from pit walls and waste rock dumps in support of developing a Waste Rock Management Plan.

2.1 Drill Core Sample Selection

For this investigation, a total of fifty sample intervals were selected from six diamond 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 waste rock material types that will be encountered in the Copper Flat pit and samples were classified according to rock type and alteration. Typically, drill hole intervals are reviewed in the context of the final pit boundaries in order to identify ore and waste zones within the proposed pit boundaries and ensure that the proposed sample suite is spatially representative (both vertically and horizontally) of waste rock. However, because a block model and pit outline is not available at this time for the Copper Flat project, sample intervals were selected based on the frequency of occurrence of each material within the drill holes, drill hole distribution and known geology of the deposit. For each sample interval, the coarse reject material was collected and sent to the laboratory for sample preparation and testing as described below.

2.2 Bulk Surface Samples

To augment the drill core sample set, twenty four samples were collected from the surface of the existing waste rock dumps and pit wall exposures for geochemical testing. Existing waste rock dumps and pit walls 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 of the main material types were collected based on the geology observed on the waste rock dumps and pit areas. In addition, four samples of tailings material were collected from the surface of the North tailings impoundment. These samples were submitted to McClelland Laboratories for testing as described below.

3 Geochemical Test Methods

The static and kinetic testing methods selected for this project were designed to address mineralogy, bulk geochemical characteristics, and the potential of the waste rock and pit walls to generate acid or release metals. “Static testing” is a general term describing those analytical methods applied to characterize acid generation and metal leaching characteristics of material at the time of testing and does not account for temporal changes that may occur in the material as chemical weathering proceeds. Static tests provide a balance of acid generating and acid consuming reactions at an end point and also may be used to determine the potential magnitude of leaching metals from a given material.

Static testing is distinguished from “kinetic tests”, which evaluate the rate of sulfide oxidation and metal release over time. Static testing provides a conservative approximation of acid generation and trace metal release potential, which is used to determine where more comprehensive kinetic testing is warranted. Based on the results of the static test work, materials that exhibit uncertain or highly variable geochemical behavior may require further characterization using kinetic test methods to determine the rates and character of longer-term leaching.

The static test methods identified for this project were selected to address total acid generating or neutralizing potential of the samples and concentration of constituents in leachates derived from the material. Static testing methodologies include the following:

- Multi-element analysis using four-acid digest and ICP analysis to determine total metal and metalloid content;

- Examination of material by optical microscopy and X-Ray diffraction (XRD) to assess mineralogy and to identify sulfide and carbonate minerals present within the material types;
- Acid Base Accounting (ABA) using the modified Sobek method (Memorandum No. 96-79) with sulfur speciation by hydrochloric acid and nitric acid extraction;
- Net Acid Generating (NAG) test that reports the final NAG pH and final NAG value after a two-stage hydrogen peroxide digest; and
- Nevada Meteoric Water Mobility Procedure (MWMP - ASTM E2242-02) and Profile II analysis of leachate.

These test methods and the criteria commonly used in the evaluation of the resulting data set are described in the following sections. Samples were submitted to McClelland Laboratories (MLI) in Sparks, Nevada for sample preparation and MWMP extraction. The MWMP extracts were then sent to WetLabs, a Nevada Certified laboratory, in Sparks, Nevada for chemical analysis. Splits of each sample were submitted to SVL Laboratories in Kellogg, Idaho for ABA and NAG testing and ALS Chemex in Reno, Nevada for multi-element analysis (respectively).

Upon completion of the static test work, a small sub-set of samples representing the most significant waste rock types were selected from the static test database for kinetic testing. The kinetic testing method selected for this project is the standard humidity cell test procedure (ASTM D-5744-96).

A sample matrix summarizing the number of samples collected for the main material types (as defined by rock type and alteration) is provided in Table 3. Typically, the number of samples selected for testing based on the relative percentage of each material type predicted to be mined according to the current resource and geologic block models. However, because a bock model and relative percentage of the different material types are not available at this time, the number of samples selected is based on our experience with this type of deposit as well as the occurrence of each material type on the waste rock dump surfaces and in the drill hole database.

Table 3: Copper Flat Sample Frequency

Lithology	Alteration	ABA/NAG/Multi-Element			MWMP			HCT		
		Drillcore	Grab	Total	Drillcore	Grab	Total	Drillcore	Grab	Total
Dolerite	Propylitic		2	2		2	2			0
Andesite	Propylitic		4	4		2	2		2	2
Quartz Monzonite	Argillic	6	2	8	3	2	5	2		2
	Biotite	3	1	4	1	1	2	1		1
	Leach Cap	5	4	9	2	2	4	1	1	2
	Potassic	6		6	3		3	2		2
	Propylitic	3		3	1		1	1		1
	Quartz Sericite	5	4	9	2	2	4	1	1	2
Quartz Monzonite Breccia	Argillic	5	1	6	2	1	3	1	1	2
	Biotite	6		6	2		2	2		2
	Leach Cap	2	1	3	1	1	2		1	1
	Potassic	2	1	3	2	1	3	1		1
	Propylitic	4		4	3		3	2		2
	Quartz	3		3	2		2	1		1
Tailings	-		4	4		2	2			0
Total		50	24	74	24	16	40	15	6	21

4 Preliminary Findings

Below are the preliminary conclusions that can be drawn from the geochemical data available to date. These conclusions are preliminary based on the results of the static testwork program and may change depending upon the HCT results, once available.

- Multi-element results show that all material types are characterized by elevated concentrations of silver, cadmium, copper, molybdenum, rhenium, sulfur, selenium, tellurium and tungsten. The elevation of these elements can be explained by the common association of these elements with porphyry copper deposits (Rose, Hawkes and Webb, 1979). The greatest levels of enrichment were observed in the Breccia-Leach Cap material.
- The BLM considers waste rock to be non-acid generating without kinetic testing if there is 300 percent excess neutralizing capacity (i.e., NP:AP> 3) and the NNP is greater than 20 eq. kg CaCO3/ton. Based on the results of the ABA testwork, the majority of the Copper Flat samples demonstrate an uncertain potential for acid generation with NP:AP values less than 3 and NNP values less than 20 eq. kg CaCO3/ton. However samples tend towards net acid generating rather than net neutralizing, with an average AP of 27.2 kg $CaCO_3$/ton and an average NP of 24 kg $CaCO_3$/ton. The exception to this is the propylitically altered material that generally exhibited non-acid forming (NAF) characteristics based on NPR values greater than 3.
- The results of the static testwork demonstrated that samples with sulfide sulfur content greater than 1% are most likely to be acid forming (AF) based on NNP values less than -20 eq. kg $CaCO_3$/ton (Figure 2). However, comparison of ABA and static NAG testwork results suggests that sulfide sulfur content is not the sole control on the acid generating potential of the Copper Flat materials.

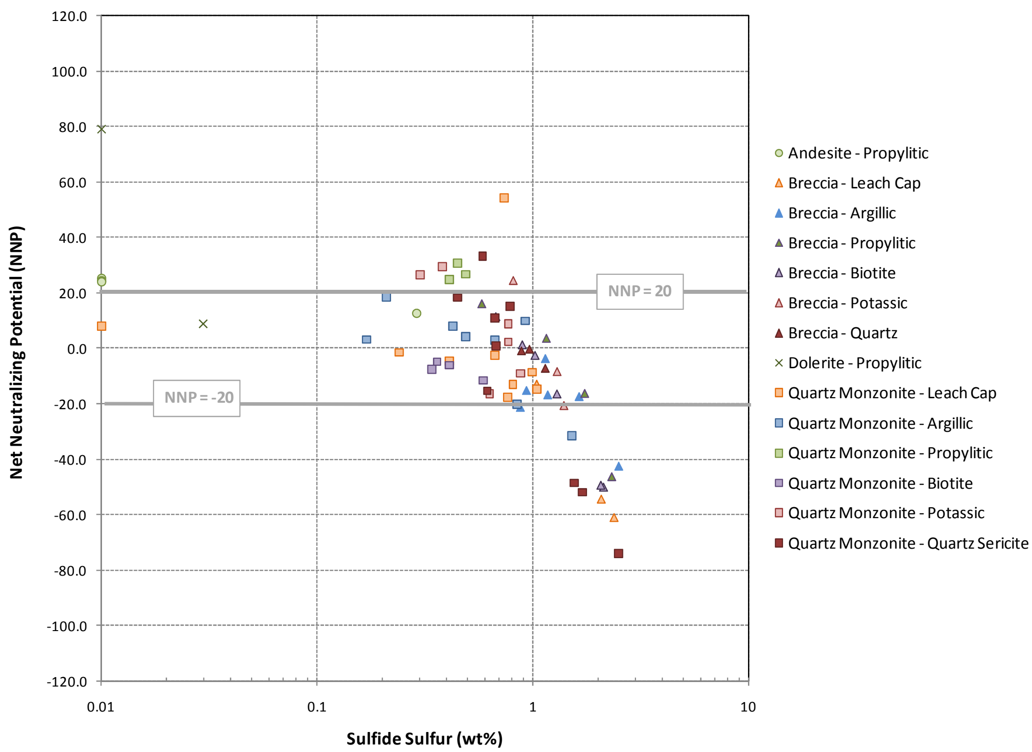

Figure 2: Scatter plot of sulfide sulfur vs. NNP

- The results of the static NAG testing demonstrate that only the Breccia-Leach Cap and Quartz Monzonite-Quartz Sericite material types show high capacity PAF characteristics. Most other materials are unlikely to be problematic in terms of long-term acid generation based on the results of the NAG testwork.
- In general, metal mobility and metal leaching from the Copper Flat materials was found to be low, with constituents generally being released at concentrations below analytical detection limits in the MWMP leachates under circum-neutral to moderately alkaline pH (pH 6.9 – 8.8 s.u.) conditions.
- Samples that showed the highest levels of metal and acidity release were observed in grab samples collected from the waste rock dumps and pit walls (rather than core samples). Furthermore, the majority of the metal load from the grab samples was found to be made up of copper, suggesting that the elevated metal release was related to the flushing of soluble copper salts from the surface of the materials rather than the oxidation of sulfide minerals. This hypothesis is further supported by the poor correlation between metal release and the sulfide sulfur content of the materials.
- Historic tailings material collected from the North tailings dam has a residual sulfide (pyritic) sulfur content of approximately 0.75 percent by weight. However, the material was also found to have available buffering capacity, and NAG testwork confirms that this material is unlikely to be acid forming in the long-term. MWMP leach test results indicate that some copper leaching may occur from the tailings material at neutral pH.

5 Additional Work

Humidity cell testing has been initiated on 21 samples of representative waste rock and is currently in Week 1 of a multi-week kinetic testwork program (40+ weeks). The results of the humidity cell testing will be used to define and quantify rates of metal release from the material types and will be used as source terms for geochemical prediction modeling. This will utilize site-specific knowledge about hydrology, climate, hydrogeology, topography and engineering in order to allow prediction of future water quality in the pit lake and waste rock dump run-off.

A geologic block model is required to determine the relative percentages of each material type and determine if the number of samples selected for each material type is adequate for the characterization program. In addition, the sample intervals need to be reviewed in context of the anticipated pit boundary in order to determine if the current dataset is spatially representative of the deposit, or determine if additional sample collection is required. Future exploration drilling presents an opportunity to collect additional samples for geochemical testing from core holes to provide adequate spatial coverage of the deposit as the resource is expanded.

EXPLANATION

- 2010 Surface Samples
- 2010 Drillcore Samples
- 1997 Surface Samples

Feet

0 500 1,000

1 inch = 500 feet

IF THE ABOVE BAR DOES NOT SCALE 1 INCH, THE DRAWING SCALE IS ALTERED

SRK Consulting
Engineers and Scientists

DESIGN: JP	DRAWN: JQG	REVIEWED: -
CHECKED: -	APPROVED: -	DATE: 2/4/2011
FILE NAME: GIS_Database_Samples_AP_JQG_20110202		

COPPER FLAT

NEW MEXICO COPPER CORP

COPPER FLAT SAMPLES

DRAWING NO. FIGURE 1 | SHEET 1 OF 1 | REVISION NO. A

SRK JOB NO. 191000-03

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Appendix 7-E

Copper Flat Geochemical Characterization Program
Incorporation of the 1997 Static Test Data
(SRK Mar 2011)

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Technical Memorandum

To:	Cynthia Ardito, Intera Inc.	Date:	March 30, 2011
Cc:	Steve Raugust, New Mexico Copper Corporation	From:	Ruth Warrender, Amy Prestia, Rob Bowell,
Subject:	Copper Flat Geochemical Characterization Program: Incorporation of 1997 Static Test Data	Project #:	191000.03

This memorandum has been prepared by SRK Consulting (SRK) to provide Intera Inc. with a comparison of geochemical data from two separate static testwork programs carried out by SRK in both 1997 and 2010. The memorandum also discusses incorporation of the historic (1997) data into the current (2010/2011) geochemical characterization and modeling work.

1 Pre-1996 Testwork Program

As part of the initial planning and baseline studies on behalf of Alta Gold, SRK (US) Inc collected a small suite of samples from drill core, tailings and waste rock for acid base accounting, short term leachate and kinetic testing. The kinetic testing program was only run for 28 weeks. None of the current investigators were involved in this work but Rob Bowell produced a report on the work due to changes in staff in SRK (US) prior to reporting of the study. 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.

2 1997 Testwork 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 detailed geological and geochemical maps of the waste rock dumps and pits.. A total of 141 surface grab samples were collected from as part of the 1997 characterization program and these samples were analyzed for field net acid generation (NAG) and paste chemistry. Forty six of these samples were then subject to laboratory Acid Base Accounting (ABA) testwork and 59 samples were submitted for NAG testwork. This work was reported in the *Copper Flat Waste Rock Management Plan* (SRK, 1998). It is important to note that further work was planned but Alta Gold went bankrupt prior to confirming work plan for further kinetic testing and leachate assessment.

3 2010 Testwork 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 update the previous geochemical characterization and modeling work carried out in 1997. This is based on subsequent revisions to standards outlining the characterization of mine waste, which have become significantly more involved since the previous assessment was carried out. A number of statutory regulations have also been reviewed and modified since this 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.

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

1. A total of 50 drill hole samples were collected at depth from recent 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 waste rock material types that will be encountered in the pit during mining operations.
2. A total of 24 bulk surface grab samples from pit wall exposures, existing waste rock dumps and the tailings impoundment. Sampling these existing waste rock dumps and pit walls 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. Coverage of this data set is more comprehensive than the previous studies.

It was anticipated that the samples collected as part of the 2010 characterization program would augment the existing (1997) geochemical dataset and update the geochemical characterization and modeling work to meet current standards.

4 Comparison of 1997 and 2010 Static Test Data

In order to ensure that the geochemical datasets collected in both 1997 and 2010 are comparable, SRK has undertaken a comparison of the testwork results obtained from ABA and NAG tests. This comparison has assessed the two datasets as a whole and has not considered variations within individual material types. This is because the material type designations used in both the 1997 and the 2010 assessments were different, and thus this would not be an appropriate comparison. For example the 1997 geochemical characterization program delineates samples according to oxidation (e.g. sulfide, transitional, oxide), whilst the 2010 program classifies materials according to alteration (e.g. propylitic, argillic, silicic). Nonetheless, the lithology types sampled during both the 1997 and 2010 geochemical characterization programs are comparable (Table 1).

Table 1: Summary of 1997 and 2010 Sampling

1997 sampling		**2010 sampling**	
Material type	**Number of samples**	**Material type**	**Number of samples**
Quartz Monzonite	94	Quartz Monzonite	39
Quartz Breccia	28	Quartz Monzonite Breccia	25
Andesite	1	Andesite	4
Biotite Breccia	10	Dolerite	2
Quartz Vein	8		

Comparison of the 1997 and 2010 data sets is illustrated on scatter plots and box and whisker plots preseted in Figure 1 to Figure 7**.**

The scatter plot comparing the sulfide sulfur content and net neutralizing potential (NNP) of the 1997 and 2010 samples provided in Figure 1 demonstrates that the two sample sets are broadly comparable, with a similar range in values. However, the 2010 data set generally has more samples that fall within the zone of uncertainty or that are non-acid forming. Conversely, the 1997 data set contains more samples that show potentially acid forming (PAF) characteristics. The box and whisker plot provided in Figure 2 shows the range and median values of NNP for each data set. This demonstrates that the two data sets are comparable in terms of the range of NNP values, but the samples collected in 1997 generally show a trend towards more acid generating characteristics. A reason for this may have been bias in collecting higher sulfide or weathered material on the dumps, whereas a more representative sample set was collected in 2010.

The tendency of the 1997 samples towards acid generating characteristics is also illustrated in the scatter plot of paste pH vs. sulfide sulfur content presented in Figure 3. This shows that the paste pH values for the samples collected in 1997are generally lower in comparison to the 2010 data. This is likely to reflect the nature of the samples themselves, with the 1997 samples being entirely grab samples collected from surface waste rock dumps and the 2010 samples being a mixture of both surface grab samples and also drill core material from depth. The significance of this difference in sample type is that surface grab samples are likely to be characterised by the presence of soluble (and potentially acidic) salts on the material surface, whereas the drill core samples are likely to be largely unweathered. Consideration of the grab samples only (Figure 4) shows a slightly better correlation between the two datasets, but paste pH values are still generally higher than observed in the 1997 dataset.

Comparison of 1997 and 2010 NAG testwork results (Figure 5) shows a fairly significant difference between the two datasets. This is largely due to a difference in testwork methodology, with the 1997 analysis including the determination of NAG values for samples with a NAG pH greater than 4. This is different to the 2010 methodology employed, whereby the NAG value was only determined for samples showing a NAG pH less than 4 s.u. Comparison of the two datasets for only samples with a NAG pH less than 4 shows that the samples are broadly similar in terms of their net acid generating potential (Figure 6 and Figure 7).

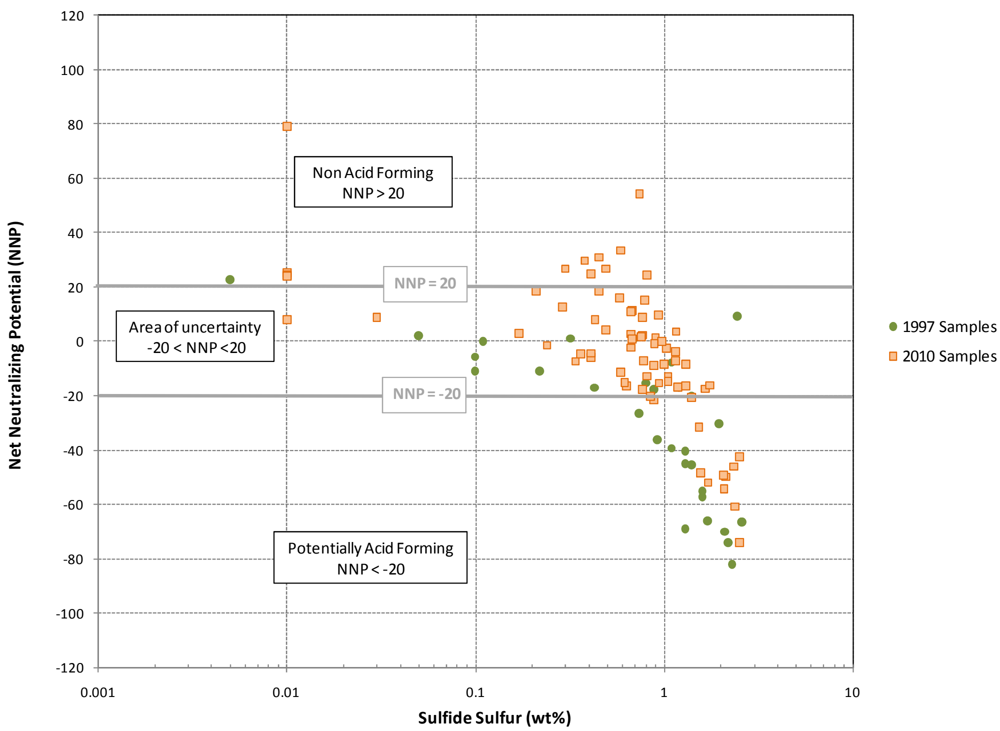

Figure 1: Scatter Plot of Sulfide Sulfur vs. Net Neutralizing Potential (NNP)

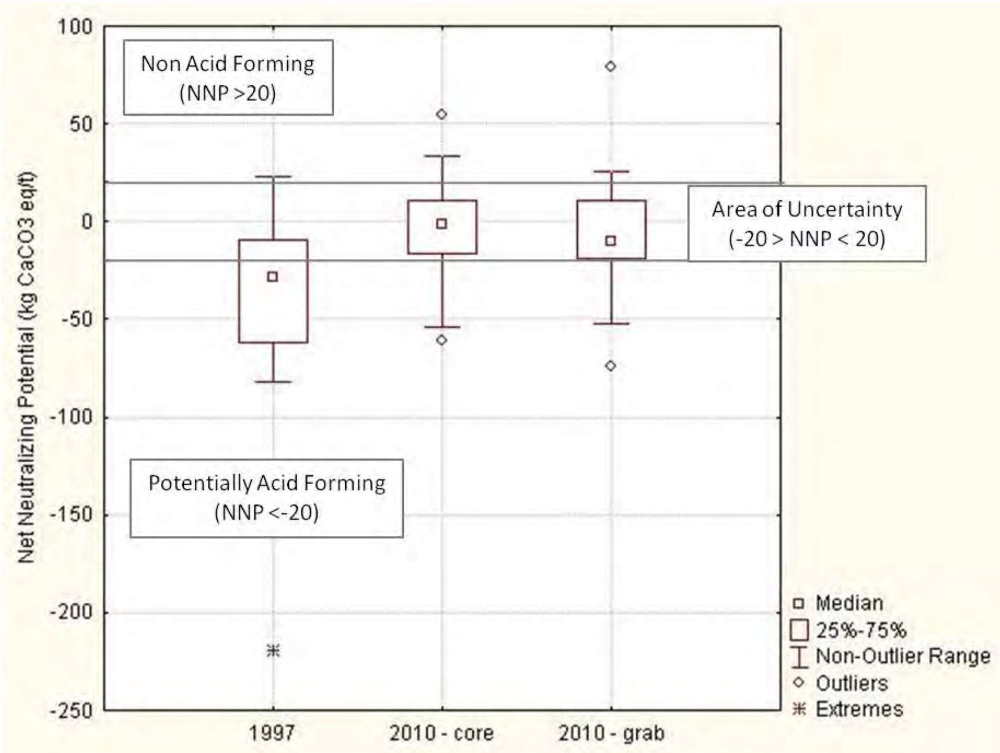

Figure 2: Box and Whisker Plot of Net Neutralizing Potential (NNP)

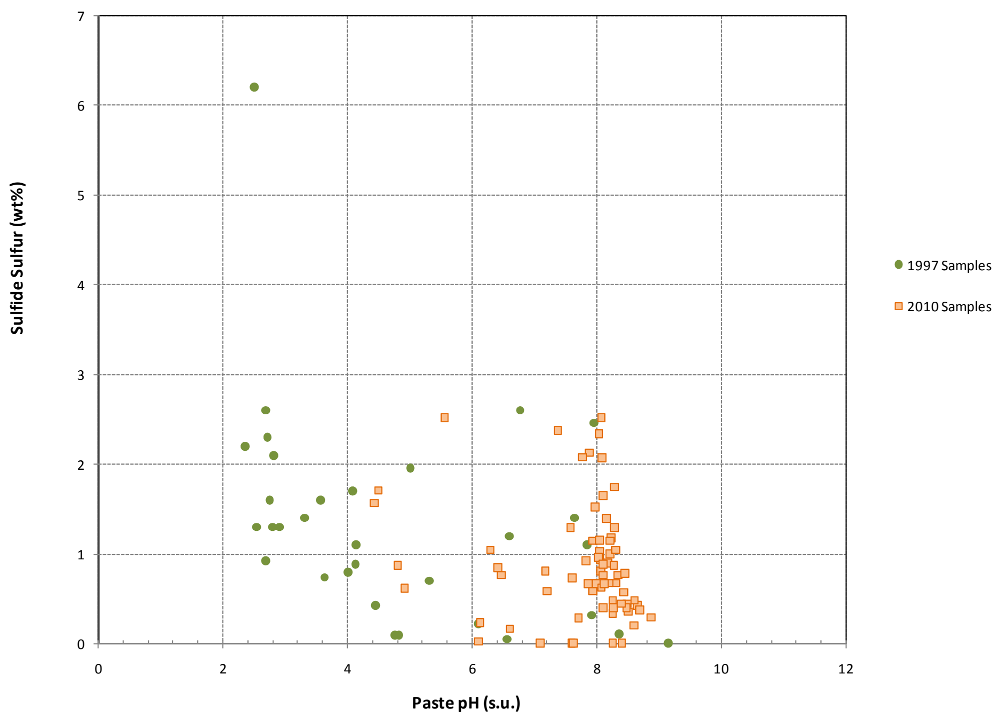

Figure 3: Scatter Plot of Paste pH vs. Sulfide Sulfur Content

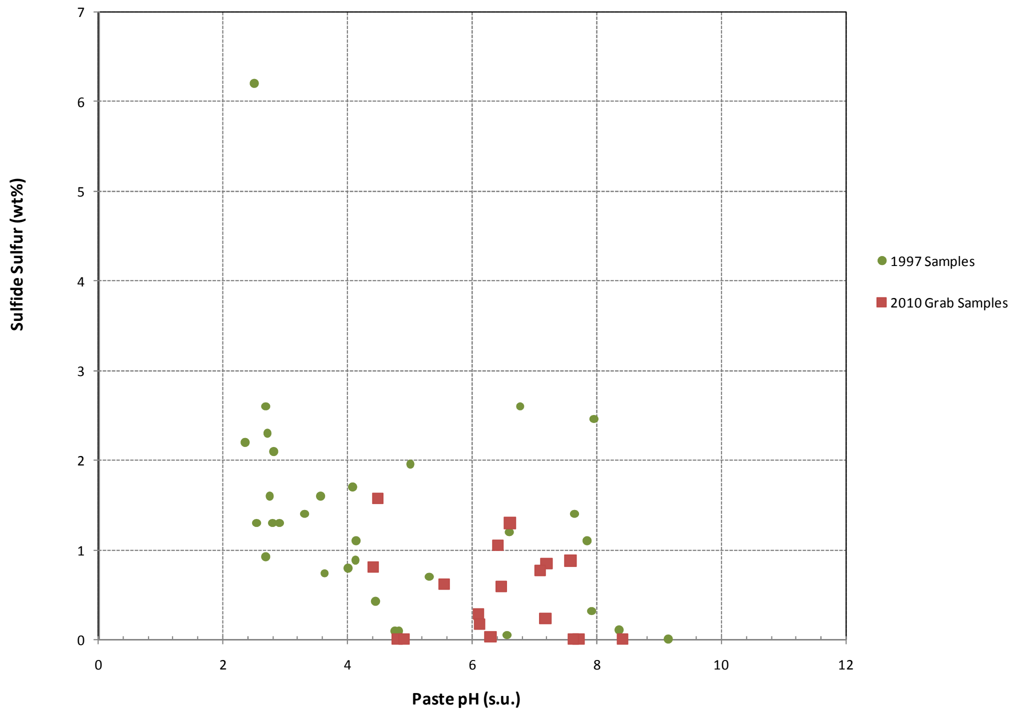

Figure 4: Scatter Plot of Paste pH vs. Sulfide Sulfur Content (grab samples only)

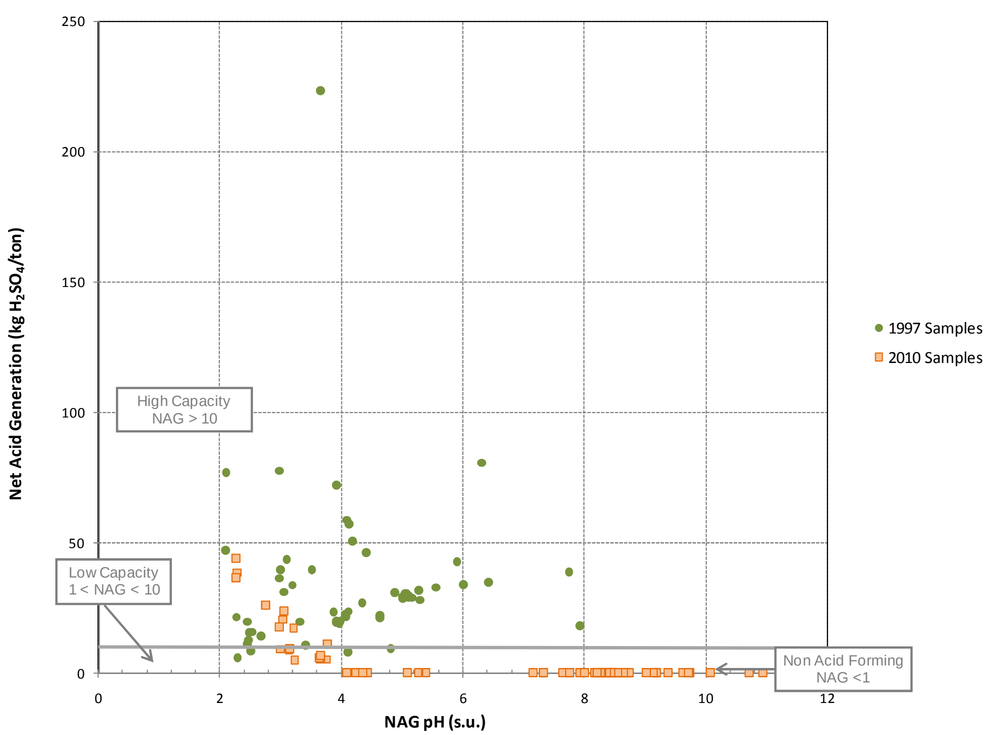

Figure 5: Scatter Plot of NAG pH vs. Net Acid Generation (NAG) value

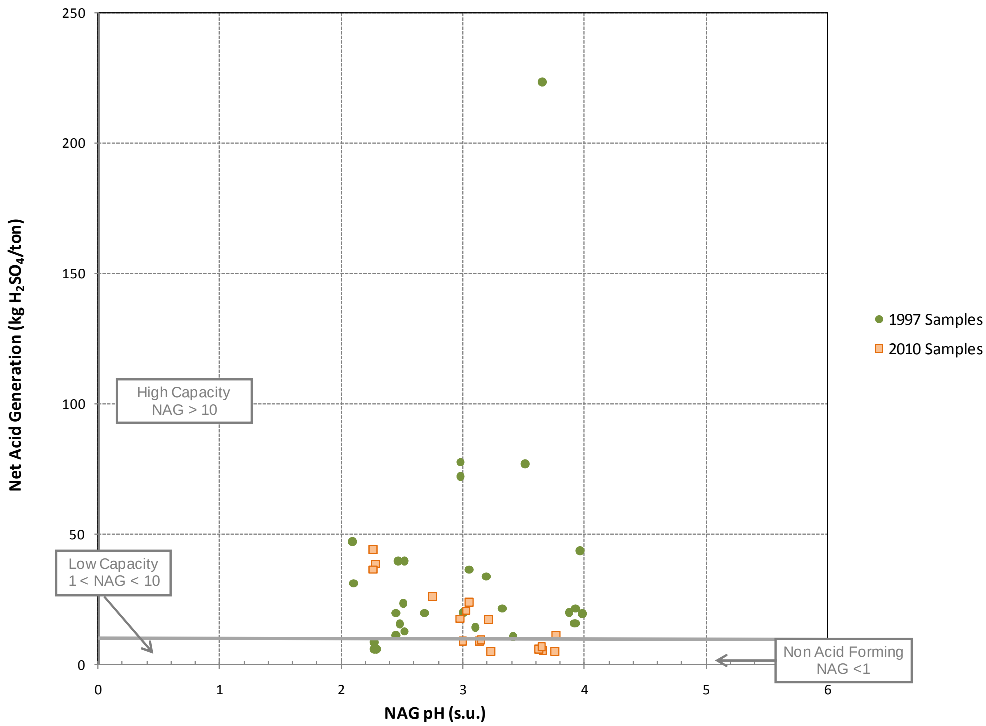

Figure 6: Scatter Plot of NAG pH vs. Net Acid Generation (NAG) value for Samples with NAG pH <4

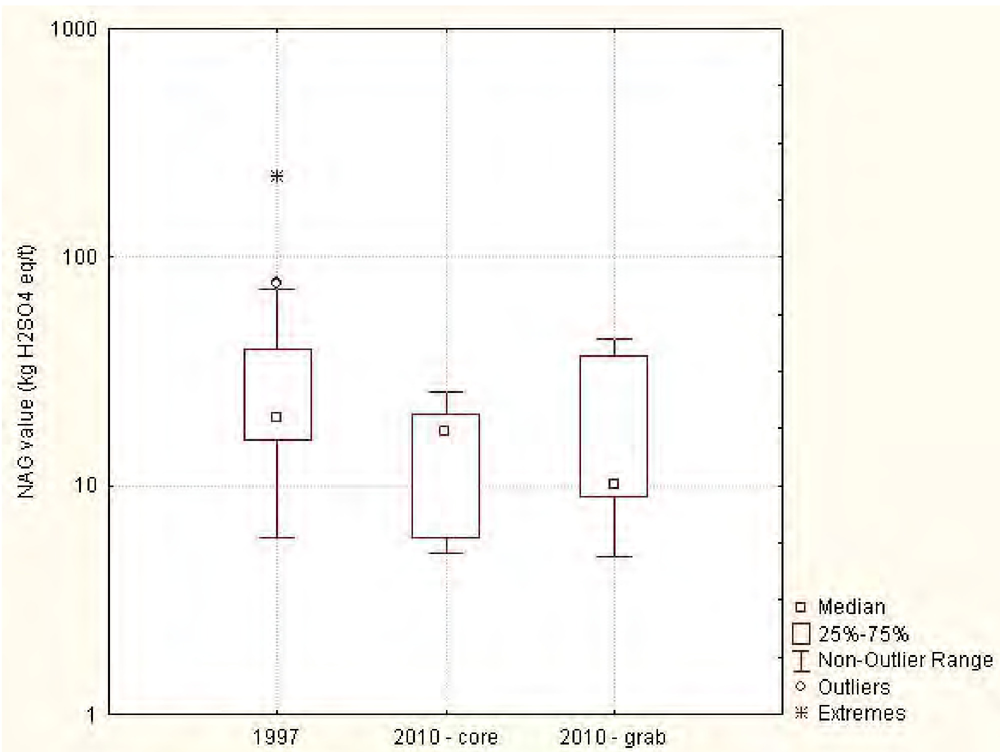

Figure 7: Box and Whisker Plot of NAG value for Samples with NAG pH <4

5 Summary

In general, consideration of both the 1997 and 2010 geochemical databases shows that they are comparable in terms of their geochemical characterization and acid generating potential. However, the samples collected in 1997 show a trend towards having a generally greater acid generating potential, whilst the 2010 dataset contains more samples that show uncertain or non acid forming characteristics. Any significant differences observed between the two datasets are either a function of testwork methodology utilized (in the case of the NAG results) or as a result of the nature of the samples themselves (i.e. grab samples vs. core). Another possible reason for the difference is a bias in the 1997 sample collection (i.e., preferential selection of highest sulfide/weathered materials).

Based on this comparison, the 1997 samples are analogous to waste rock materials that have been exposed to oxygen and water for over 20 years and have developed soluble acidic salts as a result of weathering. Therefore, it is important to incorporate this data into the current investigation in order to capture the range of waste rock behavior associated with the Copper Flat deposit. However, in order to properly utilize these data, the two datasets need to be reconciled with respect to the material type designations. This exercise is currently ongoing.

Appendix 7-F

Copper Flat Kinetic Testwork Update
(SRK July 2011)

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External Memorandum

To:	Steve Raugust	**From:**	Rob Bowell, Amy Prestia, Ruth Warrender
Company:	New Mexico Copper Corporation	**UK Project Number:**	UK03939
Copied to:	Ann Carpenter	**Project Title:**	Copper Flat
File Ref:	*P:\U3939 Copper Flat Scoping Study\Project\Reps\Kinetic testwork\U3939_Copper_Flat_kinetic_test work_update_July_2011_v3.docx*	**Date:**	July 2011
Subject:	**Copper Flat Kinetic Testwork Update**		

Introduction

SRK Consulting 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, New Mexico. This work follows on from the static testwork program previously undertaken by SRK as described in the *Copper Flat Geochemical Characterization Program. Technical Memorandum* submitted on February 7, 2011. As part of the kinetic testwork program, twenty-one samples representative of potential waste rock are currently undergoing humidity cell testing (HCT) at McClelland Laboratories in Sparks, Nevada. These samples were collected from the coarse reject and grab samples to represent the range of ABA and NAG testwork results observed for the primary material types on site. Details of these samples and their material types (comprising of lithology and alteration type) are provided in Table 1. The cells have been operating for a 24-week period, and the purpose of this memorandum is to provide an overview of the test methods and results to week 16 and to provide recommendations for continuation of the kinetic testwork program.

Table 1: Details of HCTs

Lithology	Alteration	Lithology code	Sample ID	Type	Pyritic sulfur	NNP	NPR	NAG pH	Total NAG	MWMP pH	Metals release
Andesite	Propylitic	And - Prop	SRK 0864	Grab	0.01	24.4	81.3	8.29	0	7.18	Low
			SRK 0866	Grab	0.29	12.5	2.37	3.23	4.9	6.92	Low
Breccia	Argillic	Bx - Arg	604811	Core	1.15	-3.9	0.89	8.42	0	8.24	Low
			SRK 0854	Grab	0.88	-21.5	0.22	3.77	10.98	4.54	High
	Biotite	Bx - Bio	604767	Core	2.13	-49.9	0.25	3.21	17.26	7.8	Low
			605033	Core	0.9	1.1	1.04	8.3	0	8.37	Low
	Leach Cap	Bx - LC	SRK 0872	Grab	1.05	-13.0	0.60	3.14	8.82	3.05	Moderate
	Propylitic	Bx - Prop	604862	Core	1.16	3.5	1.10	8.28	0	8.11	Low
			604867	Core	2.34	-46.2	0.37	4.24	0	8.06	Low
	Quartz	Bx - Qtz	604787	Core	0.97	-0.2	0.99	8	0	8.28	Low
	Potassic	Bx - Pot	604854	Core	1.4	-20.6	0.53	5.08	0	8.16	Low
Quartz Monzonite	Argillic	QM - Arg	604562	Core	1.53	-31.6	0.34	7.75	0	8.28	Low
			604606	Core	0.67	2.7	1.13	9.6	0	8.31	Low
	Biotite	QM - Bio	604673	Core	0.41	-5.9	0.54	3.66	5.29	8.33	Low
	Leach Cap	QM - LC	604569	Core	1.05	-14.8	0.55	8.33	0	8.25	Low
			SRK 0867	Grab	0.77	-17.7	0.27	4.35	0	4.84	Moderate
	Potassic	QM - Pot	604669	Core	0.63	-16.5	0.16	4.08	0	8.39	Low
			604653	Core	0.77	2.3	1.10	8.38	0	-	-
	Propylitic	QM - Prop	605153	Core	0.49	26.7	2.75	8.56	0	8.15	Low
	Quartz sericite	QM - QS	SRK 0858	Grab	0.62	-15.3	0.21	3.15	9.22	3.99	Moderate
			604656	Core	0.59	33.4	2.82	8.2	0	8.27	Low

Methods

The kinetic testing method selected for this project is the standard humidity cell test procedure designed to simulate water-rock interactions in order to evaluate the rate of sulfide mineral oxidation and thereby predict acid generation and metals mobility (ASTM D-5744-96). Under ASTM methodology, the test typically runs for a minimum of 20 weeks and follows a seven-day cycle. During the seven-day cycle, water is trickled over the rock for two days. Air that is humidified slightly above room temperature is introduced at the bottom of the column for two days of each cycle followed by two days of dry air. On the seventh day, the sample is rinsed with distilled water and the extracted solution is collected for analysis. Key laboratory parameters including pH, alkalinity, acidity, electrical conductivity, speciated iron and sulfate are measured on a weekly basis by McClelland Laboratories. In addition, the samples are analysed for a full Profile II metals suite at WetLabs (a Nevada certified laboratory) for the first four weeks of the HCT program, after which the frequency of metals analysis is reduced to every fourth week (i.e. weeks 4, 8, 12, 16 …etc).

The HCT results provide an estimate of the rate of leaching of constituents from a material and reflect long-term geochemical behaviour of mine material being exposed to alternating cycles of wetting and drying. The changes in these reaction rates through the course of the test can be used to estimate whether the sample will be net acid generating or net acid neutralizing, and what constituents will be mobilized from the material under long-term weathering and oxidation conditions. As such, HCT results can be used to refine predictions based on static test data.

HCT results can be interpreted as early, middle, and late stage responses. The early stage response is dominated by the chemistry of the first flush of readily soluble minerals and sorbed constituents that are stored in the sample, often the result of geological weathering and formed prior to reaction in the column, which can be easily dissolved and rinsed from the sample. This flush includes secondary minerals that are highly soluble, such as halides and some metal sulfate minerals, as well as desorption of weakly-held species on mineral surfaces. The middle stage response is characterized by a gradual stabilization of dissolution reaction rates of primary mineral phases. For strongly basic or acidic samples, the middle stage response is usually brief, and the late stage response tends to be the same as the middle stage response. The late phase response is characterized by the depletion of available acidic or neutralizing phases, resulting in stabilization of the effluent at either acidic or alkaline pH. The late stage response may occur at any time in the kinetic test cycle and reflects long-term sulfide oxidation, flushing of constituents, and attainment of steady state chemistry with little fluctuation in the release rates. At this point, the cells have characterized the release rate of the material, and the tests can be terminated.

As a general rule, the HCTs reach steady state conditions when constituent concentrations remain constant for more than four consecutive weeks following evidence of sulfide leaching in previous leaching cycles. After the leaching reactions have been adequately characterized in the HCT, the cell is rested for two weeks and rinsed again to determine if significant salt accumulation has occurred during the resting period.

Quality Control

Both McClelland and WetLabs laboratories operate internal QA/QC procedures to ensure adequate data quality. This includes the analysis of certified reference materials in addition to analytical blanks and duplicates. However, SRK also apply a number of QA/QC checks on the received data, including the calculation of ion balances to determine the balance of cations and anions in the solutions, the comparison between electrical conductivity (EC) and total dissolved solids (TDS) and a comparison of pH measurements from both McClelland and WetLabs. The results of the quality control exercise are summarised in Figure 1 to Figure 3, which shows generally good data quality.

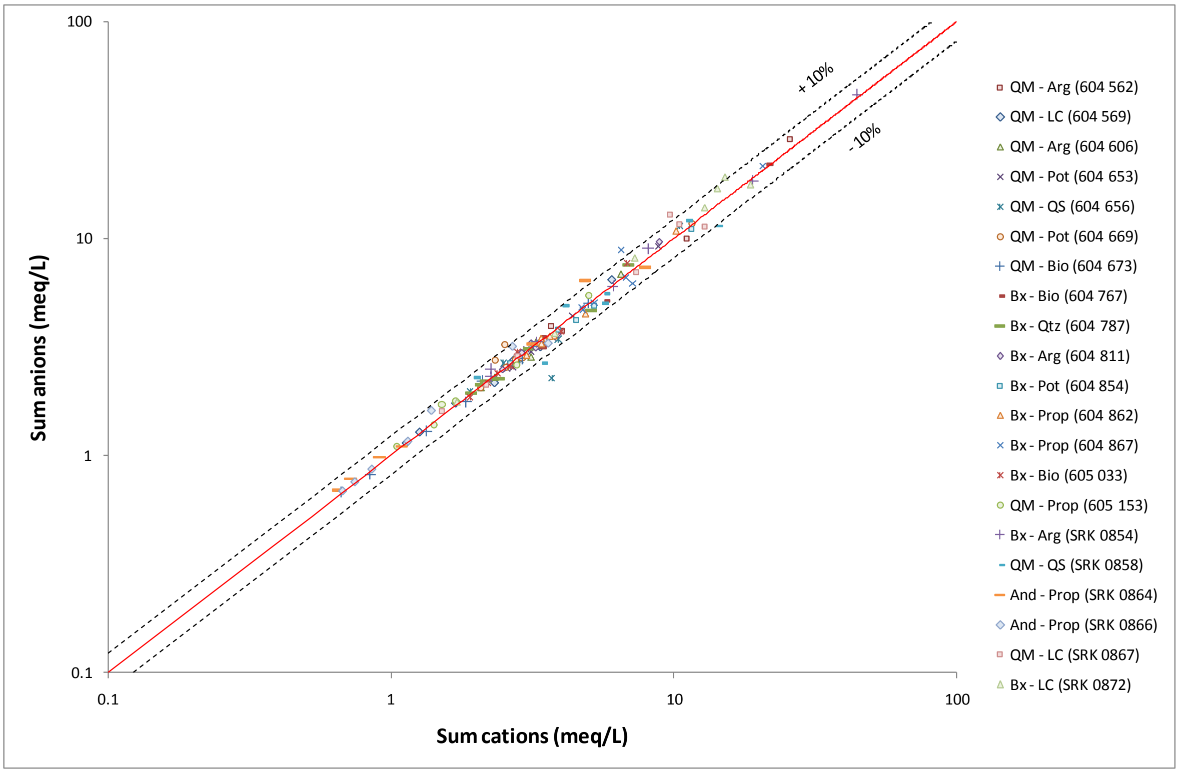

Figure 1: Ion balance plot for the Copper Flat HCTs

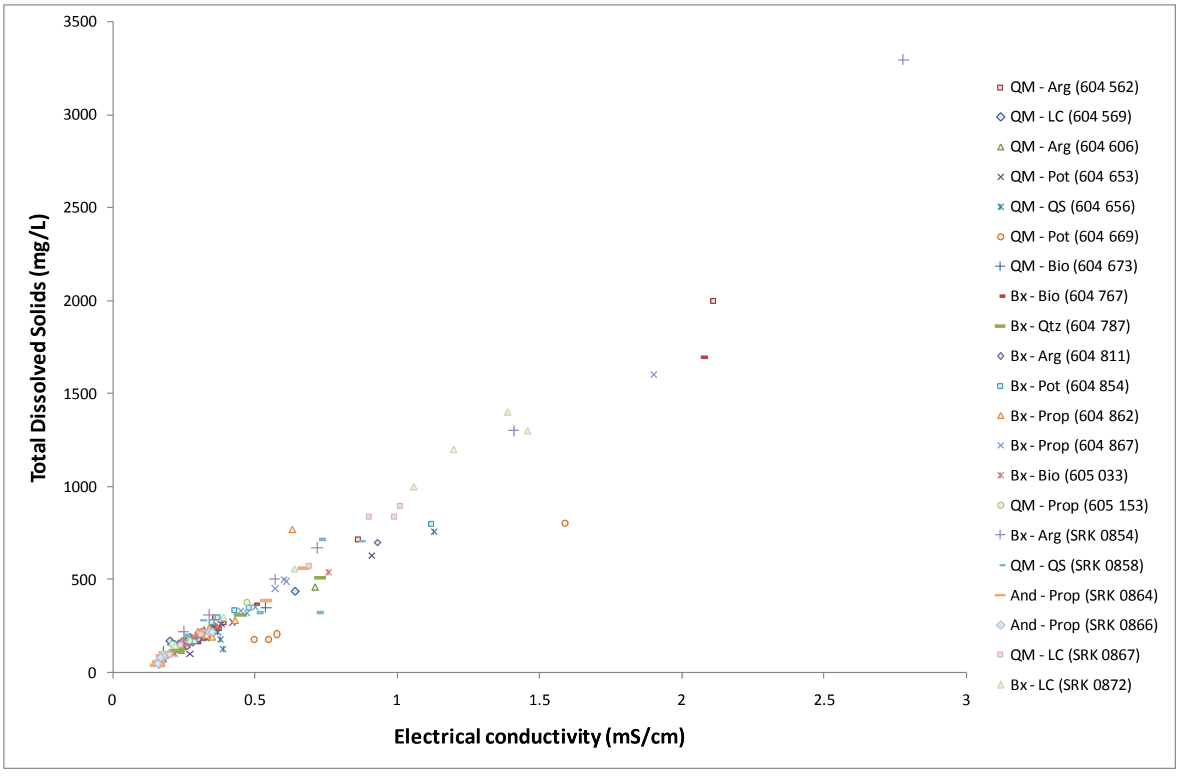

Figure 2: Scatter plot comparing EC vs. TDS

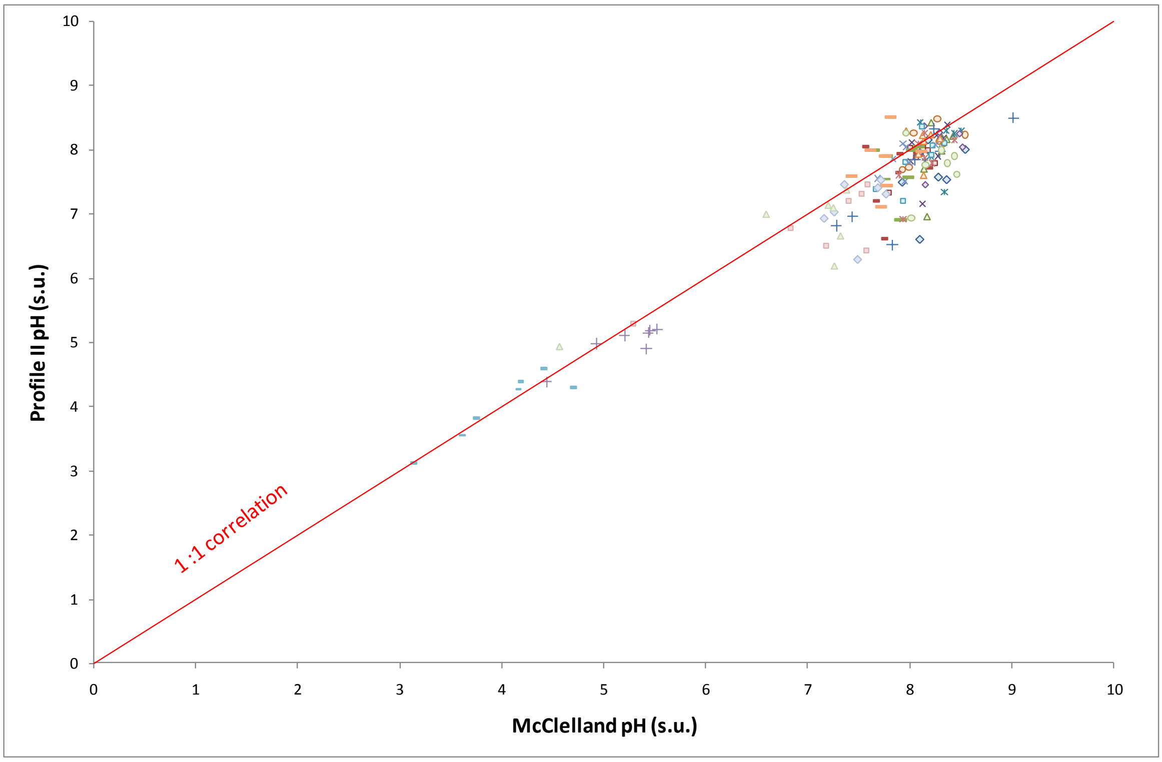

Figure 3: Scatter plot comparing McClelland pH and WetLabs pH

Preliminary Findings

The preliminary findings of the HCT testwork program are outlined in the following section and time-series plots for the main parameters are presented in Figure 4 to Figure 14.

The trends in effluent pH for each of the cells are presented in Figure 4. This demonstrates that the majority of cells are producing circum-neutral pH leachates (pH 7 to 8.5) up to week 17, with effluent pH remaining relatively stable throughout this period. However cells SRK 0858 (QM-QS) and SRK 0854 (Bx-Arg) have both produced acidic leachates (pH 3 to 5) since week zero, which is likely to reflect the fact that material in these cells was from surface grab samples that were noted as having secondary copper sulfate salts on the material surface. These salts are likely to be readily-soluble and flushing during the leach cycle may generate acidic leachates and likely result in elevated sulfate and metals release. Indeed Figure 5 and Figure 8 show that cell SRK 0854 (Bx-Arg – collected from the Sternberg lode) shows particularly elevated sulfate and copper release, with up to 1043 mg/kg and 376 mg/kg release, respectively at week zero. Observations made during the field sampling program show that material within the Sternberg lode has significant chalcanthite ($Cu^{2+}SO_4.5H_2O$) on the material surface. Dissolution of this mineral during the HCT leach cycles is thus likely to be generating the low pH and elevated metals concentrations observed in the resulting leachate from this cell.

The leachates from most cells show elevated electrical conductivity (EC) during the first five weeks of testing, which corresponds to an initial flush of sulfate from the cells. However, iron release was below analytical detection limits from the majority of samples (Figure 7), indicating that the initial flush in sulfate concentrations is not related to sulfide oxidation but rather to the flushing of readily-soluble sulfate salts from the material surface. In contrast, the increase in effluent iron and sulfate concentrations in cell SRK 0858 (QM-QS) after week nine indicate the onset of sulfide oxidation in this cell. This is supported by the corresponding drop in pH and increase in effluent metal concentrations.

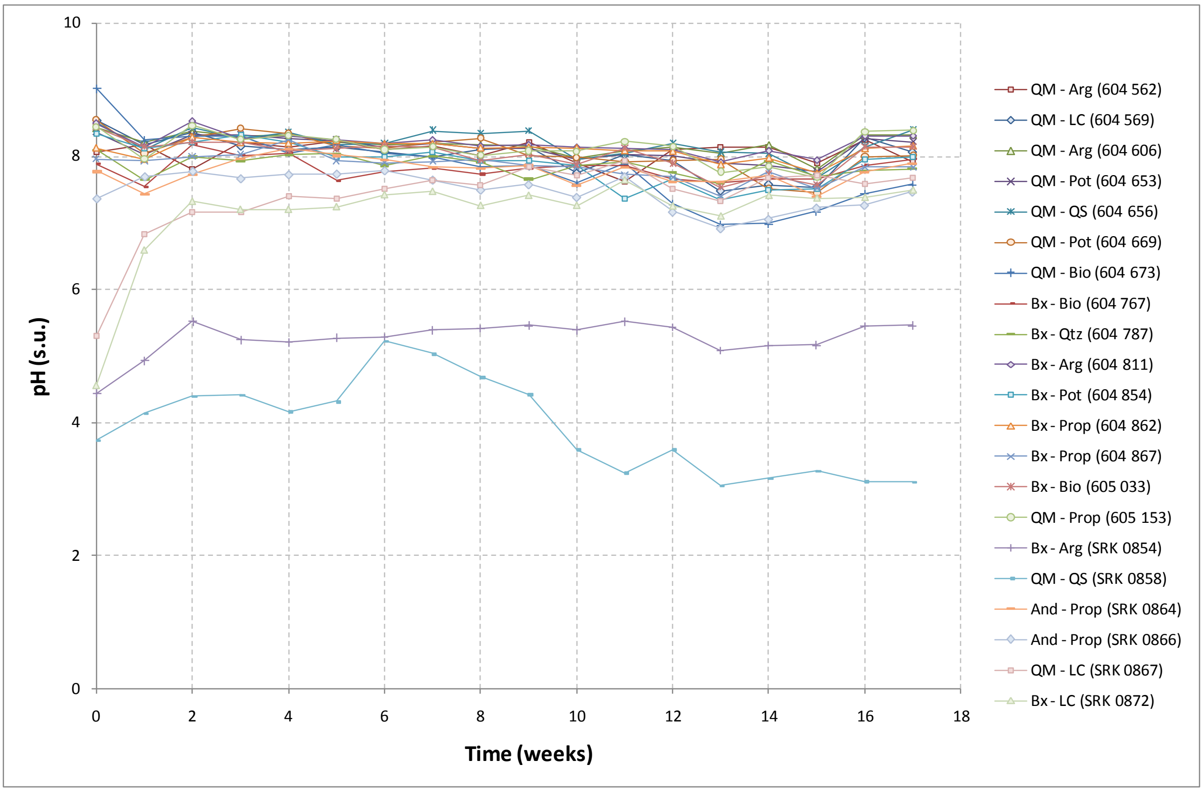

Figure 4: HCT effluent pH

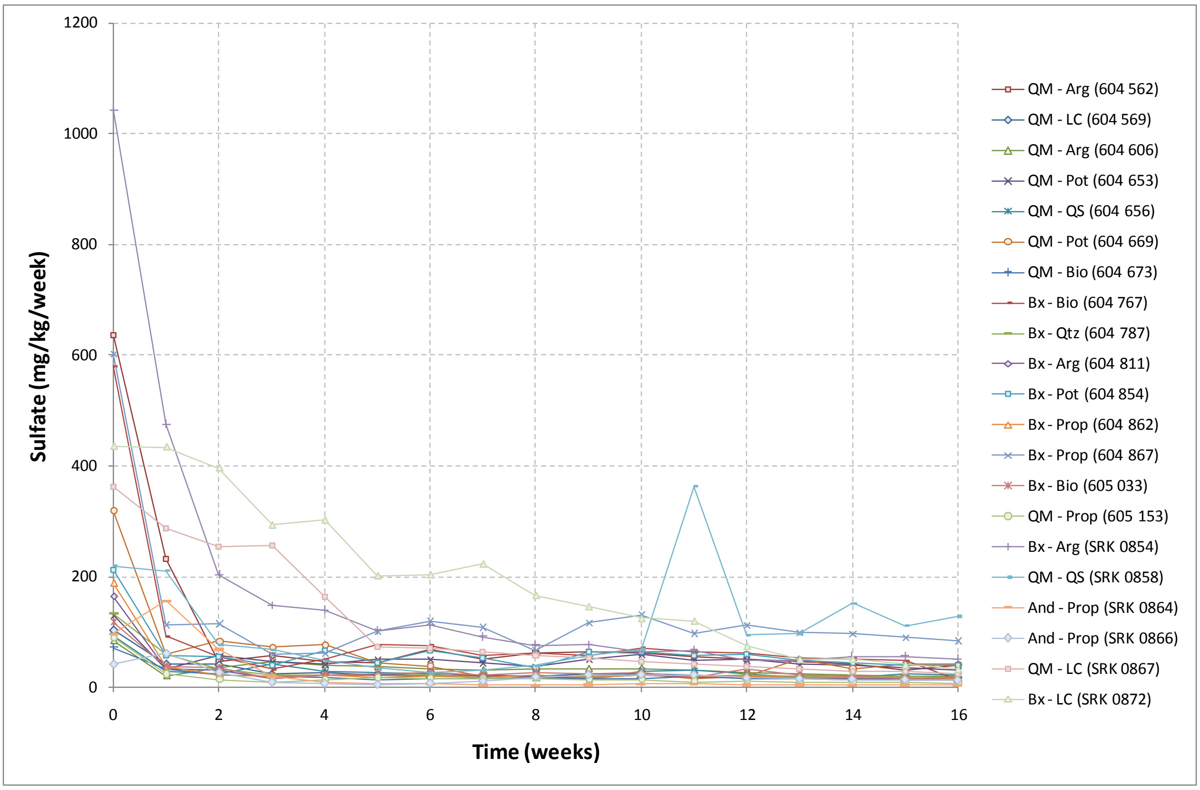

Figure 5: HCT effluent sulfate

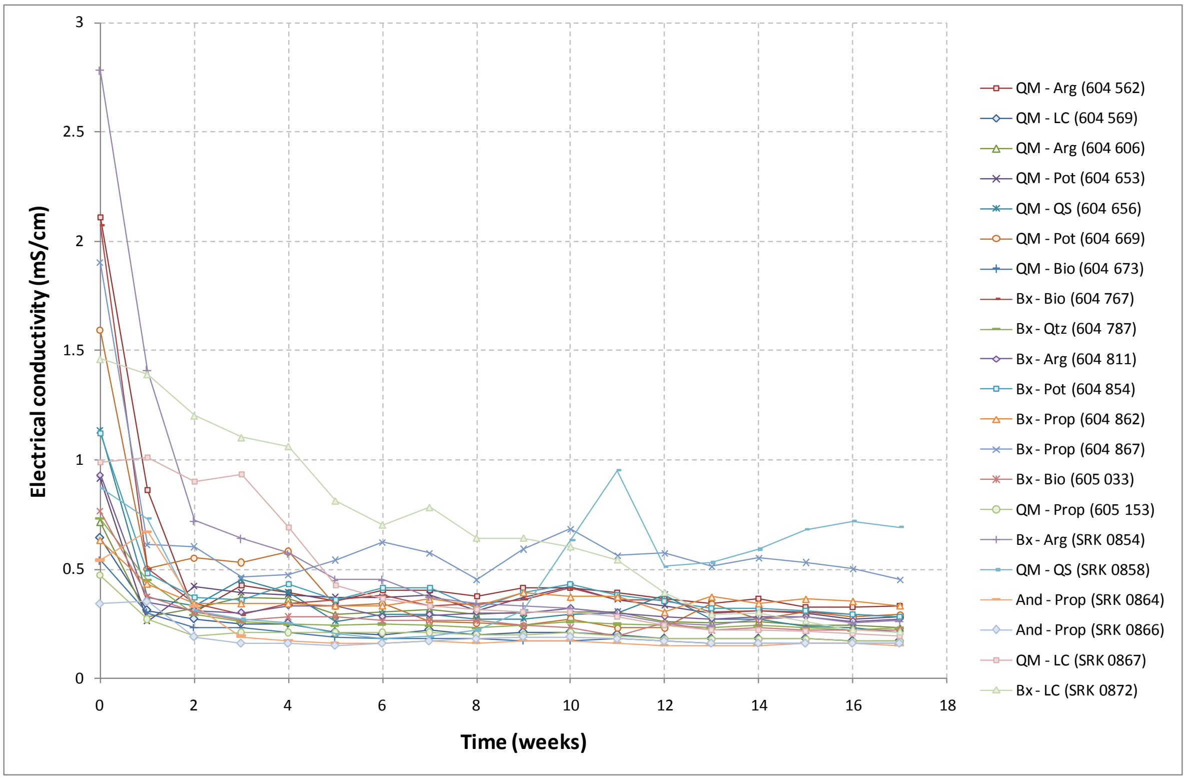

Figure 6: HCT effluent EC

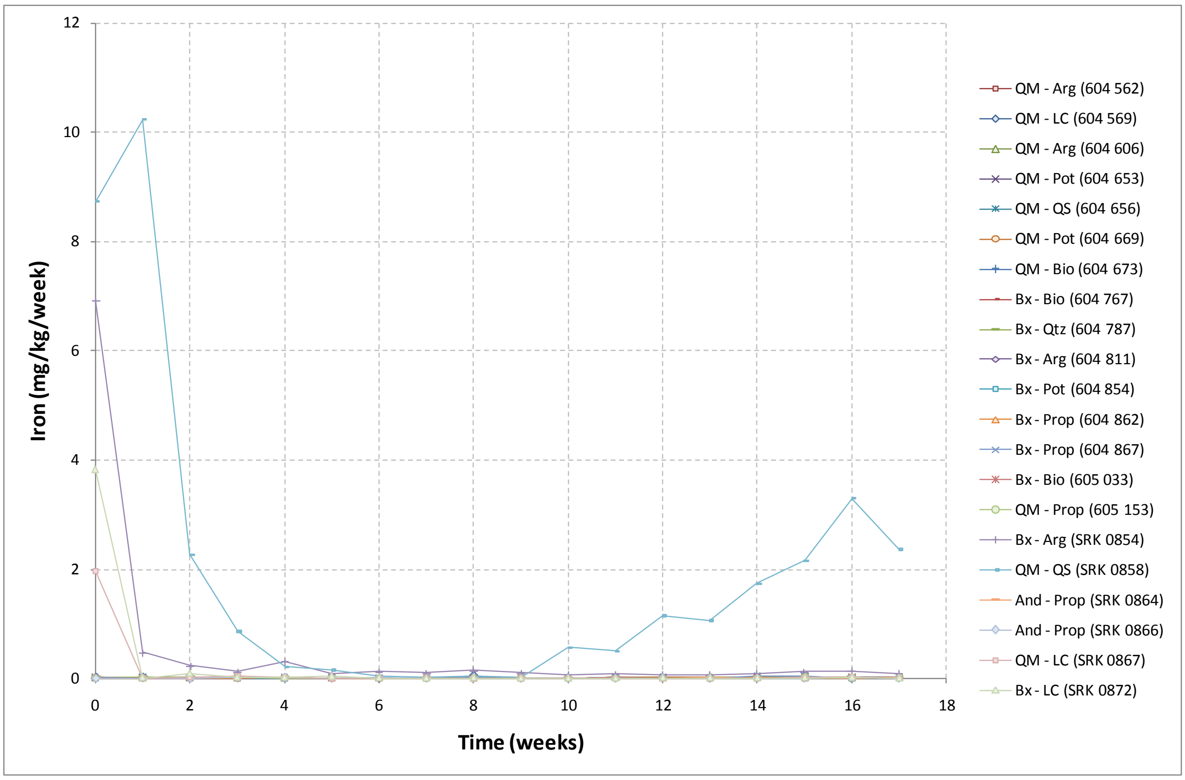

Figure 7: HCT effluent iron

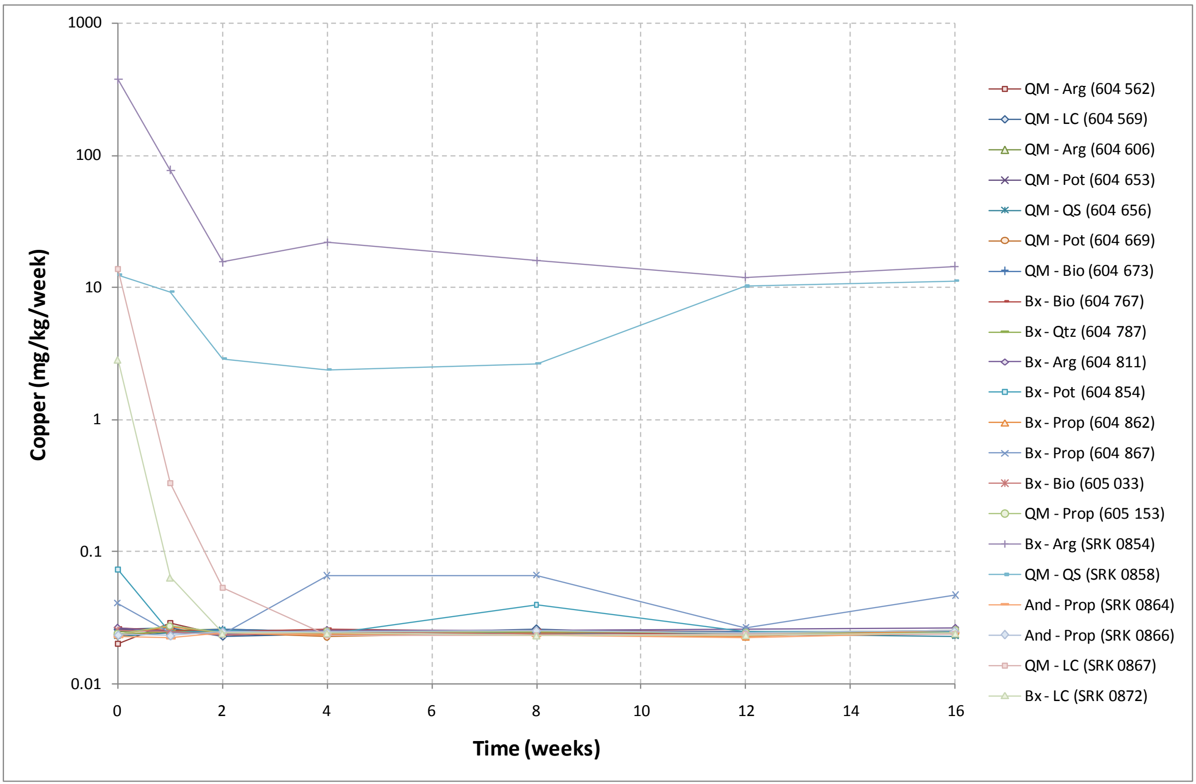

Figure 8: HCT effluent copper

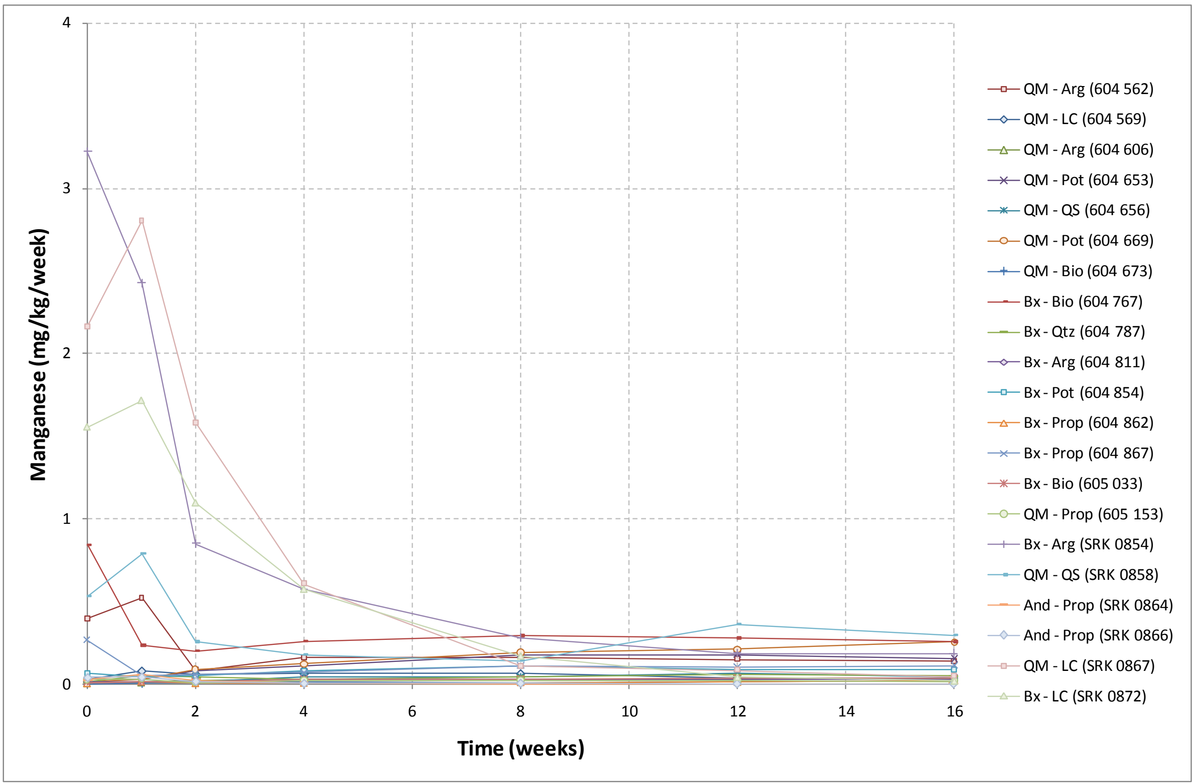

Figure 9: HCT effluent manganese

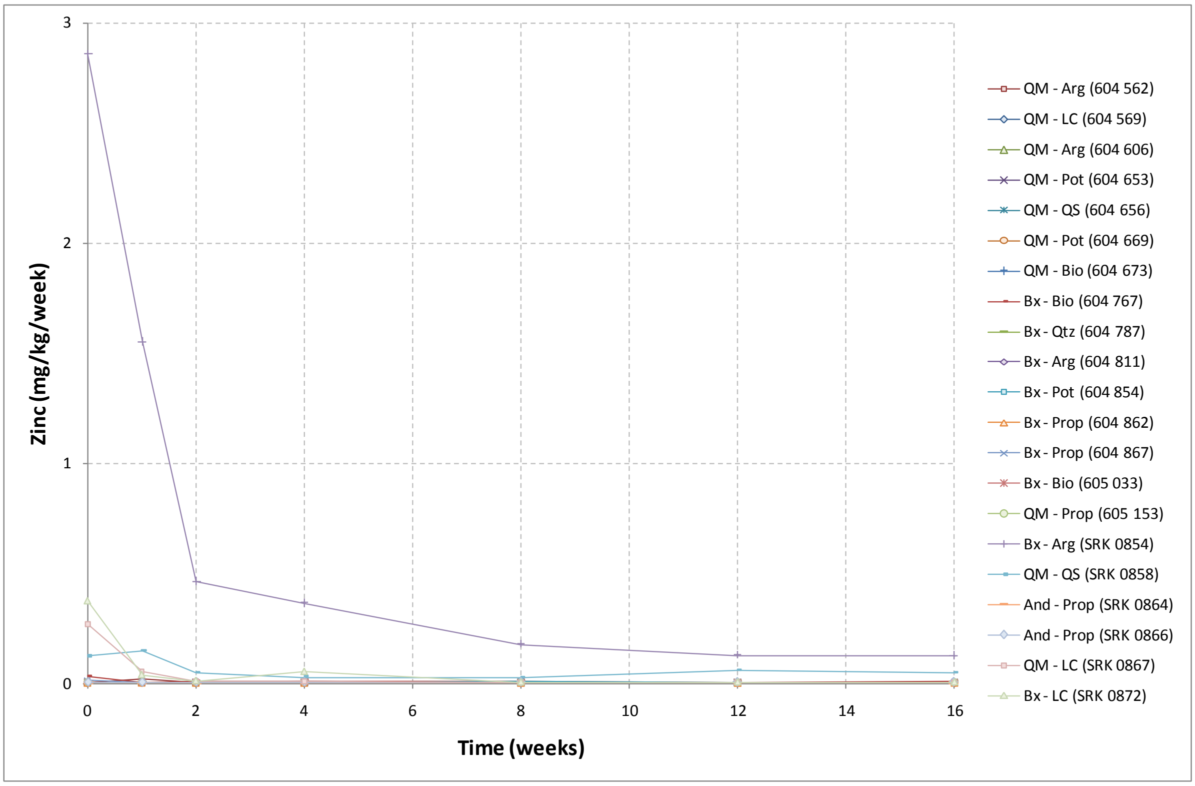

Figure 10: HCT effluent zinc

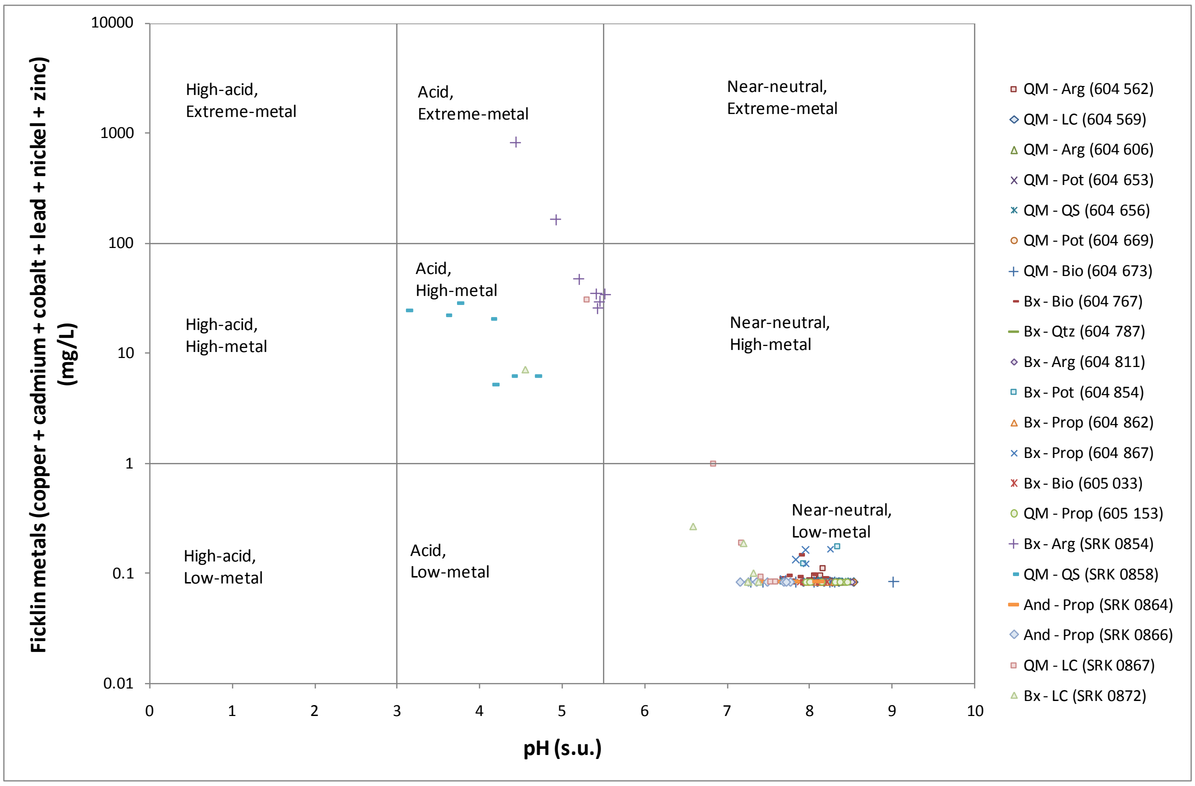

Figure 11: Ficklin plot

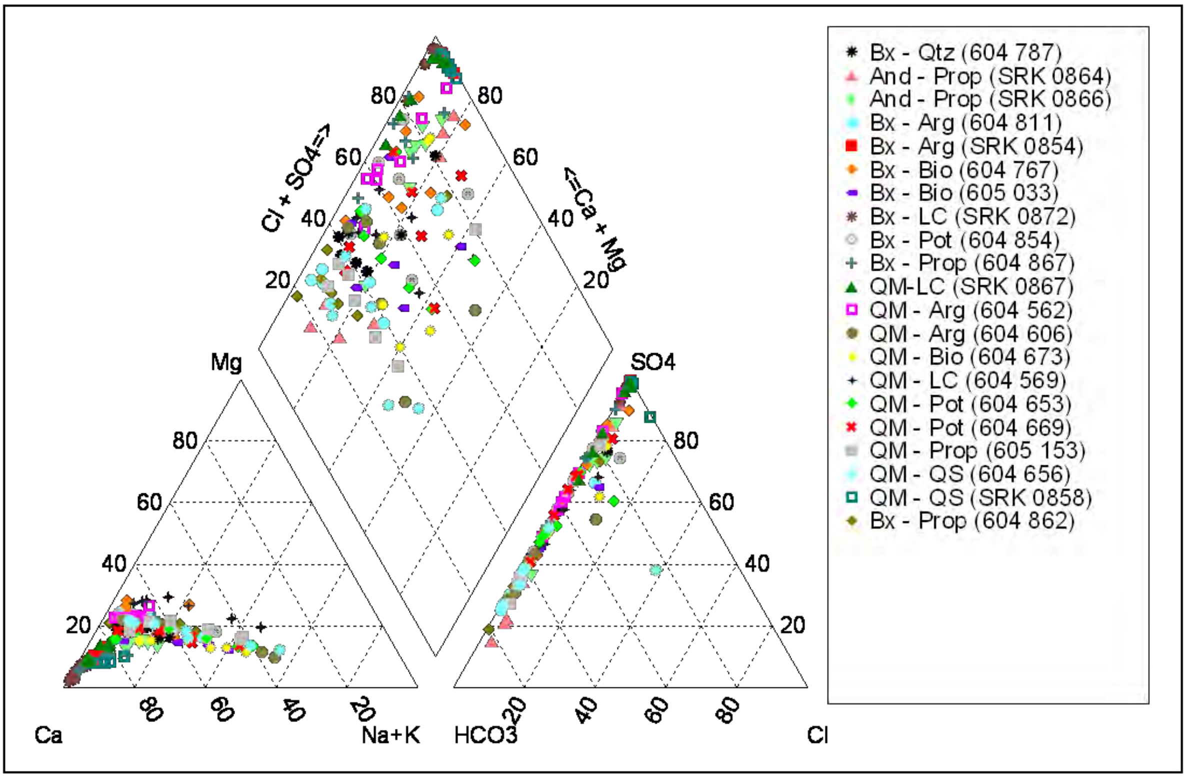

Figure 12: Piper plot

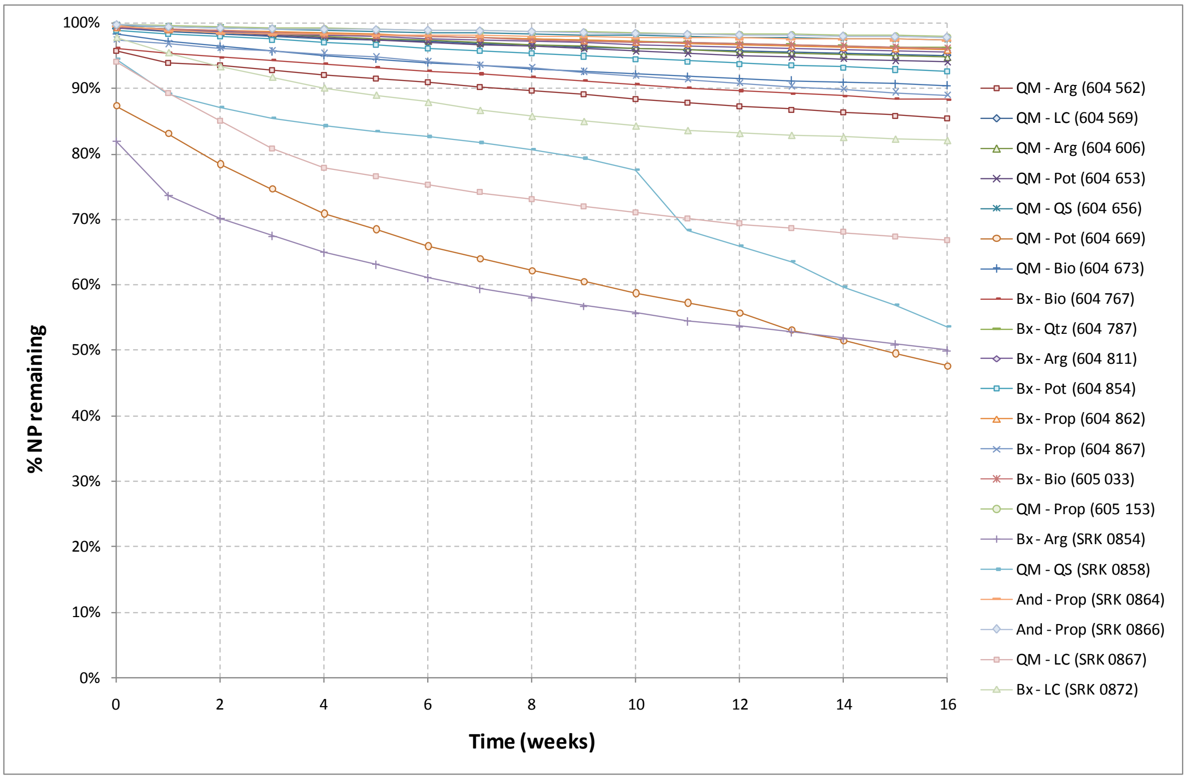

Figure 13: Plot of % neutralization potential (NP) remaining

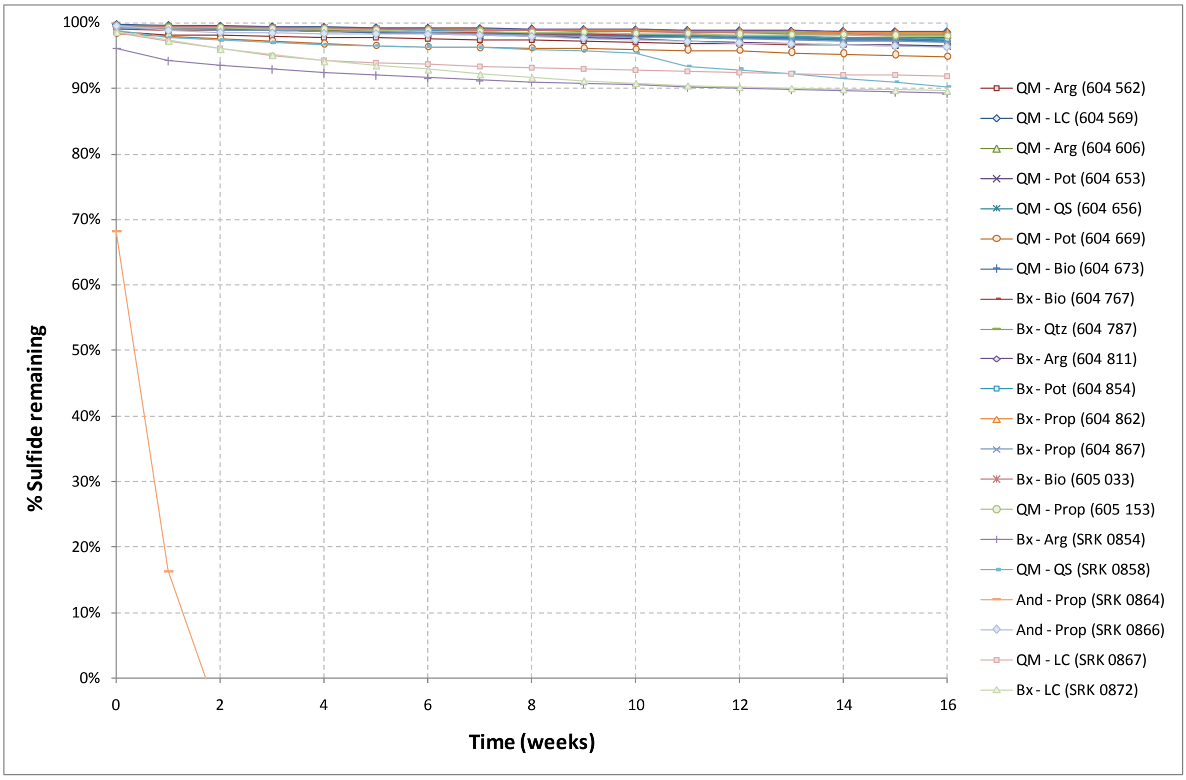

Figure 14: Plot of % sulfide remaining

Metal release from the drill core samples was generally low, with many parameters being at or near analytical detection limits in the leachates (including aluminium, arsenic, cadmium, chromium and copper). Metal release from the grab samples was generally slightly higher, with detectable release of zinc, copper, manganese and molybdenum, particularly in the first 5 weeks of testwork. Again, this is likely to represent the flushing of soluble acid sulfate salts from the material surface, which lowers the pH and increases the solubility of base metal ions. This is supported by the Ficklin plot presented in Figure 11, which shows that leachates from the majority of cells can be classed as near-neutral, low-metal waters based on effluent pH greater than 5.5 s.u. and Ficklin metal concentrations less than 1 mg/L. However, leachates from cells SRK 0854 (Bx-Arg) and SRK 0858 (QM-QS) can be classed as acid, high-metal waters based on Ficklin metal concentrations up to 837 mg/L.

The Piper plot presented in Figure 12 shows that the leachates from most cells can be classed as calcium + sulfate (Ca + SO_4) type waters, with calcium representing the major cation in solution and sulfate the major anion. However, leachates from cells containing propylitically-altered material are predominantly calcium + bicarbonate (Ca + HCO_3) type waters, which reflects the alteration style (primarily epidote – $Ca_2(Al_2Fe^{3+})Si_3O_{12}(OH)$).

Figure 13 shows that there has been a gradual depletion of neutralizing potential (NP) in the HCT cells over the course of the testwork period, with only four cells showing consumption of more than 20 percent of available buffering capacity after 16 weeks of testing. This indicates that significant buffering is still available in the other cells. However, it should also be noted that most cells also have greater than 90% sulfide remaining after 16 weeks (Figure 14), indicating that there is still potential for acid generation in the cells. The most rapid depletion of NP occurs in cells SRK 0854 (Bx-Arg), SRK 0858 (QM-QS), SRK 0867 (QM-LC) and 604669 (QM-Pot), which have between 45 and 70% of NP remaining after 16 weeks. This rapid NP consumption is likely to be related to the low initial NP (less than 6 kg $CaCO_3$ eq/t) in these samples.

Comparison with Static Testwork Results

A comparison of the static test results with the corresponding HCT results provides an indication of the effectiveness of the static tests in predicting longer term behaviour (see Table 2). As shown in Table 2 the results of the HCT tests to date are not consistent with the prediction of acid generation based on ABA results. However, the correlation between the HCT results and the acid generation prediction from the NAG results shows a better correlation and indicates the NAG test is more effective in predicting the acid generating potential of waste rock material. The discrepancy between ABA and NAG/HCT results indicates that there may be some silicate buffering capacity in the Copper Flat material types. Although this silicate buffering potential is unlikely to be high magnitude, it may initially modify/buffer pH if present in a reactive form (e.g. Nesbit and Jambor, 1998)[1]. It should be stressed that the HCT predictions in Table 2 are preliminary and may not reflect the long term behaviour of the material. Those cells predicted to be acid generating from the ABA and NAG tests may eventually develop acidic conditions as the HCT testing continues and the neutralization capacity of the cells is consumed. This is supported by the two grab samples collected from the surface of the waste rock dumps that have been exposed to water and oxygen. These samples show generally lower pH and higher metals release, which is related to the flushing of readily-soluble secondary salts from the material surfaces. These results suggest that as the Copper Flat waste rock material weathers and sulfide minerals oxidise, the potential for acid generation and metal mobility increases.

Table 2: Comparison of HCT results with static testwork results

Lithology	Alteration	Lithology code	Cell ID	Acid Generation Prediction*		
				ABA	NAG	HCT
Andesite	Propylitic	And - Prop	SRK 0864	NAF	NAF	NAF
			SRK 0866	NAF	PAF	NAF
Breccia	Argillic	Bx - Arg	604811	PAF	NAF	NAF
			SRK 0854	PAF	PAF	PAF
	Biotite	Bx - Bio	604767	PAF	PAF	NAF
			605033	NAF	NAF	NAF
	Leach Cap	Bx - LC	SRK 0872	PAF	PAF	NAF
	Propylitic	Bx - Prop	604862	NAF	NAF	NAF
			604867	PAF	NAF	NAF
	Quartz	Bx - Qtz	604787	PAF	NAF	NAF
	Potassic	Bx - Pot	604854	PAF	NAF	NAF
Quartz Monzonite	Argillic	QM - Arg	604562	PAF	NAF	NAF
			604606	NAF	NAF	NAF
	Biotite	QM - Bio	604673	PAF	PAF	NAF
	Leach Cap	QM - LC	604569	PAF	NAF	NAF
			SRK 0867	PAF	NAF	NAF
	Potassic	QM - Pot	604669	PAF	NAF	NAF
			604653	NAF	NAF	NAF
	Propylitic	QM - Prop	605153	NAF	NAF	NAF
	Quartz sericite	QM - QS	SRK 0858	PAF	PAF	PAF
			604656	NAF	NAF	NAF

* **PAF** = Potentially Acid Forming; **NAF** = Non Acid Forming

[1] Nesbitt, H.W. and Jambor, J.L. (2008). Role of mafic minerals in neutralizing ARD, demonstrated using a chemical weathering methodology. In: L.J. Cabri and D.J. Vaughan (eds) Modern Approaches to Ore and Environmental Mineralogy. Mineralogical Association of Canada Short Course Volume 27, pp403-421

Conclusions and Recommendations

Based on the first 16 weeks of HCT data, the ARDML behaviour of the Copper Flat materials appears to be related not to lithology or alteration style, but rather to the extent of weathering prior to sample collection. The relatively ‘fresh’ drill core samples are currently generating circum-neutral pH leachates and show minimal metals release. There is also no evidence of the onset of sulfide oxidation in these cells up to week 16. In contrast, the oxidised grab samples collected from the surface show generally lower pH and higher metals release, which is related to the flushing of readily-soluble secondary salts from the material surfaces. This implies that exposure of materials as a result of mining (and subsequent oxidation) may result in the generation of acidic, metal-rich leachates over time. However, the rate of sulfide oxidation is likely to be slow.

The ASTM Procedure for humidity cell tests (ASTM, 1996) calls for a minimum test duration of 20 weeks. However, there is no technical basis for this recommendation and in most cases with sulfide bearing materials, 20 weeks is insufficient to allow complete reaction of the sample material and some samples may take 60 weeks or more to stabilize (Price, 1997). Essentially, there is no established criteria for the termination of kinetic tests, rather the point at which HCTs should be terminated is project specific and will be determined by the physical and chemical characteristics of the samples and the objectives of the test (Mills, 1998).

The main objectives of the Copper Flat kinetic test program are to provide a prediction of acid generation potential of the samples and predict the rate of leaching of constituents under the accelerated test conditions. Geochemical reactions and reaction rates monitored throughout the testing include sulfide oxidation, depletion of neutralization potential, and mineral dissolution (INAP, 2010). The HCTs should be executed until the majority of the mineral reactions that can be predicted from mineralogy or static testing have been observed. This endpoint can be assessed by monitoring the release rates of key constituents such as pH, sulfate, acidity, alkalinity and iron as well as dissolved metals and metalloids. It is common practice to terminate cells when the release rates for these leachate parameters become relatively constant with time and there is no substantial change in the calculated release rate (INAP, 2010).

Based on the findings of the humidity cell testwork program to date, SRK recommend that all cells are continued beyond 20 weeks for a number of reasons including:

- mineral reactions are still taking place and the cells have not yet reached steady-state;
- only one cell has shown evidence of the onset of sulfide oxidation despite static test predictions that indicate some of the samples have a potential to generate acid;
- there is still considerable sulfide remaining in the material and sulfide oxidation may still be initiated.

Continuation of the cells beyond 20 weeks will provide a better understanding of the expected long term leachate water quality for the Copper Flat deposit. Based on the results reviewed to date, the HCTs will likely need to run for a minimum of 40 weeks to provide qualified meaningful data that can be used to define and quantify rates of metal release from the material types and can be used to develop source terms for geochemical prediction modelling using the USGS program PHREEQC. This modelling exercise will use site-specific knowledge about hydrology, climate, hydrogeology, topography and engineering in order to allow prediction of future water quality in the pit lake and waste rock dump run-off.

Appendix 8-A

Surface Water and Seepage Measurement Location Field Data

Appendix 8-A. Surface Water and Seepage Measurement Location Field Data

Sample ID	Collection Date	Temp. (deg. C)	pH	Spec. Conductance (µg/cm)	DO percent	DO total	Flow or Q (ft^3/s)
CSCS-B	8/25/2010	19.1	7.33	647	20.1	1.88	0.150
	11/4/2010	16.2	7.35	678	16.4	1.62	0.022
	1/20/2011	15.3	7.56	670	40.5	4.06	0.002
	4/19/2011	16.1	7.34	701	38.1	3.75	0.002
CSCS-C	8/25/2010	26.8	7.12	105	60.8	4.84	
	11/5/2010	12.0	7.3	386	10.9	1.16	
LAC-1	6/28/2011	17.9	6.88	442	32.6	3.07	0.212
LAC-2	6/28/2011	19.4	7.37	439	81.4	7.47	0.369
LAC-3	6/28/2011	21.8	8.22	420	110.1	9.63	0.051
LAC-4	6/28/2011	26.4	8.46	380	125.8	10.12	0.023
LAC-5	6/28/2011	27.9	7.73	469	118.2	9.23	0.018
LAC-6	6/28/2011	29.5	8.4	454	123.3	9.4	0.021
LAC-A	8/24/2010	21.5	8.39	227	89.3	7.88	
	8/31/2010	23.1	8.24	255	92.2	7.89	5.186
	11/3/2010	13.9	8.44	318	99.1	10.24	0.993
	1/18/2011						1.054
	4/26/2011	19.8	8.5	345	110.0	10.13	0.035
LAC-B	8/24/2010	21.4	8.32	265	87.3	7.72	
	8/31/2010	21.3	8.08	317	95.4	8.45	6.732
	11/3/2010	21.1	8.25	491	92.2	8.19	0.617
	1/18/2011						3.821
	4/26/2011	23.8	8.27	625	95.5	8.05	1.218
LAC-C	8/23/2010	25.1	8.09	310	85.3	7.02	
	8/30/2010						3.327
	8/31/2010	23.1	7.82	357	100.3	8.55	
	11/3/2010	18.1	7.85	387	81.7	7.69	0.831
	1/18/2011	18.0	7.61	380	95.6	9.04	0.633
	4/26/2011	20.2	8.02	458	121.6	11	0.628
LAC-D	8/24/2010	19.0	8.24	386	87.3	6.1	
	8/30/2010	23.4	7.6	411	68.2	5.8	1.438
	11/4/2010	14.8	8.38	437	82.9	8.39	1.296
	1/18/2011						0.665
	4/25/2011	27.0	8.83	363	98.9	7.87	0.125

Appendix 8-A. Surface Water and Seepage Measurement Location Field Data

Sample ID	Collection Date	Temp. (deg. C)	pH	Spec. Conductance (µg/cm)	DO percent	DO total	Flow or Q (ft^3/s)
LAC-E	8/20/2010	23.9	8.1	335	85.5	7.2	
	11/10/2010	16.3	8.08	453	88.7	8.68	2.218
	1/19/2011	13.3	8.34	431	93.4	9.77	0.945
	4/27/2011	18.0	8.67	436	91.7	8.4	1.055
NWS	8/24/2010	27.8	7.62	633	43.5	3.41	
	8/31/2010	27.9	7.6	618	49.3	3.86	1.100
	11/3/2010	27.9	7.49	610	41.9	3.28	0.731
	1/18/2011						1.093
	4/26/2011	27.9	7.56	701	42.6	3.33	0.899
PC-1	6/29/2011	23.5	7.56	607	58.1	4.92	0.241
PC-2	6/29/2011	23.4	8.19	602	94.4	8.01	0.18
PC-3	6/29/2011	23.4	8.29	602	105.8	9.16	0.134
PC-4	6/29/2011	27.1	8.29	577	95.0	7.69	0.186
PC-5	6/29/2011	27.9	8.51	564	133.2	10.45	0.010
PC-6	6/29/2011	24.2	7.61	535	58.2	4.87	0.662
PC-7	6/29/2011	25.5	8.02	540	97.6	7.98	0.879
PC-8	6/29/2011	31.9	8.84	424	158.9	11.65	0.058
PC-9	6/29/2011	26.4	8.57	506	149.2	11.99	0.156
PC-10	6/29/2011	27.7	8.66	476	122.0	9.58	0.037
PC-11	6/30/2011	19.9	7.66	540	79.3	7.2	0.148
PC-12	6/30/2011	25.7	8.24	484	129.5	10.53	0.228
PC-13	6/30/2011	25.8	8.61	437	134.5	10.92	0.076
PC-14	6/30/2011	21.2	7.93	538	91.9	8.08	0.330
PC-15	6/30/2011	24.0	8.14	527	101.6	8.53	0.337
PC-16	6/30/2011	25.6	8.54	486	131.8	10.74	0.024
PC-A	8/24/2010	21.2	8.25	551	94.8	8.41	
	8/27/2010						2.803
	11/8/2010	14.9	8.13	502	92.1	9.25	0.062
	1/26/2011	11.3	8.36	443	78.4	8.53	0.146
	4/20/2011	18.3	8.44	525	86.7	8.15	0.026
PC-B	8/26/2010	29.0	8.36	463	79.2	6.08	4.436
	11/8/2010	15.8	8.11	575	75.2	7.43	0.002

Appendix 8-A. Surface Water and Seepage Measurement Location Field Data

Sample ID	Collection Date	Temp. (deg. C)	pH	Spec. Conductance (µg/cm)	DO percent	DO total	Flow or Q (ft^3/s)
PC-C	8/26/2010	23.8	8.54	473	81.3	6.84	7.447
	11/9/2010	13.9	8.35	581	87.0	8.97	0.422
	1/25/2011	9.4	8.25	591	82.1	9.38	0.294
	4/20/2011	22.3	8.46	572	89.6	7.82	0.325
PC-D	8/27/2010	19.1	8.34	495	71.1	6.57	5.45
	11/9/2010	18.8	8.31	507	90.9	8.48	0.43
	1/25/2011	15.4	8.38	520	98.0	9.81	0.509
	4/21/2011	15.8	8.2	531	95.2	9.38	0.313
PCS-A	8/26/2010	24.3	7.93	541	47.6	3.98	0.639
	11/9/2010	24.3	7.53	542	53.0	4.42	0.410
	1/25/2011	24.3	7.62	545	50.2	4.2	0.412
	4/28/2011	24.3	7.41	539	54.5	4.55	0.437
SWQ-2	8/25/2010	27.5	9.32	78	155.7	12.32	
SWQ-3	1/27/2011	9.7	7.81	3868	108.2	12.15	
WS	8/25/2010	33.7	8.05	762	75.1	5.72	0.006
	11/4/2010	24.6	7.67	760	39.2	3.26	0.003
	1/20/2011	21.1	7.9	728	54.3	4.81	0.748
	4/19/2011	24.7	7.96	774	59.3	4.92	0.002
WSCS-A	8/25/2010	21.5	8.56	517	61.4	5.41	
	1/20/2011	5.9	7.84	1448	67.2	8.38	

Notes:
deg. C = degrees Celsius
DO = dissolved oxygen
µS/cm = micro Siemens per centimeter
ft^3/s = cubic feet per second

Appendix 8-B

Seepage Study Report

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August 25, 2011

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RE: Seepage Investigation Report for Portions of Las Animas and Percha Creeks, Sierra County, New Mexico

This letter report summarizes the field work completed by INTERA Incorporated (INTERA) to collect seepage flow measurements along Las Animas Creek and Percha Creek in support of the Copper Flat Mine Project. The objective of the work is to gain a better understanding of the surface water hydrology for specific reaches of each creek and of surface water-groundwater interactions. These data will complement the development and application of a groundwater-flow model to assess potential impacts to water resources from groundwater withdrawals associated with proposed mining activity.

Background

The Copper Flat Mine and the project area defined for this investigation (Figure 1) are located within the Lower Rio Grande watershed, as defined by the New Mexico Water Quality Control Commission (WQCC). Two creeks, Las Animas to the north and Percha to the south, drain the area around the proposed mine permit boundary (Figure 1). Las Animas and Percha Creeks both have ephemeral, intermittent, and perennial reaches. Las Animas Creek varies from perennial at surface water sample location LAC-A to intermittent approximately 13 miles downstream, near seepage measurement LAC-6, and is considered ephemeral to Caballo Reservoir, approximately five more miles downstream. Percha Creek flow varies from intermittent at surface water sample location PC-A to perennial from seepage measurement location PC-1 to seepage measurement location PC-8, just upstream from surface water sample location PC-D (Figure 1). The flow in Percha Creek is also perennial from PC-11 through PC-16, intermittent for several miles, and then becomes ephemeral for approximately eight miles to Caballo Reservoir. Although both Las Animas Creek and Percha Creek have perennial reaches, neither creek contributes perennial flow to the Lower Rio Grande Basin.

Existing Data

Existing data were used to help design the seepage study and select sampling locations. The site selection was documented in a separate Letter Report submitted by INTERA to NMCC (INTERA, 2011). A brief summary of Davie and Spiegel (1967) and other useful reports follow.

Hydrographic Surveys

In 1967, William Davie, Jr. and Zane Spiegel published a hydrograph survey report of Las Animas Creek for the New Mexico State Engineer Office. The report details the geology of the region and the hydrogeology of the Santa Fe group sediments and alluvium.

Davie and Spiegel (1967) reported the depth of the alluvium in Las Animas Creek at the Interstate-25 bridge to be 30 feet (ft) and the depth of the alluvium in Percha Creek at the Interstate-25 bridge to be 40 ft.

The Percha Shale, which underlies Las Animas Creek west of the Animas Uplift, 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 1). Groundwater entering Las Animas Creek from Pennsylvanian rocks, particularly NWS spring, was measured at a temperature of about 27 degrees Celsius (^{o}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 by INTERA were also recorded at approximately 27^{o}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. This location was not accessible during the seepage investigation.

The construction of diversion ditches and shallow wells along Las Animas Creek have caused local and seasonal changes in the water in the alluvium and 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. Groundwater in the Paleozoic rocks, the Santa Fe group, and the alluvium is hydraulically connected and interacts with the surface flow of Las Animas Creek (Davie and Spiegel, 1967).

In 2000, the Office of the State Engineer 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 (OSE, 2000). A U.S. Geological Survey stream-gauging station located on Percha Creek near Hillsboro has been recording peak flow data in Percha Creek since 1957 (USGS, 2011). Flow has ranged from 0 cubic feet per second (ft^3/s) to 19,900 ft^3/s, with an average peak flow of 2,058.4 ft^3/s and a median peak flow of 750 ft^3/s (Figure 2).

Surface water in Las Animas and Percha creeks was most recently investigated by INTERA in the summer and fall of 2010 and winter and spring of 2011. The results of this work will be published by INTERA in a Baseline Data Report to be submitted by THEMAC Resources Group Ltd. to the New Mexico Energy, Minerals and Natural Resources Department, Mining and Minerals Division in Quarter 1 of 2012. The data collected during 2010 and 2011 comprises seasonal flow measurements for both Las Animas Creek and Percha Creek. Please see Figure 3 for the quarterly flow measurements on Las Animas Creek and Figure 4 for the quarterly flow measurements on Percha Creek. These data were used to identify measurement locations for the seepage investigation. The quarterly measurement locations are identified on Figure 1. In addition, historical data were collected by Adrian Brown Consultants (ABC) in the 1990s and these data were also reviewed prior to the seepage investigation. ABC collected flow and water quality data from Percha Creek and Las Animas Creek in support of previous permitting efforts associated with opening the Copper Flat Mine in the 1990s (ABC, 1996).

Seepage Investigation

Methods

Volumetric flow measurement locations were identified by INTERA to gain an understanding of the low-flow conditions in Las Animas Creek and Percha Creek. Measurement locations were chosen to quantify reaches that were gaining and losing. Originally, INTERA identified 18 measurement locations for the seepage investigation; however, THEMAC Resources Group Ltd. was denied access to Ladder Ranch. This eliminated all measurement locations upstream of the western boundary identified on Figure 1 upstream past LAC-A. The reach of Las Animas Creek accessible for flow measurements extended approximately eight miles, but water was only flowing in a little more than one mile of this reach. Six measurement locations were identified in Las Animas Creek (Figure 5). The investigation reach for Percha Creek was approximately 18.5 miles, but the perennial reach of Percha Creek totaled only about four miles. Sixteen measurement locations were identified in Percha Creek (Figure 6).

The timing for recording measurements was selected to occur during a relatively dry period of the year to characterize only base flow contributions that make up the low-flow stage. Base flow represents the contributions of groundwater to stream discharge and typically varies with time and location, but can account for a significant proportion of stream flow during dry periods, when the contributions from direct runoff and interflow (shallow subsurface flow) decrease.

Stream flow measurements were obtained in June 2011 using standard techniques for open-channel flow. Volumetric flow was measured using a Marsh-McBirney Flo-Mate™ 2000, which is designed for characterizing open-channel flow; a top-setting wading rod; and a tape measure or tagline. Assembly, calibration, and operation of the flow meter followed the procedures described in NMED SWQB (2007). At each measurement location listed in Table 1, and shown on Figure 1, a straight reach was identified to collect flow measurements where the streambed was uniform and relatively free of boulders and aquatic vegetation. The width of the stream was measured using a tape measure, then subdivided so that each stream section between vertical profiles contained no more than 10% of the discharge (e.g., if the stream is <5 ft wide, vertical profiles would be 0.5 ft apart). Following procedures in NMED SWQB (2007) for stream depths more than 0.15 ft but less than 2.5 ft, the velocity measurement was taken at a depth that was equal to 60% of the total depth when measured from the surface of the water. Flow measurements were recorded in the field and volumetric stream flow at each location was calculated in the office.

Table 1. Volumetric Flow Measurement Locations

Stream System	Site Name	Location Rationale	Substrate Material
Las Animas Creek	LAC-1	Beginning of flow within accessible reach.	Cobbles and coarse gravel
	LAC-2	Increased flow downstream of LAC-1.	Cobbles and coarse gravel
	LAC-3	Flow decreasing.	Coarse gravel and sand, some cobbles
	LAC-4	Last measurable point in flowing reach. Temporary dam built.	Coarse gravel and sand, some cobbles
	LAC-5	First measurable point in flowing reach.	Coarse gravel and sand
	LAC-6	Last measurable point in flowing reach.	Gravel and sand, some cobbles

Stream System	Site Name	Location Rationale	Substrate Material
Percha Creek	PC-1	First measurable point at beginning of flow.	Coarse gravel and sand
	PC-2	Last measurable point upstream of box.	Coarse gravel and sand
	PC-3	First measurable point in box.	Cobbles and coarse gravel
	PC-4	Quarterly measuring point PC-C.	Gravel and sand
	PC-5	Upstream of spring input.	Coarse gravel, cobbles, and sand
	PC-6	At spring, quarterly measuring point PCS-A.	Coarse gravel
	PC-7	Downstream of spring input.	Coarse gravel and sand
	PC-8	Last measurable point in flowing reach.	Coarse cobbles and gravel
	PC-9	First measurable point in flowing reach.	Coarse cobbles and gravel
	PC-10	Last measurable point in flowing reach, upstream of quarterly measuring point PC-D.	Cobbles and gravel
	PC-11	First measurable point in flowing reach.	Coarse gravel and sand, some large cobbles
	PC-12	Increased flow.	Coarse gravel and sand, some large cobbles
	PC-13	Decreased flow.	Cobbles, coarse gravel, and sand
	PC-14	Downstream of dry tributary identified as having a spring.	Large cobbles and gravel
	PC-15	Measurable point before narrow canyon.	Cobbles and coarse gravel
	PC-16	Downstream of narrow canyon, last measurable point in flowing reach.	Cobbles, gravel, and coarse sand

The total discharge (Q) at each measurement location for Las Animas Creek and Percha Creek was calculated as:

$$Q = \sum_{i-1}^{n} q_i$$

where

q_i =the discharge (ft/s) through partial section i.

The partial discharge (q_i) for any partial section at a given observation point i, (i=1,2,3,…n) can be calculated using the following formula:

$$q_i = v_i \left(\frac{b_{i+1} \quad -b_{i-1}}{2} \right) d_i$$

where

v_i =mean velocity (ft/s) at observation point *i*
b_i =distance (ft) from initial point to observation point *i*
b_{i-1} =distance (ft) from initial point to preceding location
b_{i+1} =distance (ft) from initial point to next location
d_i =depth (ft) of water at location *i*

Field parameters were also collected and recorded at each measurement location. Using a handheld water quality meter, the temperature, specific conductivity, pH, and dissolved oxygen were measured immediately upstream of the reach identified for flow measurement.

Additionally, depth-to-water measurements were collected from shallow wells, where accessible. A water level meter was lowered into the well and depth to water was measured. A global positioning system (GPS) position was collected and stored in a Trimble GeoXM at each surface water measurement location and groundwater well location.

Results

Las Animas Creek

On June 28, 2011, INTERA collected data from six measurement locations along the accessible, perennial reaches of Las Animas Creek. See Attachment 1 for photos from the seepage investigation. The discharge rates were calculated and are summarized in Table 2. The measurement locations are identified on Figure 5. Calculated discharge rates were lower at each location along the creek relative to previously observed values in the seasonal hydrographs (Figure 3).

Table 2. Volumetric Flow Rate at Each Measurement Location along Las Animas Creek

Site Name	Discharge (ft^3/s)	Approximate Distance Downstream from Start of Flow (ft)
LAC-1	0.212	450
LAC-2	0.369	920
LAC-3	0.051	2,300
LAC-4	0.023	3,030
--	0.000	3,530
--	0.000	5,200
LAC-5	0.018	5,830
LAC-6	0.021	6,580
--	0.000	6,680

Only two perennial reaches were observed along the accessible portion of Las Animas Creek (Figure 5). The maximum flow rate of the first reach was approximately 0.369 ft^3/s or 165.6 gallons per minute (gpm) at measurement location LAC-2. The maximum flow rate in the second measurable reach was 0.021 ft^3/s (9.0 gpm). The volumetric flow profile for Las Animas Creek is shown in Figure 7.

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. Las Animas Creek is then a losing stream from approximately 1,000 ft below SoF to approximately 3,530 ft, where the stream dries out downstream of LAC-4. Approximately 5,200 ft below SoF, Las Animas Creek is once again a gaining stream to LAC-5, approximately 5,830 ft below SoF. At LAC-5, the surface water is very low and slow but does flow along the surface for approximately 1,480 ft before disappearing below the surface of the creek alluvium approximately 100 ft downstream of LAC-6.

Percha Creek

On June 29 and 30, 2011, INTERA collected data from 16 measurement locations along the accessible, perennial reaches of Percha Creek. See Attachment 1 for photos from the seepage investigation. The discharge rates were calculated and are summarized in Table 3. The measurement locations are identified on Figure 6. Data collected as part of this study show that discharge was lower at each location along the creek when compared to the seasonal hydrographs (Figure 4).

Table 3. Volumetric Flow Rate at Each Measurement Location along Percha Creek

Site Name	Discharge (ft^3/s)	Approximate Distance Downstream from Start of Flow (ft)
PC-1	0.241	400
PC-2	0.181	1,395
PC-3	0.134	2,080
PC-4	0.186	3,235
PC-5	0.010	4,010
PC-6	0.662	4,220
PC-7	0.879	4,370
PC-8	0.058	7,140
--	0.000	7,940
--	0.000	8,835
PC-9	0.156	8,935
PC-10	0.037	9,220
--	0.000	9,420
--	0.000	13,885
PC-11	0.148	14,385
PC-12	0.228	17,800
PC-13	0.076	19,365
PC-14	0.330	20,765
PC-15	0.337	21,875

Site Name	Discharge (ft^3/s)	Approximate Distance Downstream from Start of Flow (ft)
PC-16	0.024	24,105
--	0.000	24,605

Percha Creek had three perennial reaches during the sampling event (Figure 6). The maximum flow rate of the first reach was approximately 0.879 ft^3/s (394.4 gpm) at measurement location PC-7. Measurement location PC-7 is approximately 150 ft downstream of PC-6 at a spring input. The maximum flow rate in the second measurable reach was 0.156 ft^3/s (69.9 gpm) at measurement location PC-9. In the third perennial reach, the maximum flow rate was 0.337 ft^3/s (151.4 gpm) at measurement location PC-15. A spring was identified in the Lower Rio Grande Outlying Areas Hydrograph Survey in a dry tributary that enters Percha Creek just upstream of PC-14 and PC-15. The volumetric flow profile for Percha Creek is shown in Figure 8.

Figure 8 shows the losing and gaining reaches of Percha Creek. Flow started approximately 400 ft upstream from PC-1 with a rate of 0.241 ft^3/s (400 gpm). The rate decreased at PC-2, approximately 1,395 ft further downstream. The rate varied slightly up to the inflow from the springs at PC-6, approximately 4,220 ft downstream of the SoF and close to the end of the canyon referred to as 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 Percha "box", to Tertiary volcanic rocks and then the Upper Santa Fe Group sediments. Flow in Percha Creek decreased significantly after the "box" and all surface flow disappeared for approximately 995 ft between PC-8 and PC-9. Surface flow also ceased along a 4,500-ft interval below 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.

Seepage Rates

The seepage rates for the measured flowing reaches of Las Animas Creek and Percha Creek were quantified using a mass balance approach,

$$\text{Seepage rate} = \text{volumetric}_{\text{outflows}} - \text{volumetric}_{\text{inflows}}$$

Negative seepage rates are indicative of a losing stream reach, whereas positive seepage rates are indicative of a gaining stream reach. The results of the seepage rate calculations are summarized in Table 4. The reach with the greatest gaining rate on Las Animas Creek was from the SoF to LAC-1, 0.212 ft^3/s, and the reach with the greatest losing rate was from LAC-2 to LAC-3, -0.318 ft^3/s. The reach with the greatest gaining rate on Percha Creek was from PC-5 to PC-7, with a rate of 0.869 ft^3/s; this reach receives the inflow from the spring at PC-6 and other smaller seeps nearby. The reach with the greatest losing rate on Percha Creek was from PC-7 to PC-8, -0.820 ft^3/s.

Table 4. Seepage Rates for the Measured Reaches of Las Animas Creek and Percha Creek

Stream System	Reach	Seepage Rate (ft^3/s)	Gaining or Losing Reach
Las Animas Creek	SoF to LAC-1	0.212	Gaining
	LAC-1 to LAC-2	0.157	Gaining
	LAC-2 to LAC-3	-0.318	Losing
	LAC-3 to LAC-4	-0.028	Losing
	LAC-4 to Dry	-0.023	Losing
	Dry to LAC-5	0.018	Gaining
	LAC-5 to LAC-6	0.002	Gaining
	LAC-6 to End	-0.021	Losing
Percha Creek	Start to PC-1	0.241	Gaining
	PC-1 to PC-2	-0.061	Losing
	PC-2 to PC-3	-0.046	Losing
	PC-3 to PC-4	0.051	Gaining
	PC-4 to PC-5	-0.176	Losing
	PC-6	0.662	Inflow
	PC-5 to PC-7	0.869	Gaining
	PC-7 to PC-8	-0.820	Losing
	PC-8 to Dry	-0.058	Losing
	Dry to PC-9	0.156	Gaining
	PC-9 to PC-10	-0.119	Losing
	PC-10 to Dry	-0.037	Losing
	Dry to PC-11	0.148	Gaining
	PC-11 to PC-12	0.080	Gaining
	PC-12 to PC-13	-0.152	Losing
	PC-13 to PC-14	0.254	Gaining
	PC-14 to PC-15	0.008	Gaining
	PC-15 to PC-16	-0.314	Losing
	PC-16 to End	-0.024	Losing

Field Parameters

The field parameters temperature (°C), pH, dissolved oxygen, and specific conductivity were also collected at each of the flow measurement locations along Las Animas Creek and Percha Creek. The horizontal profiles of temperature, pH, and dissolved oxygen may be useful for determining groundwater recharge to the streambed.

The temperature at LAC-1 in Las Animas Creek is 17.93°C, approximately 1.5°C cooler than any point downstream (see Figure 9 and Table 5). The profiles for temperature, pH, and dissolved oxygen all increase from the SoF downstream to the end of flow with the exception of the pH and dissolved oxygen values at LAC-5, a gaining measurement location, where profile values were slightly lower than the values at LAC-4, a losing measurement location.

Table 5. Field Parameter Data for Las Animas Creek

Site Name	Temperature (°C)	Specific Conductivity (µS/cm)	pH	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%)
LAC-1	17.93	442	6.88	3.07	32.6
LAC-2	19.4	439	7.37	7.47	81.4
LAC-3	21.76	420	8.22	9.63	110.1
LAC-4	26.4	380	8.46	10.12	125.8
LAC-5	27.92	469	7.73	9.23	118.2
LAC-6	29.46	454	8.4	9.4	123.3

µS/cm = microSiemens per centimeter
mg/L = milligrams per liter

The field parameter profiles for Percha Creek are more varied than those for Las Animas Creek (see Figure 10 and Table 6). The temperature of Percha Creek was generally cooler in gaining reaches than it was in losing reaches. Measurement locations PC-1, PC-11, and PC-14 were all locations of groundwater influx and all had cool temperatures ranging from 19.92° to 23.48°C (see Figure 10). However, PC-2 and PC-3, losing reaches, also had relatively cool temperatures of 23.44°C and 22.39°C, respectively. These cooler temperatures may have been due to the measurement locations being in shaded areas of the stream or more complex groundwater-surface water interactions. Davie and Spiegel (1967) indicated that shallow groundwater temperatures in Las Animas Creek area are expected to be 18°–20°C and higher temperatures for gaining reaches and springs are believed to be coming from greater depths. It is possible that the groundwater feeding Percha Creek at PC-1 (23.48°C) and PC-6 (24.18°C) may be fed by deeper sources than the shallow groundwater aquifer.

In addition, the pH and dissolved oxygen for PC-1 and PC-6 had the lowest values as expected for gaining reaches. In general, pH and dissolved oxygen values at the measurement locations followed the expected profile for the gaining and losing reaches of Percha Creek, lower profile values corresponding with gaining reaches and higher profile values corresponding with losing reaches (Figure 10).

Table 6. Field Parameter Data for Percha Creek

Site Name	Temperature (^oC)	Specific Conductivity (µs/cm)	pH	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%)
PC-1	23.48	607	7.56	4.92	58.1
PC-2	23.44	602	8.19	8.01	94.4
PC-3	22.39	602	8.29	9.16	105.8
PC-4	27.05	577	8.29	7.69	95
PC-5	27.88	564	8.51	10.45	133.2
PC-6	24.18	535	7.61	4.87	58.2
PC-7	25.47	540	8.02	7.98	97.6
PC-8	31.9	424	8.84	11.65	158.9
PC-9	26.4	506	8.57	11.9	149.2
PC-10	27.66	476	8.66	9.58	122
PC-11	19.92	540	7.66	7.2	79.3
PC-12	25.69	484	8.24	10.53	129.5
PC-13	25.83	437	8.61	10.92	134.5
PC-14	21.16	538	7.93	8.08	91.9
PC-15	24	527	8.14	8.53	101.6
PC-16	25.62	486	8.54	10.74	131.8

Shallow Wells

Depth to water was also measured in shallow wells along the perennial reaches of Las Animas Creek and Percha Creek when possible. No shallow wells were identified in the study reach of Percha Creek. The depth to water was measured in five shallow wells in Las Animas Creek valley on the same day that the flow measurements were collected. See Figure 5 for the location of the wells and Table 7 for a summary of the data.

Table 7. Shallow Well Measurements along Las Animas Creek

Site Name	Depth to Water (ft)	Depth to Bottom of Well (ft)	Elevation of Ground Surface (ft amsl)	Elevation of Water Table (ft amsl)
HD Well-1	11.7	18.1	4448.8	4437.1
MW-11	13.95	17.67	4443.2	4429.3
HD Well-2	7.4	9	4442.3	4434.9
HD Well-3	11.8	23	4429.1	4417.3
HD Well-4	16.4	19	4389.8	4373.4

ft amsl = feet above mean sea level

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NMED Surface Water Quality Bureau (NMED SWQB), 2007, The 2007 NMED/SWQB standard operating procedures for data collection, July 26, 186 p.

Office of the State Engineer, State of New Mexico, 2000, Lower Rio Grande Basin hydrographic survey report: Outlying areas, Part of Doña Ana, Sierra, and Grant Counties, December 2000.

U. S. Geological Survey (USGS), 2011, Peak streamflow for the Nation, USGS 08361700 Percha Creek near Hillsboro, NM, Sierra County, New Mexico, available at: http://nwis.waterdata.usgs.gov/nwis/peak/?site_no=08361700&agency_cd=USGS&.

Sincerely,
INTERA Incorporated

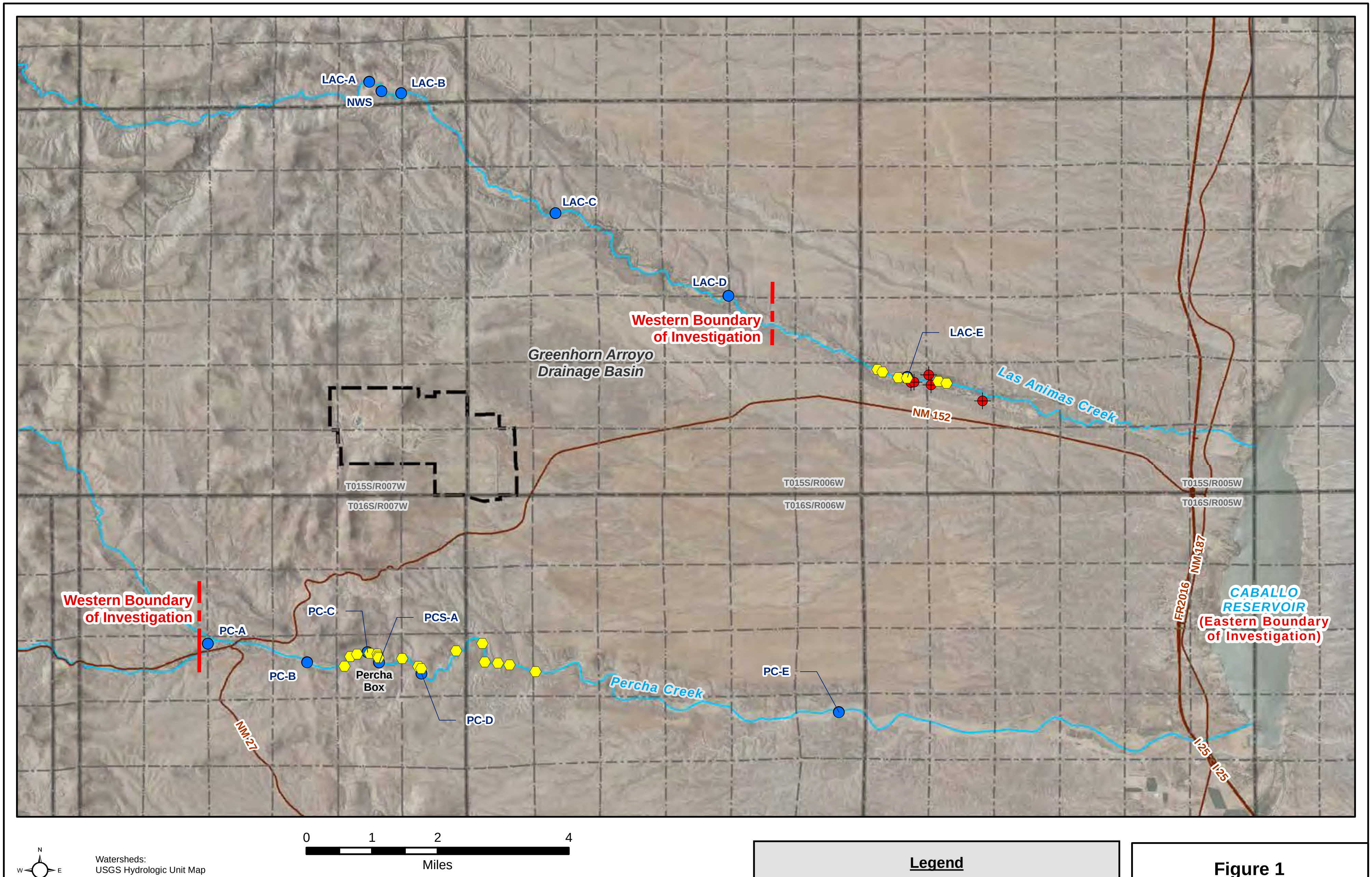
John Sigda
Senior Hydrogeologist

Annelia Tinklenberg
Hydrogeologist

Attachments:
- Figures
- Attachment 1: Photo Log

INTERA Project No.: NMCC.C001.CFM

FIGURES



Watersheds:
USGS Hydrologic Unit Map
Mine Boundary:
Tom Van Bebber
Imagery Information:
-USGS 7.5-Minutes County DOQQ mosaic
Sierra County, 2009
Projection Information:
-New Mexico State Plane West, NAD 1927

Figure 1
Seepage Investigation: Measurement Locations
New Mexico Copper Corporation

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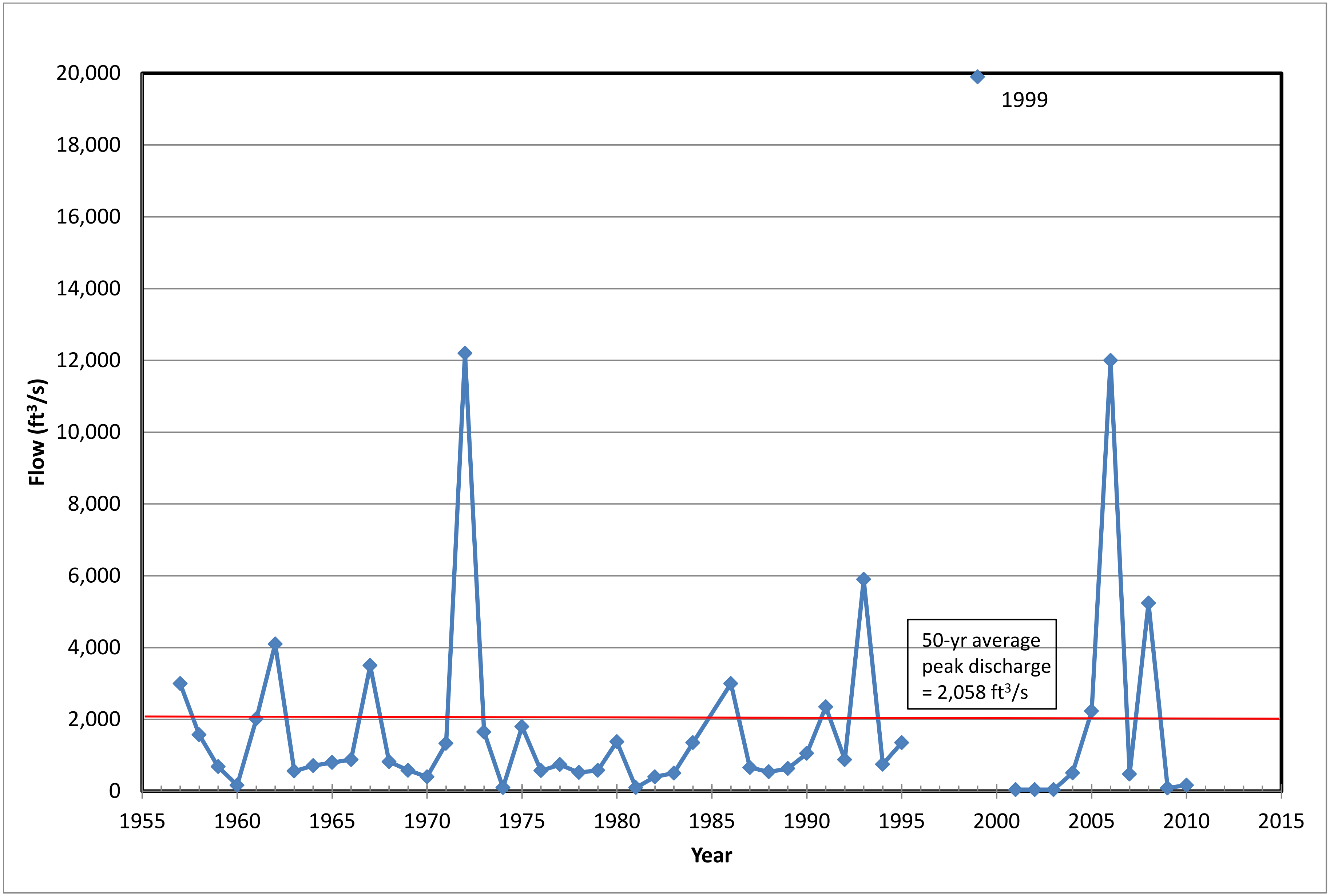


Figure 2

Seepage Investigation:

Percha Creek - Maximum Discharge (1957 - 2010)

New Mexico Copper Corporation

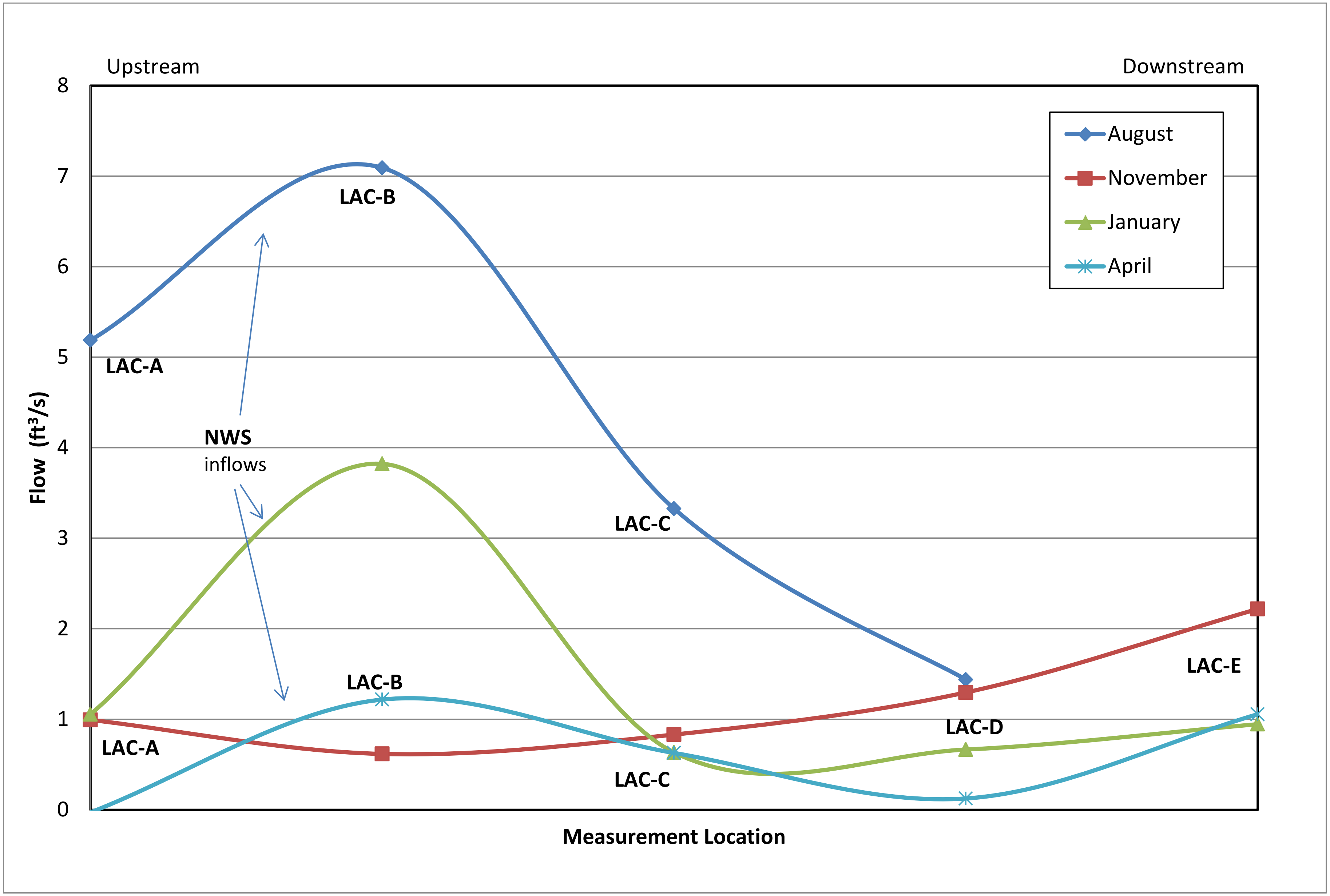


Figure 3
Seepage Investigation:
Las Animas Creek - Seasonal Flow Profile
New Mexico Copper Corporation

INTERA

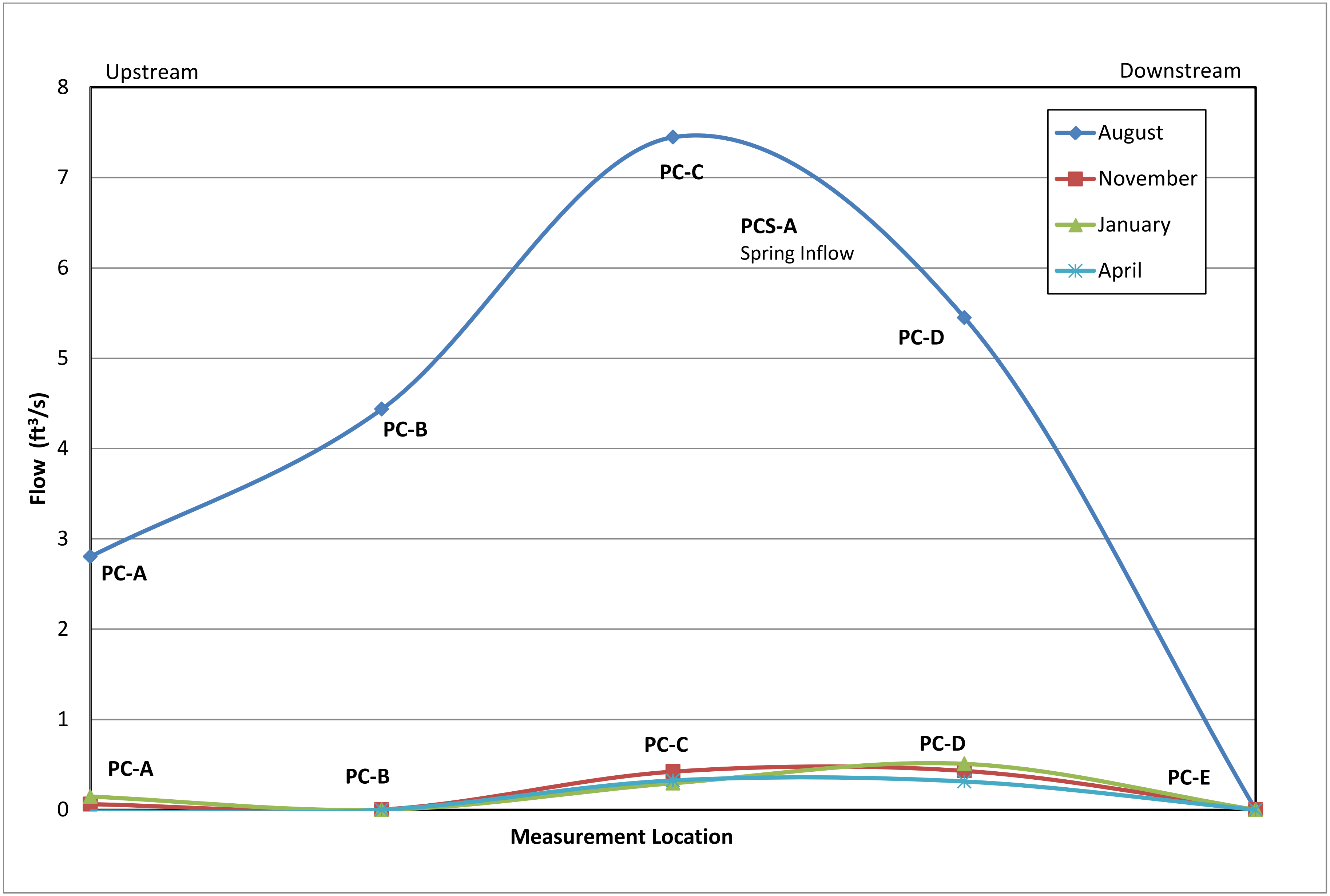
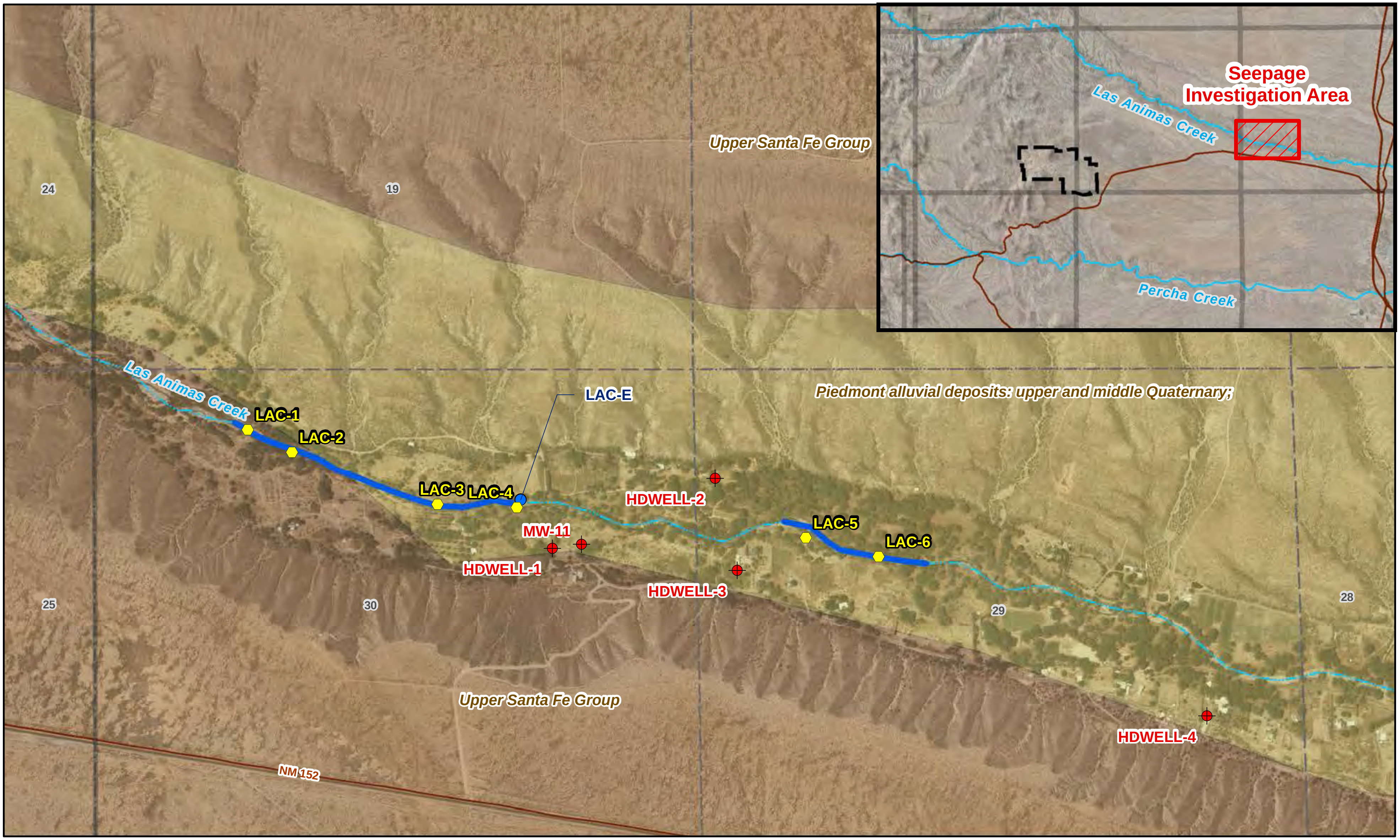


Figure 4
Seepage Investigation:
Percha Creek - Seasonal Flow Profile
New Mexico Copper Corporation



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Geology: USGS OFR 97-0052
Watersheds:
USGS Hydrologic Unit Map
Mine Boundary:
Tom Van Bebber
Imagery Information:
-USGS 7.5-Minutes County DOQQ mosaic
Sierra County, 2009
Projection Information:
-New Mexico State Plane West, NAD 1927

INTERA

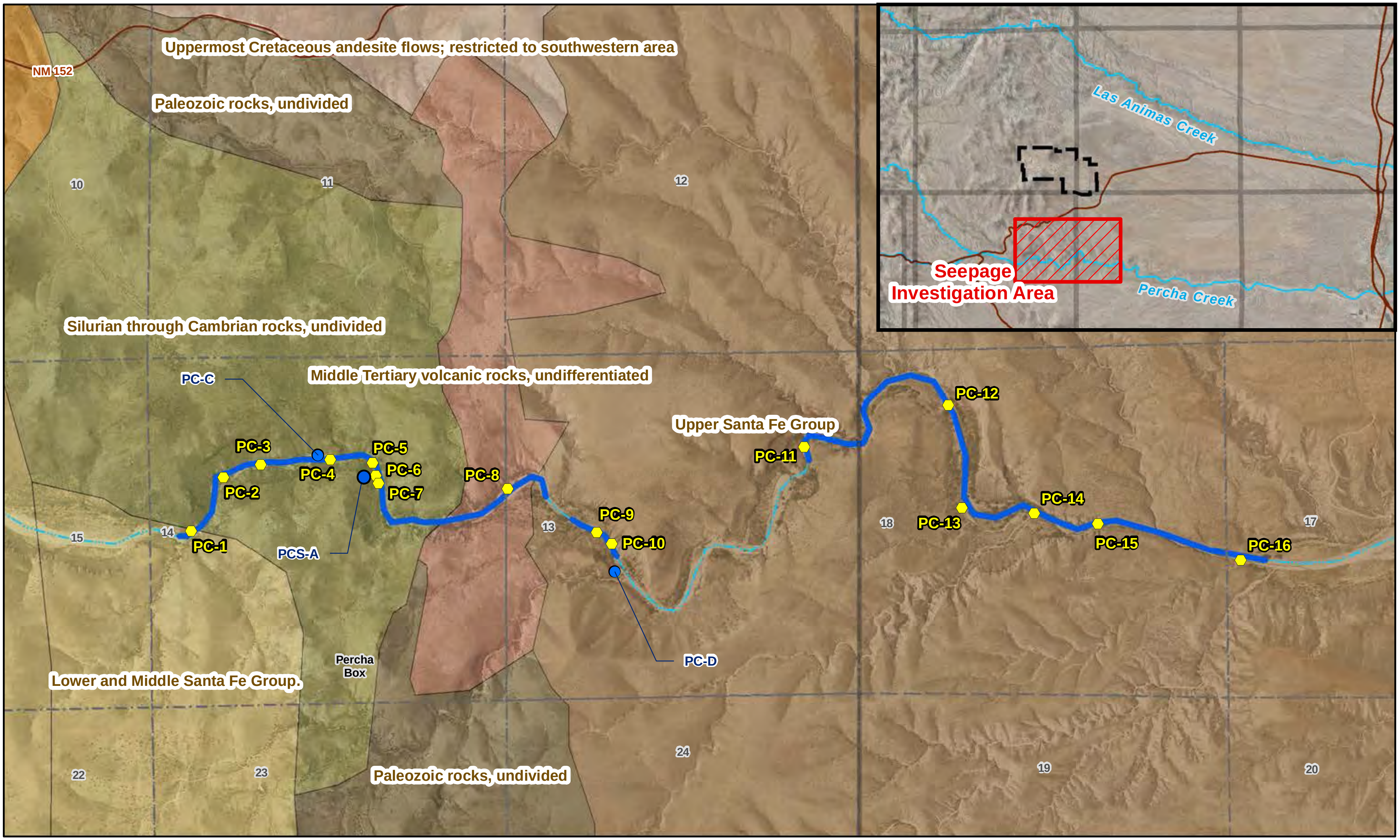
1,200 600 0 1,200
Feet

Legend

- Seepage Measurement Location
- Shallow Well
- Surface Water Sample Location
- Las Animas Perennial Flow
- Proposed Mine Permit Boundary

Figure 5
Seepage Investigation:
Las Animas Creek
New Mexico Copper Corporation

S:\Projects\NMC-001_New Mexico Copper Corporation\GIS\Maps\Seepage\Report\Fig05_SeepAnimas.mxd 8/22/2011



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Geology: USGS OFR 97-0052
USGS Hydrologic Unit Map
Mine Boundary:
Tom Van Bebber
Imagery Information:
-USGS 7.5-Minutes County DOQQ mosaic
Sierra County, 2009
Projection Information:
-New Mexico State Plane West, NAD 1927

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Figure 6
Seepage Investigation: Percha Creek
New Mexico Copper Corporation

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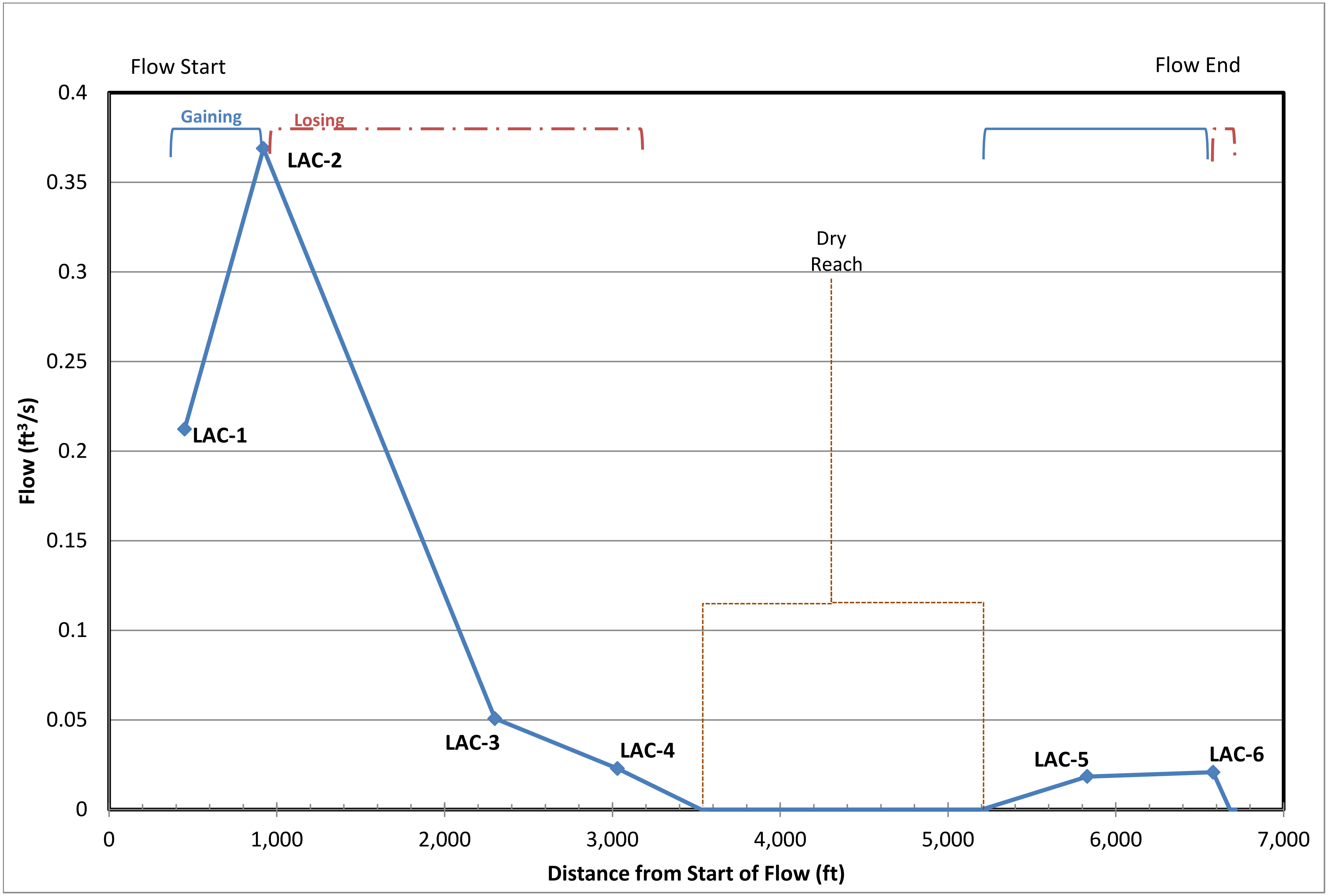


Figure 7
Seepage Investigation:
Las Animas Creek - Flow Profile
New Mexico Copper Corporation

INTERA

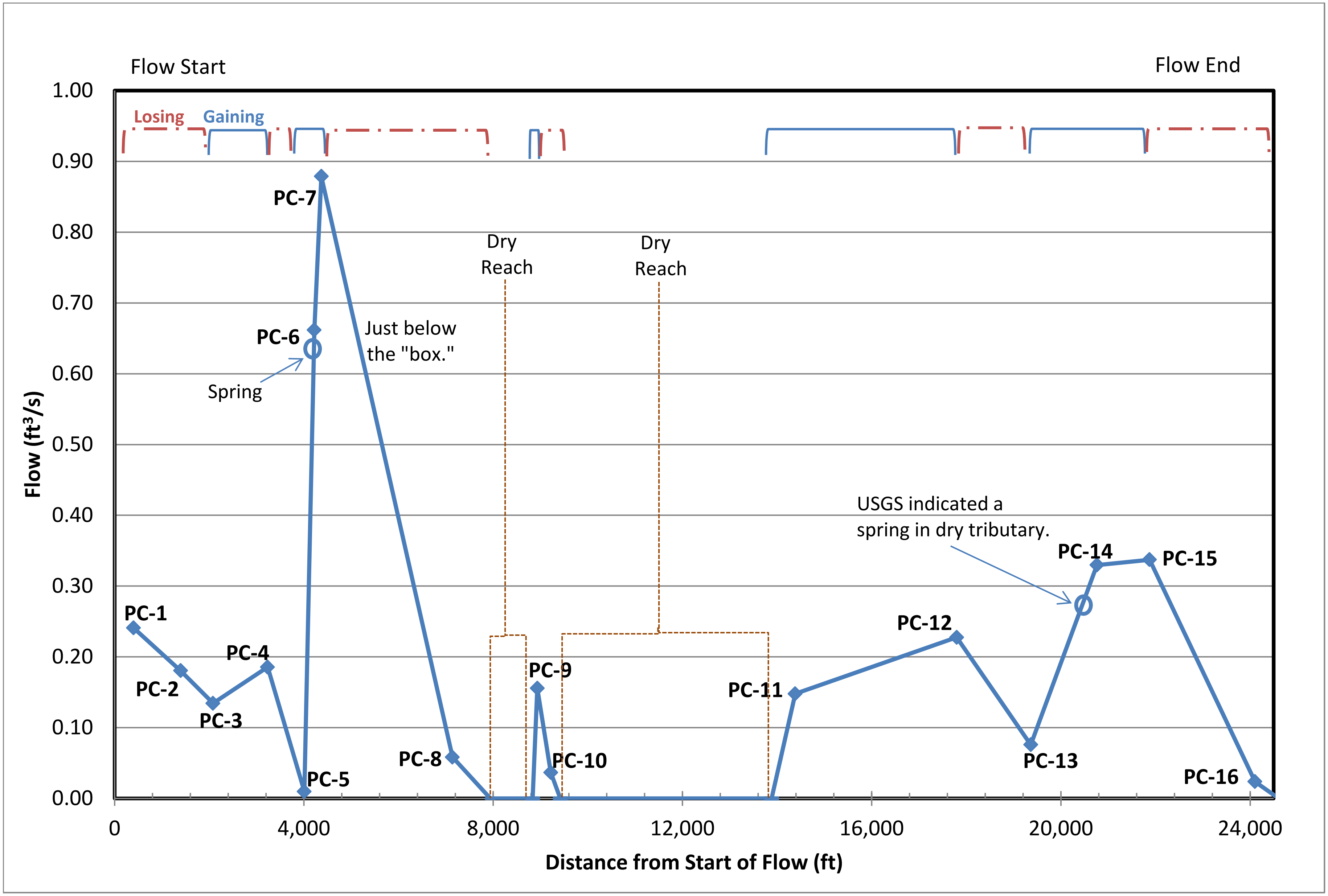
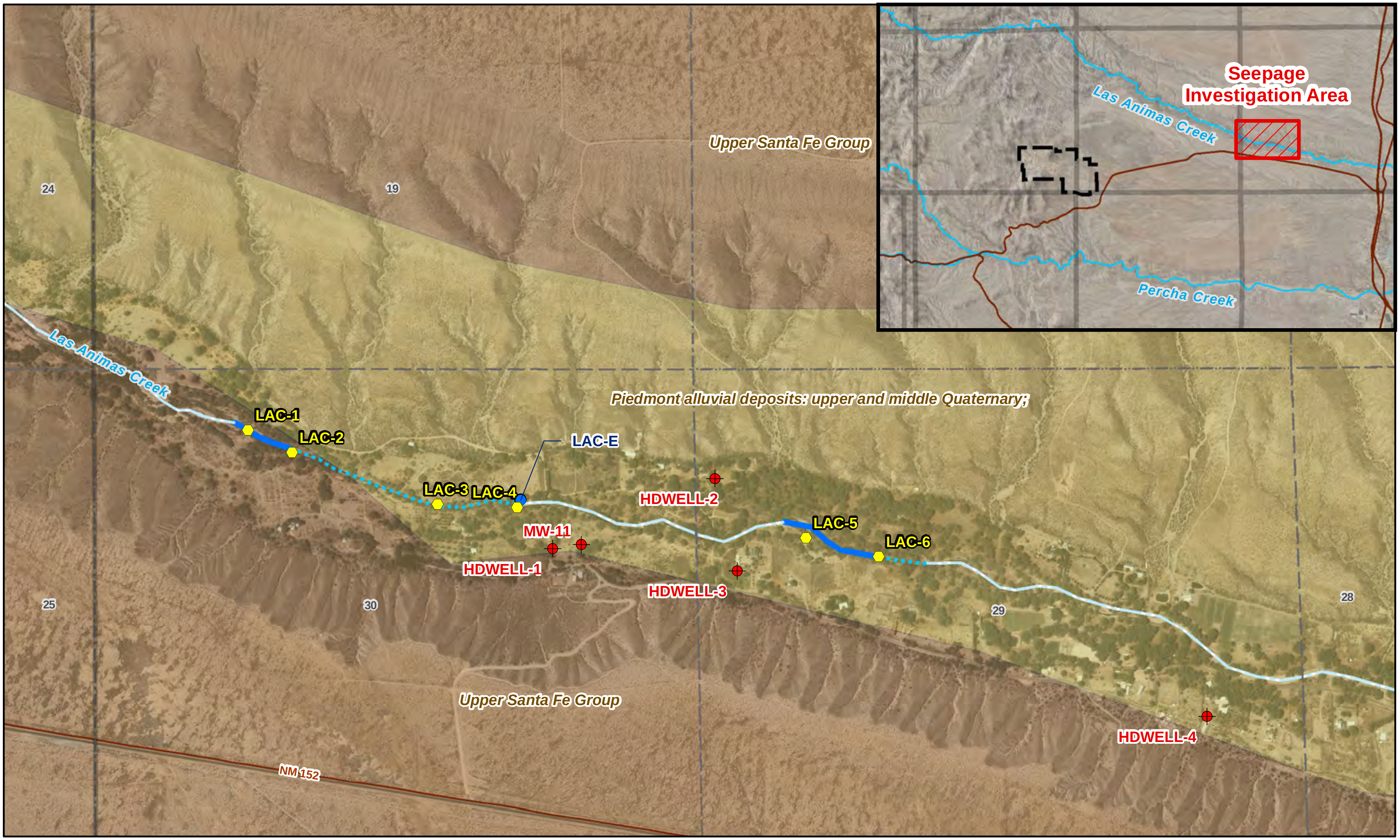


Figure 8
Seepage Investigation:
Percha Creek - Flow Profile
New Mexico Copper Corporation

INTERA



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Geology: USGS OFR 97-0052
Watersheds:
USGS Hydrologic Unit Map
Mine Boundary:
Tom Van Bebber
Imagery Information:
-USGS 7.5-Minutes County DOQQ mosaic
Sierra County, 2009
Projection Information:
-New Mexico State Plane West, NAD 1927

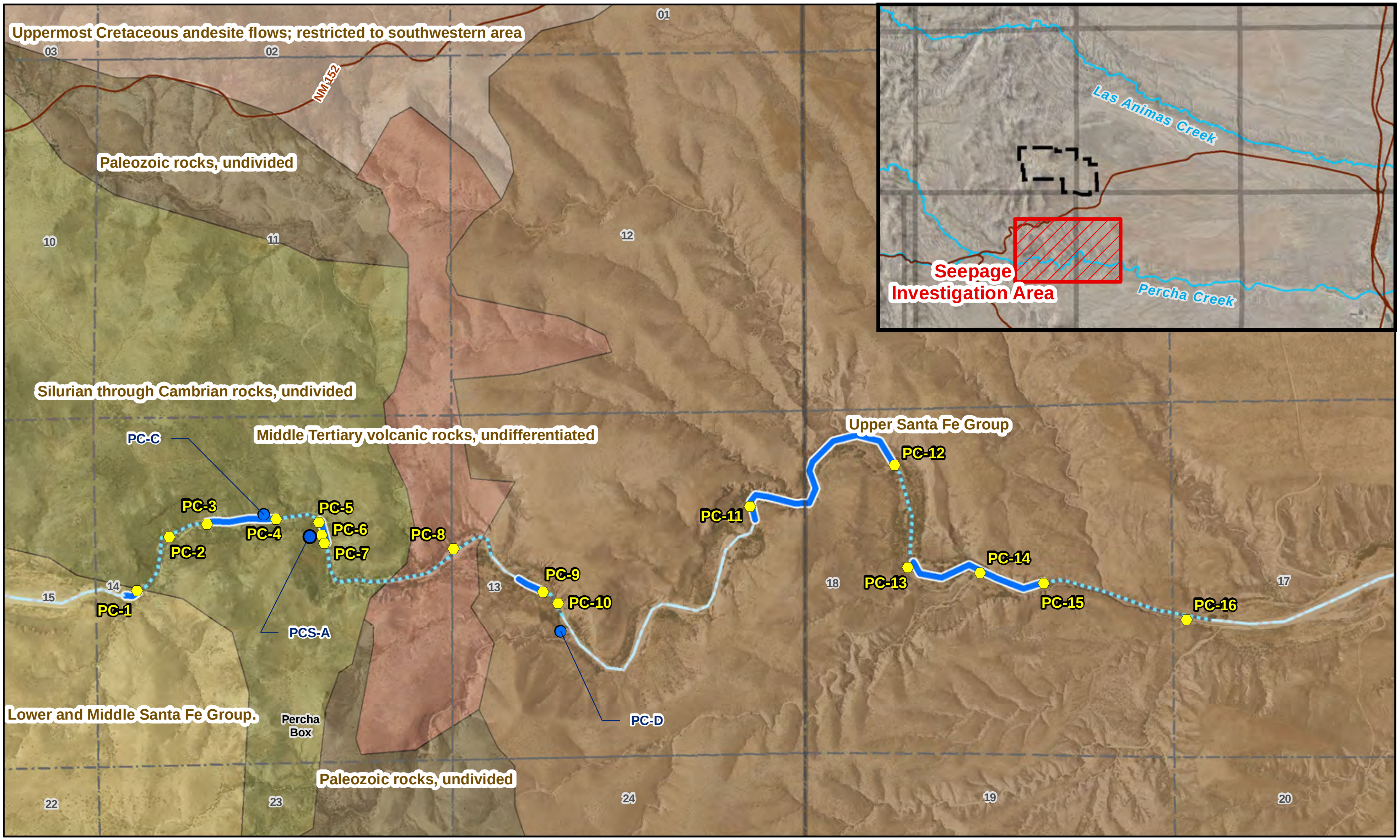
1,200 600 0 1,200
Feet

INTERA

Legend

- Seepage Measurement Location
- Shallow Well
- Surface Water Sample Location
- Dry
- Gaining
- Losing
- Proposed Mine Permit Boundary

Figure 9
Seepage Investigation: Las Animas Creek
New Mexico Copper Corporation



Watersheds:
Geology: USGS OFR 97-0052
USGS Hydrologic Unit Map
Mine Boundary:
Tom Van Bebber
Imagery Information:
-USGS 7.5-Minutes County DOQQ mosaic
Sierra County, 2009
Projection Information:
-New Mexico State Plane West, NAD 1927

INTERA

Legend

- Seepage Measurement Location
- Surface Water Sample Location
- Dry
- Gaining
- Losing
- Proposed Mine Permit Boundary

Figure 10
Seepage Investigation: Percha Creek
New Mexico Copper Corporation

S:\Projects\NMC-001_New Mexico Copper Corporation\GIS\Maps\Seepage\Report\Fig10_SeepPerchaStatus.mxd 1/4/2012

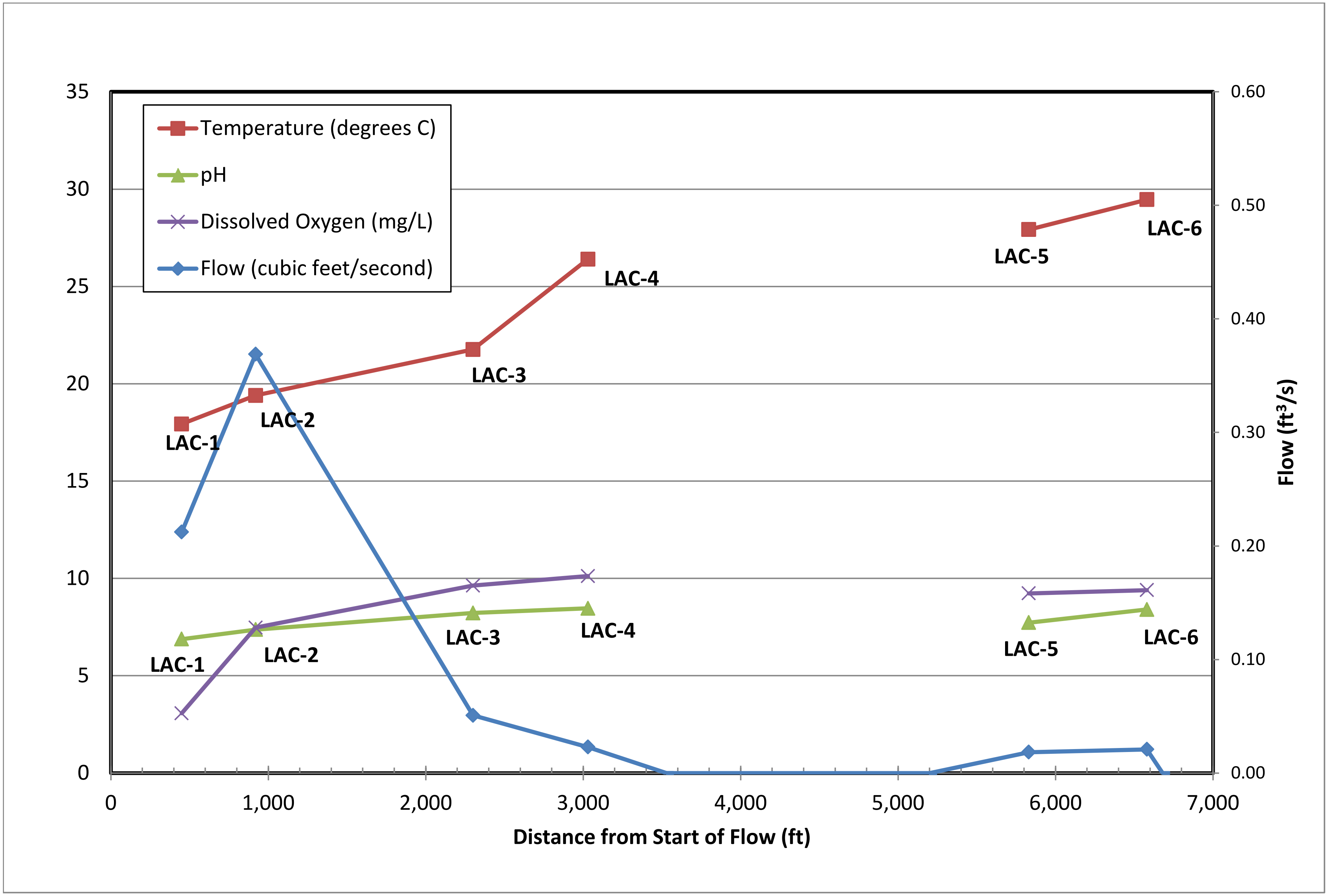


Figure 11
Seepage Investigation:
Las Animas Creek - Field Parameter Profiles
New Mexico Copper Corporation

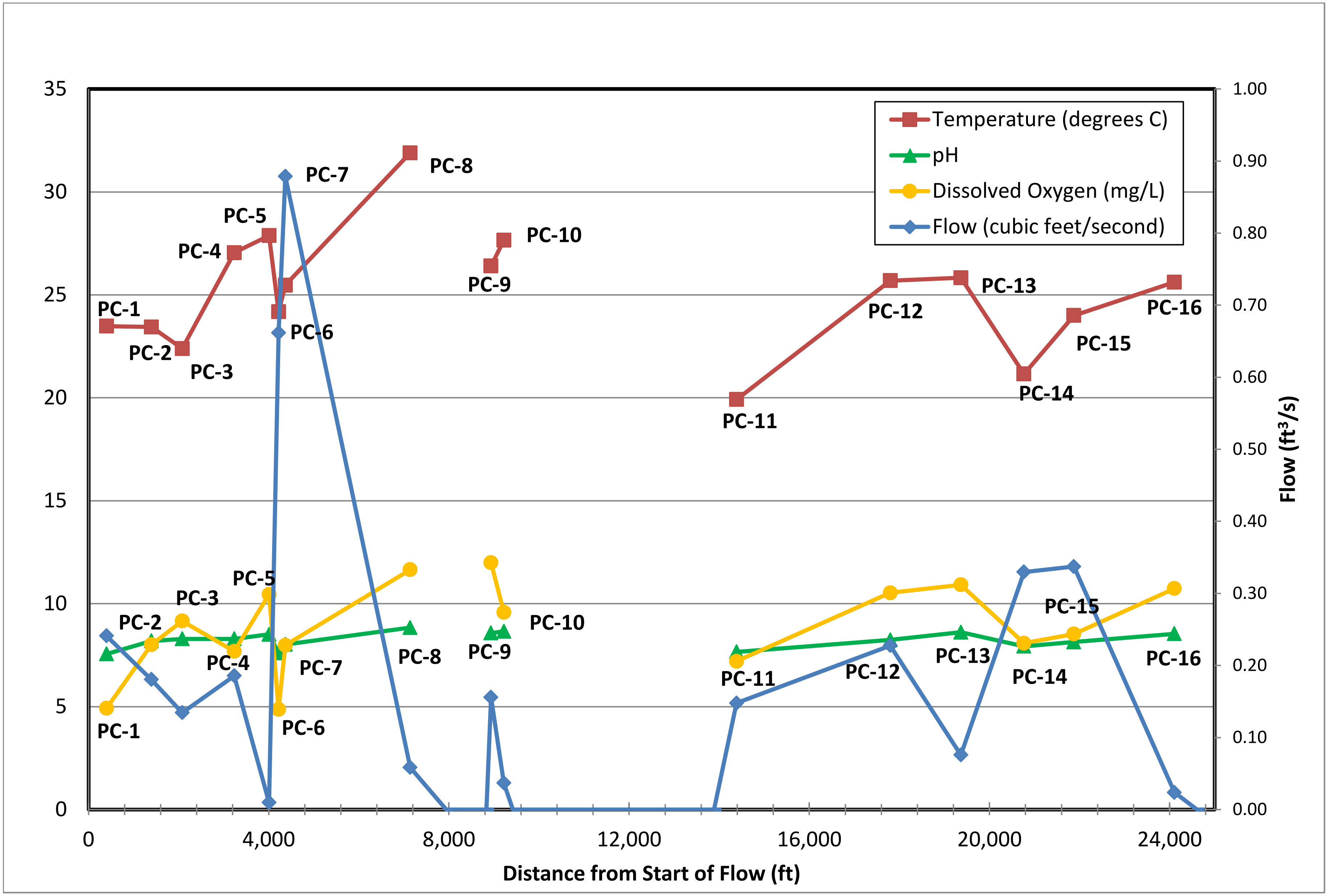


Figure 12
Seepage Investigation:
Percha Creek - Field Parameter Profiles
New Mexico Copper Corporation

ATTACHMENT 1

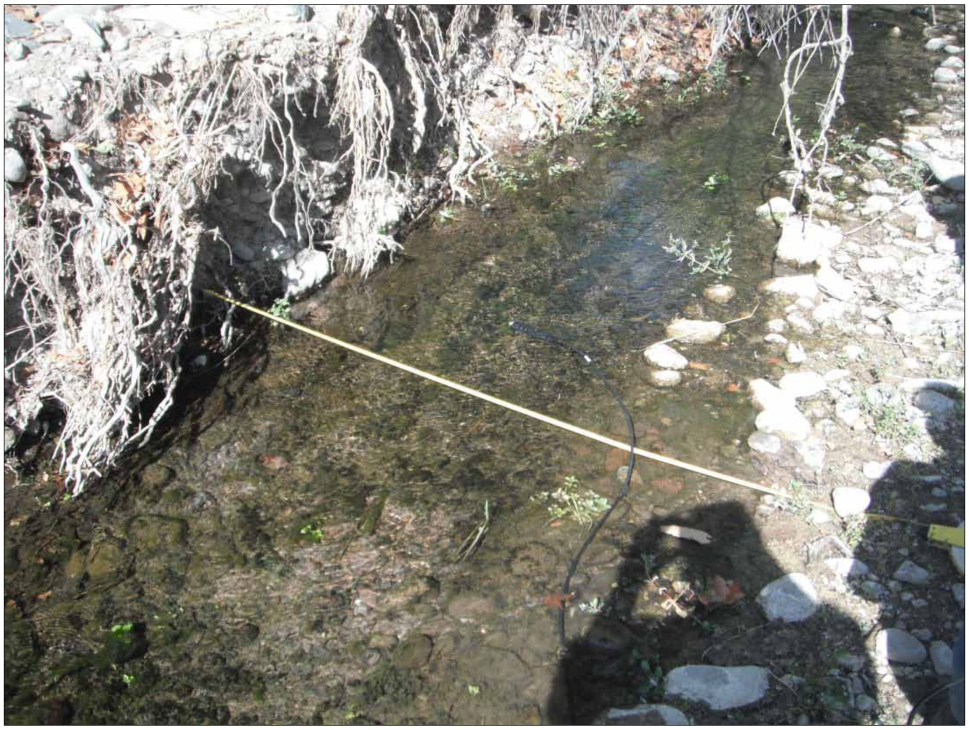
Photo Log

No. 1 – Looking upstream at LAC-1, beginning of flow in accessible reach of Las Animas Creek.

No. 2 – Looking downstream at LAC-1.

No. 3 – Looking upstream at LAC-2.

No. 4 – Looking downstream at LAC-2.



No. 5 – Looking upstream at LAC-3.

No. 6 – Looking downstream at LAC-3.

No. 7 – Looking upstream at LAC-4.

No. 8 – Looking downstream at LAC-4.

No. 9 – Looking downstream from LAC-4 to end of flow in reach.

No. 10 – Looking upstream at end of flow in reach.

No. 11 – Looking upstream at dry reach along Las Animas Creek near LAC-E, between LAC-4 and LAC-5.

No. 12 – Looking upstream at LAC-5.

No. 13 – Looking downstream at LAC-5.

No. 14 – Looking upstream at LAC-6.

No. 15 – Looking downstream at LAC-6, the last measurable reach in Las Animas Creek.

No. 16 – Hand-dug well 1 (HD Well-1) in Las Animas Valley.

No. 17 – Hand-dug well 2 (HD Well-2) in Las Animas Valley.

No. 18 – Well MW-11 in Las Animas Valley.

No. 19 – Hand-dug well 3 (HD Well-3) in Las Animas Valley.

No. 20 – Hand-dug well 4 (HD Well-4) in Las Animas Valley.

No. 21 – Beginning of flow on Percha Creek.

No. 22 – Looking upstream at PC-1.

No. 23 – Looking downstream at PC-1.

No. 24 – Looking upstream at PC-2.

No. 25 – Looking downstream at PC-2.

No. 26 – Looking downstream at PC-3.

No. 27 – Looking upstream at PC-3.

No. 28 – Looking downstream at PC-4 (also PC-C).

No. 29 – Looking upstream at PC-5, upstream of the spring inflow at PC-6.

No. 30 – Looking downstream at PC-5, upstream of the spring inflow at PC-6.

No. 31 – Looking at PC-6, the spring (also PCS-A).

No. 32 – Looking upstream at PC-7, downstream of PC-6 inflow.

No. 33 – Looking downstream at PC-7, downstream of PC-6 inflow.

No. 34 – Looking downstream at PC-8.

No. 35 – Dry reach between PC-8 and PC-9.

No. 36 – Looking downstream at PC-9.

No. 37 – Looking upstream at PC-9.

No. 38 – Looking downstream at PC-10.

No. 39 – Looking upstream at PC-10.

No. 40 – Looking downstream at quarterly monitoring site PC-D, now dry.

No. 41 – Looking upstream at the start of flow in Percha Creek above PC-11.

No. 42 – Looking downstream at the start of flow above PC-11.

No. 43 – Looking upstream at PC-11.

No. 44 – Looking downstream at PC-11.

No. 45 – Looking upstream at PC-12.

No. 46 – Looking downstream at PC-12.

No. 47 – Looking upstream at PC-13.

No. 48 – Looking downstream at PC-13.

No. 49 – Looking upstream at PC-14, downstream of a large dry tributary.

No. 50 – Looking downstream at PC-14, downstream of a large, dry tributary.

No. 51 – Looking upstream at PC-15, upstream of the second canyon.

No. 52 – Looking downstream at PC-15, upstream of the second canyon.

No. 53 – Looking upstream in the second canyon, between PC-15 and PC-16.

No. 54 – Looking at the northern wall of the canyon.

No. 55 – Santa Fe Group sediments in the north wall of the second canyon.

No. 56 – Close up of clay lenses and cemented gravels in the north wall.

No. 57 – Looking downstream within the canyon, between PC-15 and PC-16.

No. 58 – Looking upstream at PC-16, downstream of the second canyon.

No. 59 – Looking downstream at PC-16, the last measurable reach of Percha Creek.

No. 60 – Looking west, from above the Percha Creek valley, at a storm over the Black Range.

Appendix 8-C

Surface Water Analytical Results

Appendix 8-C. Surface Water Analytical Results

Sample Location	Collection Date	Alkalinity, Total (As CaCO3) (mg/L)	Aluminum (mg/L)	Ammonia (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)
	8/25/2010	230	0.035		<0.001	0.0042	0.013	<0.002	230	<0.04	<0.002	38	<2	13	<0.006	<0.006	<0.006	<0.01	6.8	0.032	<0.005	5.3	0.0028	<0.0002	0.011	<0.01
	11/4/2010	250	<0.02		<0.001	0.0045	0.015	<0.002	250	0.048	<0.002	40	<2	16	<0.006	<0.006	<0.006	<0.01	6.3	<0.02	<0.005	6	0.0079	<0.0002	0.012	<0.01
	1/20/2011	250	0.038	<5	<0.001	0.0038	0.013	<0.002	250	0.045	<0.002	43	<2	17	<0.006	<0.006	<0.006	<0.01	6.8	0.044	<0.005	6	0.0045	<0.0002	0.012	<0.01
CSCS-B	4/19/2011	250	<0.02	<1	<0.001	0.0043	0.014	<0.002	250	0.043	<0.002	43	<2	17	<0.006	<0.006	<0.006	<0.01	6.8	<0.02	<0.005	6.2	<0.002	<0.0002	0.012	<0.01
CSCS-C	8/25/2010	45	0.38		<0.001	0.0012	0.015	<0.002	45	<0.04	<0.002	11	<2	1	<0.006	<0.006	<0.006	<0.01	0.17	0.12	<0.005	2.1	0.017	<0.0002	<0.008	<0.01
	8/24/2010	100	<0.02		<0.001	0.0012	0.011	<0.002	100	<0.04	<0.002	27	<2	2.8	<0.006	<0.006	<0.006	<0.005	0.31	0.023	<0.005	5.5	0.011	<0.0002	<0.008	<0.01
	11/3/2010	160	<0.02		<0.001	0.0011	0.016	<0.002	160	<0.04	<0.002	46	<2	5.1	<0.006	<0.006	<0.006	<0.01	0.27	<0.02	<0.005	9.4	0.0085	<0.0002	<0.008	<0.01
LAC-A	4/26/2011	160	<0.02		<0.001	0.0012	0.014	<0.002	160	<0.04	<0.002	43	4.3	4.4	<0.006	<0.006	<0.006	<0.01	0.44	<0.02	<0.005	8.5	0.004	<0.0002	<0.008	<0.01
	8/24/2010	110	<0.02		<0.001	0.0016	0.012	<0.002	110	<0.04	<0.002	28	<2	8.6	<0.006	<0.006	<0.006	<0.005	0.4	0.02	<0.005	6.2	0.011	<0.0002	<0.008	<0.01
LAC-B	11/3/2010	170	<0.02		<0.001	0.004	0.022	<0.002	170	<0.04	<0.002	40	<2	47	<0.006	<0.006	<0.006	<0.01	1.1	<0.02	<0.005	11	0.0095	<0.0002	<0.008	<0.01
	8/23/2010	130	<0.020		<0.0010	0.0021	0.014	<0.0020	130	<0.040	<0.0020	36	<2.0	10	<0.0060	<0.0060	<0.0060	<0.0050	0.53	<0.020	<0.0050	6.2	0.0076	<0.00020	<0.0080	<0.010
	11/3/2010	170	<0.02		<0.001	0.0019	0.014	<0.002	170	<0.04	<0.002	49	<2	13	<0.006	<0.006	<0.006	<0.01	0.51	<0.02	<0.005	7.9	0.0045	<0.0002	<0.008	<0.01
	1/18/2011	170	<0.02	<1	<0.001	0.002	0.015	<0.002	170	<0.04	<0.002	51	<2	12	<0.006	<0.006	<0.006	<0.005	0.48	<0.02	<0.005	7.9	0.0027	<0.0002	<0.008	<0.01
LAC-C	4/26/2011	180	<0.02		<0.001	0.0018	0.014	<0.002	180	<0.04	<0.002	55	<2	19	<0.006	<0.006	<0.006	<0.01	0.48	<0.02	<0.005	8.5	<0.002	<0.0002	<0.008	<0.01
	8/24/2010	160	<0.02		<0.001	0.0022	0.018	<0.002	160	<0.04	<0.002	49	<2	12	<0.006	<0.006	<0.006	<0.005	0.52	<0.02	<0.005	7.4	0.0065	<0.0002	<0.008	<0.01
LAC-D	11/4/2010	200	<0.02		<0.001	0.0022	0.019	<0.002	200	<0.04	<0.002	55	<2	15	<0.006	<0.006	<0.006	<0.01	0.55	<0.02	<0.005	8.9	0.0048	<0.0002	<0.008	<0.01
	8/20/2010	150	<0.020		<0.0010	0.0020	0.018	<0.0020	150	<0.040	<0.0020	44	<2.0	9.8	<0.0060	<0.0060	<0.0060	<0.0050	0.45	<0.020	<0.0050	6.8	0.010	<0.00020	<0.0080	<0.010
	1/19/2011	200	<0.02	<1	<0.001	0.0017	0.021	<0.002	200	<0.04	<0.002	60	<2	13	<0.006	<0.006	<0.006	<0.005	0.5	<0.02	<0.005	8.5	<0.002	<0.0002	<0.008	<0.01
LAC-E	4/27/2011	200	<0.02		<0.001	0.0017	0.021	<0.002	200	<0.04	<0.002	60	3.4	15	<0.006	<0.006	<0.006	<0.01	0.53	<0.02	<0.005	8.3	<0.002	<0.0002	<0.008	<0.01
	8/24/2010	170	<0.02		<0.001	0.0065	0.023	<0.002	170	0.041	<0.002	39	<2	73	<0.006	<0.006	<0.006	<0.005	1.7	<0.02	<0.005	13	<0.002	<0.0002	<0.008	<0.01
	11/3/2010	170	<0.02		<0.001	0.0062	0.024	<0.002	170	0.043	<0.002	38	<2	74	<0.006	<0.006	<0.006	<0.01	1.7	<0.02	<0.005	13	<0.002	<0.0002	<0.008	<0.01
NWS	4/26/2011	170	<0.02		<0.001	0.007	0.023	<0.002	170	<0.04	<0.002	40	<2	64	<0.006	<0.006	<0.006	<0.01	1.7	<0.02	<0.005	13	<0.002	<0.0002	<0.008	<0.01
	8/24/2010	200	<0.02		<0.001	0.0016	0.04	<0.002	200	<0.04	<0.002	77	<2	8	<0.006	<0.006	<0.006	<0.005	0.46	<0.02	<0.005	14	0.027	<0.0002	<0.008	<0.01
	11/8/2010	180	<0.02		<0.001	0.0012	0.035	<0.002	180	<0.04	<0.002	70	<2	8.5	<0.006	<0.006	<0.006	<0.01	0.45	<0.02	<0.005	15	0.0046	<0.0002	<0.008	<0.01
	1/26/2011	170	<0.1	<1	<0.001	<0.001	0.029	<0.01	170	<0.2	<0.01	67	<2	8.2	<0.03	<0.03	<0.03		0.47	<0.02	<0.025	13	<0.01	<0.0002	<0.04	<0.05
PC-A	4/20/2011	200	<0.02	<1	<0.001	<0.001	0.038	<0.002	190	<0.04	<0.002	73	<2	7.3	<0.006	<0.006	<0.006	<0.005	0.5	<0.02	<0.005	13	<0.002	<0.0002	<0.008	<0.01
	8/26/2010	180	<0.02		<0.001	0.0018	0.032	<0.002	170	<0.04	<0.002	62	4.6	6	<0.006	<0.006	<0.006	<0.01	0.51	<0.02	<0.005	13	0.01	<0.0002	<0.008	<0.01
PC-B	11/8/2010	220	<0.02		<0.001	0.0013	0.037	<0.002	220	<0.04	<0.002	70	<2	11	<0.006	<0.006	<0.006	<0.01	2.1	<0.02	<0.005	12	0.0046	<0.0002	<0.008	<0.01
	8/26/2010	200	<0.02		<0.001	0.0018	0.032	<0.002	190	<0.04	<0.002	65	9.1	6	<0.006	<0.006	<0.006	<0.01	0.86	<0.02	<0.005	12	0.016	<0.0002	<0.008	<0.01
	11/9/2010	220	0.066		<0.001	0.0022	0.032	<0.002	220	<0.04	<0.002	59	2	10	<0.006	<0.006	<0.006		3.7	<0.02	<0.005	10	0.0068	<0.0002	<0.008	<0.01
	1/25/2011	220	<0.02	<1	<0.001	0.0021	0.025	<0.002	210	<0.04	<0.002	62	2.4	10	<0.006	<0.006	<0.006	<0.01	4	0.03	<0.005	11	0.0039	<0.0002	<0.008	<0.01
PC-C	4/20/2011	200	<0.02	<1	<0.001	0.0021	0.03	<0.002	200	<0.04	<0.002	47	<2	11	<0.006	<0.006	<0.006	<0.005	3.7	<0.02	<0.005	8.5	0.0038	<0.0002	0.0087	<0.01
	8/27/2010	200	<0.02		<0.001	0.002	0.029	<0.002	190	<0.04	<0.002	64	5	6.6	<0.006	<0.006	<0.006	<0.01	1.2	<0.02	<0.005	12	0.011	<0.0002	<0.008	<0.01
	11/9/2010	190	<0.02		<0.001	0.0022	0.027	<0.002	190	<0.04	<0.002	56	<2	9.7	<0.006	<0.006	<0.006	<0.005	2	<0.02	<0.005	11	0.013	<0.0002	<0.008	<0.01
	1/25/2011	190	<0.02	<1	<0.001	0.0021	0.031	<0.002	190	<0.04	<0.002	60	<2	9.3	<0.006	<0.006	<0.006	<0.01	2	<0.02	<0.005	9.8	0.0024	<0.0002	0.0096	<0.01
PC-D	4/21/2011	200	<0.02	<1	<0.001	0.0022	0.024	<0.002	200	<0.04	<0.002	59	<2	9.7	<0.006	<0.006	<0.006	<0.005	1.9	<0.02	<0.005	10	0.0057	<0.0002	<0.008	<0.01
PCS-A	8/26/2010	200	<0.02		<0.001	0.0019	0.0099	<0.002	200	<0.04	<0.002	64	<2	8.5	<0.006	<0.006	<0.006	<0.01	1.6	0.05	<0.005	10	<0.002	<0.0002	<0.008	<0.01
PWS-1	8/19/2010	<20	540		<0.0010	0.0016	<0.10	0.14	<20	<2.0	0.14	470	<2.0	21	<0.30	1.5	80	<0.0050	51	1600	<0.25	190	24	<0.0010	<0.40	<0.50
	12/28/1982										<0.005			10			<0.05	<0.01	0.3	<0.01			<0.05	<0.001	<0.05	
	2/21/1983										<0.005			20			<0.05	<0.01	0.3	<0.01			<0.05	<0.001	<0.05	
	7/16/1992													47.2												
	11/27/1992													16.7												
SWQ-1	2/25/1993													28.9												

Appendix 8-C. Surface Water Analytical Results

Sample Location	Collection Date	Nitrate (As N)+Nitrite (As N) (mg/L)	Nitrate as N (NO3) (mg/L)	Nitrogen (mg/L)	Nitrogen, Nitrate (As N) (mg/L)	Nitrogen, Nitrite (As N) (mg/L)	pH	Phenols (mg/L)	Phosphorus, Orthophosphate (As P) (mg/L)	Potassium (mg/L)	Residue, Total (mg/L)	Selenium (mg/L)	Silica (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)
	8/25/2010	<1					7.7			4.2	500	0.0012		35	<0.005	96	640	63	38	<0.001	453	0.0019	<0.05	<0.01
	11/4/2010				0.36	<0.1	7.49			4.2		0.0011		33	<0.005	110	690	70	130	<0.001	490	0.0014	<0.05	<0.01
	1/20/2011				0.2	<0.1	7.8			3.8		0.0015		32	<0.005	100	730	78	78	<0.001	482	0.0023	<0.05	<0.01
CSCS-B	4/19/2011	<1					7.64			3.7		<0.001		29	<0.005	110	690	79	62	<0.001	491	0.003	<0.05	0.017
CSCS-C	8/25/2010	<1					7.37			2.1	890	<0.001		19	<0.005	4.7	110	3.5	530	<0.001	445	<0.001	<0.05	<0.01
	8/24/2010	<1					8.25			1.8	180	<0.001		21	<0.005	12	220	7.5	<10	<0.001	173	<0.001	<0.05	0.015
	11/3/2010	<1					8.27			2.1		<0.001		22	<0.005	18	320	9.4	<10	<0.001	218	<0.001	<0.05	0.02
LAC-A	4/26/2011				<0.1	<0.1	8.47			2.1		<0.001		21	<0.005	17	330	11	<10	<0.001	241	0.0012	<0.05	0.06
	8/24/2010	<1					8.2			2	200	<0.001		21	<0.005	17	260	9	<10	<0.001	188	<0.001	<0.05	0.014
LAC-B	11/3/2010	<1					8.19			3.3		<0.001		15	<0.005	48	480	20	<10	<0.001	292	<0.001	<0.05	<0.01
	8/23/2010	<1.0					8			2.1	220	<0.0010	42		<0.0050	21	300	11	<10	<0.0010	218	<0.0010	<0.050	<0.010
	11/3/2010	<1					7.8			2.2		<0.001		19	<0.005	24	390	15	<10	<0.001	252	<0.001	<0.05	<0.01
	1/18/2011	<1					8.06		<0.5	1.9		<0.001		19	<0.005	22	410	18	10	<0.001	266	<0.001	<0.05	0.01
LAC-C	4/26/2011				<0.1	<0.1	8.23			2		<0.001		19	<0.005	23	420	20	<10	<0.001	287	0.0011	<0.05	0.042
	8/24/2010	<1					8.08			2	260	<0.001		17	<0.005	23	370	12	<10	<0.001	255	<0.001	<0.05	<0.01
LAC-D	11/4/2010				<0.1	<0.1	8.32			2.2		<0.001		18	<0.005	28	450	13	<10	<0.001	300	<0.001	<0.05	<0.01
	8/20/2010	<1.0					8			1.9	260	<0.0010	42		<0.0050	20	330	11	11	<0.0010	236	<0.0010	<0.050	<0.010
	1/19/2011				<0.1	<0.1	8.35		<0.5	1.3		<0.001		20	<0.005	24	450	13	<10	<0.001	295	0.0012	<0.05	<0.01
LAC-E	4/27/2011				<0.1	<0.1	8.41			1.3		<0.001		19	<0.005	23	430	14	<10	<0.001	291	0.0012	<0.05	0.037
	8/24/2010	<1					7.96			3.7	350	<0.001		12	<0.005	65	580	29	<10	<0.001	342	0.0011	<0.05	0.012
	11/3/2010	<1					7.74			4		<0.001		11	<0.005	69	590	28	<10	<0.001	339	0.001	<0.05	<0.01
NWS	4/26/2011				0.21	<0.1	7.84			3.8		<0.001		12	<0.005	67	600	28	<10	<0.001	357	0.0013	<0.05	0.046
	8/24/2010	<1					8.31			1.3	360	<0.001		14	<0.005	16	510	70	<10	<0.001	344	0.002	<0.05	<0.01
	11/8/2010	<1					8.23			<1		<0.001		13	<0.005	16	490	69	<10	<0.001	316	0.0021	<0.05	0.013
	1/26/2011	<1					8.3			1		<0.001		12	<0.025	15	470	71	10	<0.001	298	0.0025	<0.25	<0.05
PC-A	4/20/2011						8.35			<1		<0.001		13	<0.005	14	510	74	<10	<0.001	330	0.0025	<0.05	0.029
	8/26/2010	<1					8.46			1.7	320	<0.001		15	<0.005	14	450	49	<10	<0.001	311	0.0016	<0.05	0.018
PC-B	11/8/2010	<1					8.23			2.9		<0.001		19	<0.005	44	580	70	<10	<0.001	378	0.0019	<0.05	<0.01
	8/26/2010	<1					8.51			1.8	350	<0.001		16	<0.005	18	470	50	15	<0.001	329	0.0016	<0.05	0.016
	11/9/2010	<1					8.36			3.2		<0.001		20	<0.005	56	580	70	<10	<0.001	371	0.0018	<0.05	0.026
	1/25/2011				0.27	<0.1	8.35			2.5		<0.001		21	<0.005	38	560	68	<10	<0.001	378	0.0022	<0.05	<0.01
PC-C	4/20/2011				<0.1	<0.1	8.39			3.1		<0.001		20	<0.005	58	560	70	<10	<0.001	373	0.0018	<0.05	0.036
	8/27/2010	<1					8.45			2.1	340	<0.001		16	<0.005	23	480	53	<10	<0.001	335	0.0019	<0.05	0.025
	11/9/2010	<1					8.3			2.8		<0.001		16	<0.005	37	500	63	<10	<0.001	316	0.0022	<0.05	<0.01
	1/25/2011				0.22	<0.1	8.37			2.9		<0.001		16	<0.005	60	490	65	<10	<0.001	330	0.0029	<0.05	<0.01
PC-D	4/21/2011				<0.1	<0.1	8.27			2		<0.001		17	<0.005	35	520	62	<10	<0.001	340	0.0026	<0.05	0.015
PCS-A	8/26/2010	1					8.04			2.4	350	0.0011		17	<0.005	33	520	56	<10	<0.001	353	0.0027	<0.05	0.047
PWS-1	8/19/2010	<1.0					2			<50	15000	0.086	150		<0.25	<50	6500	11000	<10	<0.0010	13900	1.4	<2.5	12
	12/28/1982		0.9				8					<0.005						68			250			
	2/21/1983		4.4				8					<0.005						161			470			
	7/16/1992						7.37											298.3			965			
	11/27/1992						8.31											180.8			545			
SWQ-1	2/25/1993						8.34											323.1			844			

Appendix 8-C. Surface Water Analytical Results

Sample Location	Collection Date	Alkalinity, Total (As CaCO3) (mg/L)	Aluminum (mg/L)	Ammonia (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)
	10/27/1981		<0.01			<0.01	<0.2			<0.1	<0.005	175		46	<0.01	<0.02	<0.05	<0.01	0.8	<0.05	<0.02		<0.05	0.004	<0.05	
	2/25/1982										<0.005			80			<0.05	<0.01	0.7	0.13			<0.05	<0.001	<0.05	
	5/12/1982										<0.005			108			<0.05	<0.01	0.7	<0.01			<0.05	<0.001	<0.05	
	2/21/1983										<0.005			68			<0.05	<0.01	0.7	<0.01			<0.05	<0.001	<0.05	
	5/13/1983										<0.005			84			<0.05	<0.01	0.8	<0.01			<0.05	<0.001	<0.05	
	8/9/1983										<0.005			142			<0.05	<0.01	0.7	<0.01			0.058	<0.001	<0.05	
	11/1/1983										<0.005			72			<0.05	<0.01	0.8	<0.01			<0.05	<0.001	<0.05	
	12/23/1983										<0.005			82			<0.05	<0.01	0.5	<0.01			<0.05	<0.001	<0.05	
	3/16/1984										<0.005			68			<0.05	<0.01	0.8	<0.01			<0.05	<0.001	<0.05	
	5/30/1984										<0.005			94			<0.05	<0.01	0.8	<0.01			<0.05	<0.001	<0.05	
	9/12/1984										<0.005			80			<0.05	<0.01	0.9	<0.01			<0.05	<0.001	<0.05	
	11/27/1984										<0.005			88			<0.05	<0.01	0.8	<0.01			<0.05	<0.001	<0.05	
	5/17/1985													102												
	11/13/1985													94												
	10/13/1986													136												
	7/19/1991					<0.002	<0.01		362.4		<0.005	561.1	0	217	<0.02				0.57	<0.05	<0.005	129.1	<0.02	<0.0002		
	7/16/1992													93.4												
	10/8/1992													131												
	12/15/1992													193												
	2/25/1993													136												
	6/23/1994													197												
	1/29/1995													89.2												
	3/29/1995													83.9												
	6/27/1995													127												
	9/21/1995													31.1												
	1/10/1996													167												
	4/3/1996													223												
	9/25/1996													144												
	1/15/1997													148												
SWQ-2	8/25/2010	21	1.5		<0.001	<0.001	0.01	<0.002	21	<0.04	<0.002	6.5	<2	0.71	<0.006	<0.006	0.085	<0.01	0.57	0.67	<0.005	2.4	0.015	<0.0002	<0.008	<0.01
	10/27/1981		<0.01			<0.01	<0.2			<0.01	<0.005	107		46	<0.01	<0.02	<0.05	<0.01	0.6	<0.05	<0.02		<0.05	<0.001	<0.05	
SWQ-2A	2/25/1982										<0.005			50			<0.05	<0.01	0.7	0.1			<0.05	<0.001	<0.05	
	7/19/1991					<0.002	0.03		270.9		<0.005	334.1	0	144	<0.02				0.73	0.14	<0.005	84.6	<0.02	<0.0002		
	8/29/1991												0	231			0.015									
	11/26/1991													141			0.001									
	3/15/1992													99.2												
	5/25/1992													103												
	7/16/1992													129												
	10/8/1992													174												
	11/27/1992													161												
	12/15/1992													222												
	2/25/1993													151												
SWQ-3	9/28/1993													227												

Appendix 8-C. Surface Water Analytical Results

Sample Location	Collection Date	Nitrate (As N)+Nitrite (As N) (mg/L)	Nitrate as N (NO3) (mg/L)	Nitrogen (mg/L)	Nitrogen, Nitrate (As N) (mg/L)	Nitrogen, Nitrite (As N) (mg/L)	pH	Phenols (mg/L)	Phosphorus, Orthophosphate (As P) (mg/L)	Potassium (mg/L)	Residue, Total (mg/L)	Selenium (mg/L)	Silica (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)
	10/27/1981		6.6	<0.05			8.7	<0.005				<0.005			<0.02			460			1060			
	2/25/1982		4.2				8.1					<0.005						658			1360			
	5/12/1982		3				7.9					<0.005						700			1380			
	2/21/1983		0.8				8.4					<0.005						445			990			
	5/13/1983		0.3				8.4					<0.005						517			1120			
	8/9/1983		<0.2				8					<0.005						675			1620			
	11/1/1983		0.3				8.2					<0.005						553			1170			
	12/23/1983		11.2				8					<0.005						550			1180			
	3/16/1984		5.3				8.3					<0.005						515			1140			
	5/30/1984		0.4				8.1					<0.005						720			1420			
	9/12/1984		0.4				8.1					<0.005						577			1190			
	11/27/1984		<0.2				8.2					<0.005						675			1360			
	5/17/1985						8											770			1640			
	11/13/1985						7.9											770			1590			
	10/13/1986						7.9											830			1840			
	7/19/1991		12.74				7.57			10.9		<0.001			<0.02	264.3	4310	1585.5			3019			
	7/16/1992						7.57											1154.9			2305			
	10/8/1992						7.53											1470.5			2685			
	12/15/1992						7.61											1613			3108			
	2/25/1993						7.58											1459.3			2713			
	6/23/1994						8.87											2369			3958			
	1/29/1995						7.64											1286.2			2653			
	3/29/1995						7.83											1388.2			2866			
	6/27/1995						7.74											1877			3235			
	9/21/1995						7.58											271.2			500			
	1/10/1996						7.37											2336.9			3991			
	4/3/1996						8.06											2566.3			4464			
	9/25/1996						7.66											1987			3997			
	1/15/1997						7.43											1356			3436			
SWQ-2	8/25/2010	<1					7.42			1.9	130	<0.001		12	<0.005	3.3	89	11	35	<0.001	78	<0.001	<0.05	<0.01
	10/27/1981		0.3	<0.05			8.2	<0.005				<0.005			<0.02			360			830			
SWQ-2A	2/25/1982		0.2				8.4					<0.005						320			800			
	7/19/1991		1.39				7.52			7.4		<0.001			<0.02	189.5	3120	1108.2			2191			
	8/29/1991						7.82											1884.2			3596			
	11/26/1991						7.71											1419			2857			
	3/15/1992						8.08											1247.6			2393			
	5/25/1992						8.07											1185.2			2380			
	7/16/1992						7.66											1654			3364			
	10/8/1992						7.49											1667.4			3611			
	11/27/1992						8.35											952.2			1866			
	12/15/1992						8.15											1549.4			3436			
	2/25/1993						8.01											1573.7			2974			
SWQ-3	9/28/1993						8.13											1254			4432			

Appendix 8-C. Surface Water Analytical Results

Sample Location	Collection Date	Alkalinity, Total (As CaCO3) (mg/L)	Aluminum (mg/L)	Ammonia (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)
	6/23/1994													157												
	1/29/1995													238												
	3/29/1995													101												
	6/27/1995													200												
	9/21/1995													179												
	1/10/1996													112												
	4/3/1996													157												
	9/25/1996													96.7												
	1/15/1997													148												
	8/19/2010	250	<0.020		<0.0010	<0.0010	0.062	<0.0020	250	0.14	<0.0020	530	<2.0	130	<0.0060	<0.0060	0.062	<0.0050	1.5	0.055	<0.0050	190	0.14	<0.00020	0.047	<0.010
	10/21/2010	530	<0.02		<0.001	<0.005	0.053	<0.002	530	0.089	<0.002	630	<2	93	<0.006	<0.006	0.023		1.3	0.049	<0.005	260	0.032	<0.0002	0.03	<0.01
SWQ-3	4/27/2011	430	<0.02		<0.001	<0.001	0.032	<0.002	430	0.075	<0.002	610	<2	74	<0.006	<0.006	0.011	<0.01	1.4	<0.02	<0.005	210	0.027	<0.0002	0.022	<0.01
	8/25/2010	220	<0.02		<0.001	<0.001	0.01	<0.002	220	<0.04	<0.002	7.2	<2	17	<0.006	<0.006	<0.006	<0.01	16	<0.02	<0.005	<1	0.021	<0.0002	<0.008	<0.01
	11/4/2010	230	<0.02		<0.001	<0.001	0.0098	<0.002	230	0.066	<0.002	7.4	<2	18	<0.006	<0.006	<0.006	<0.01	15	<0.02	<0.005	<1	0.015	<0.0002	<0.008	<0.01
	1/20/2011	240	<0.02	<1	<0.001	<0.001	0.01	<0.002	240	0.069	<0.002	7.5	<2	18	<0.006	<0.006	<0.006	<0.01	15	<0.02	<0.005	<1	0.0093	<0.0002	<0.008	<0.01
WS	4/19/2011	240	<0.02	<1	<0.001	<0.001	0.012	<0.002	240	0.071	<0.002	7.5	<2	18	<0.006	<0.006	<0.006	<0.01	19	<0.02	<0.005	<1	0.03	<0.0002	<0.008	<0.01
	8/25/2010	200	0.74		<0.001	0.0081	0.016	<0.002	200	<0.04	<0.002	9.5	<2	8.6	<0.006	<0.006	<0.006	<0.01	13	0.36	<0.005	1.2	0.018	<0.0002	0.011	<0.01
WSCS-A	1/20/2011	400	0.18	<1	<0.001	0.0031	0.063	<0.002	400	0.043	<0.002	50	<2	50	<0.006	<0.006	<0.006	<0.01	6.4	0.12	<0.005	6.3	0.006	<0.0002	0.011	<0.01

Notes:
Blank indicates not analyzed.
Metals analyzed using EPA Method 200.7/200.8/245.1/9012B and reported in mg/L

Appendix 8-C. Surface Water Analytical Results

Sample Location	Collection Date	Nitrate (As N)+Nitrite (As N) (mg/L)	Nitrate as N (NO3) (mg/L)	Nitrogen (mg/L)	Nitrogen, Nitrate (As N) (mg/L)	Nitrogen, Nitrite (As N) (mg/L)	pH	Phenols (mg/L)	Phosphorus, Orthophosphate (As P) (mg/L)	Potassium (mg/L)	Residue, Total (mg/L)	Selenium (mg/L)	Silica (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)
	6/23/1994						8.37											1712			2934			
	1/29/1995						7.93											1671.7			3185			
	3/29/1995						8.23											1709.7			3216			
	6/27/1995						7.51											1792.4			3393			
	9/21/1995						8.73											2382			3741			
	1/10/1996						7.78											1936.6			3666			
	4/3/1996																	2236.3			3635			
	9/25/1996						7.64											1153			2568			
	1/15/1997						8.13											1356			3436			
	8/19/2010	<1.0					8			5.7	4700	0.013	40		<0.0050	490	4100	2900	<10	<0.0010	4500	0.029	<0.050	0.023
	10/21/2010	<1					7.99			4.3		0.016		19	<0.005	520	4600	3100	<10	<0.001	5080	0.027	<0.05	0.48
SWQ-3	4/27/2011				0.15	<0.1	7.92			3.8		0.0065		18	<0.005	410	4400	2900	23	<0.001	4590	0.012	<0.05	0.031
	8/25/2010	<1					8.3			10	590	<0.001		64	<0.005	160	720	89	<10	<0.001	597	<0.001	<0.05	0.016
	11/4/2010				<0.1	<0.1	7.88			11		<0.001		62	<0.005	160	760	88	<10	<0.001	592	<0.001	<0.05	<0.01
	1/20/2011				<0.1	<0.1	8.13			10		<0.001		65	<0.005	160	800	100	<10	<0.001	581	<0.001	<0.05	<0.01
WS	4/19/2011	<1					8.08			11		<0.001		65	<0.005	160	750	120	<10	<0.001	617	<0.001	<0.05	<0.01
	8/25/2010	3.3					8.38			7.8	1200	<0.001		19	<0.005	130	600	65	420	<0.001	780	<0.001	<0.05	<0.01
WSCS-A	1/20/2011				2.7	<0.1	8.26			11		0.0018		13	<0.005	290	1600	300	900	<0.001	1000	0.0054	<0.05	<0.01

Notes:
Blank indicates not analyzed.
Metals analyzed using EPA Method 200.7/200.8/245.1/9012B and reported in mg/L

Appendix 8-D

Surface Sediment Analytical Results

Appendix 8-D. Surface Sediment Analytical Results

Sample Location	Collection Date	Aluminum (mg/L)	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Boron (mg/L)	Cadmium (mg/L)	Calcium (mg/L)	Chromium (mg/L)	Cobalt (mg/L)	Copper (mg/L)	Cyanide (mg/L)	Iron (mg/L)	Lead (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Molybdenum (mg/L)	Nickel (mg/L)	Potassium (mg/L)	Selenium (mg/L)	Silicon (mg/L)	Silver (mg/L)	Sodium (mg/L)	Thallium (mg/L)	Uranium (mg/L)	Vanadium (mg/L)	Zinc (mg/L)
LAC-E	5/4/2011	0.48	<0.001	<0.001	0.01	<0.002	0.073	<0.002	8.5	<0.006	<0.006	<0.006	<0.01	0.24	<0.005	<1	0.022	<0.0002	<0.008	<0.01	<1	<0.001	4.6	<0.005	13	<0.001	<0.001	<0.05	<0.01
PC-C	4/20/2011	0.37	<0.001	0.0021	0.0079	<0.002	<0.04	<0.002	9.8	<0.006	<0.006	0.0096		0.21	<0.005	1.2	0.017	<0.0002	<0.008	<0.01	<1	<0.001	4.3	<0.005	16	<0.001	<0.001	<0.05	<0.01
SWQ-2	4/28/2011	<0.02	<0.001	<0.001	0.019	<0.002	<0.04	<0.002	79	<0.006	<0.006	0.014	<0.01	<0.02	<0.005	15	0.003	<0.0002	0.0082	<0.01	2.9	0.0022	3.3	<0.005	41	<0.001	<0.001	<0.05	<0.01
SWQ-3	4/27/2011	0.079	<0.001	<0.001	0.023	<0.002	<0.04	<0.002	73	<0.006	<0.006	<0.006	<0.01	0.033	<0.005	10	<0.02	<0.0002	0.011	<0.01	<1	0.0013	2.9	<0.005	25	<0.001	0.0014	<0.05	<0.01

Notes:

Blank indicates not analyzed.

Sediment samples were analyzed as leachate and so units were reported in mg/L.

Metals analyzed using EPA Method 200.7/200.8/245.1/9012B and reported in mg/L

Appendix 8-E

Pit Lake Analytical Results

Appendix 8-E. Pit Lake Analytical Results

Sample Location	Depth	Collection Date	Alkalinity, Total (As CaCO3) (mg/L)	Aluminum (mg/L)	Ammonia (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)
PL-WQ	NA	4/3/1989		<0.1				<0.1	<0.1	96.4	<0.1	<0.1	570		47.3	<0.1	<0.05	<0.1			<0.1	<0.1	130	1.1		<0.1
		11/14/1990													102.2											
		2/11/1991					<0.001	<0.01		54.9		0.035	600	0	79.8	0.06				4.58	0.16	0.006	155.6	1.82	0.0004	
		7/19/1991					<0.002	<0.01		87.9		<0.005	684.1	0	88.6	<0.02				6.25	0.27	<0.005	209.1	2.03	<0.0002	
		8/29/1991													88.9			0.64								
		11/26/1991													86.6			0.084								
		3/15/1992													85.3											
		5/25/1992													89.7											
		7/16/1992													76.1											
		10/8/1992													90.1											
		11/27/1992													730.5											
		12/15/1992													88.5			3.208								
		2/25/1993													92.1											
		9/28/1993													111.2			0.001						0.02		
		3/17/1994													101.4			0.089						4.43		
		9/22/1994													140.9											
		12/12/1994		<0.05		<0.005	<0.005	<0.1	<0.002	102	<0.1	0.017	580	0	140	<0.025	<0.05	0.03		8.1	<0.05	<0.005	250	3.6	<0.001	<0.05
		12/19/1994		<0.05		<0.005	<0.005	<0.1	<0.002	104	<0.1	0.017	550	0	130	<0.025	<0.05	0.032		8.1	<0.05	<0.005	250	3.4	<0.001	<0.05
		1/29/1995													217.6											
		3/29/1995													108.6											
		6/27/1995													161.4											
		9/21/1995		0.13		<0.005	<0.005	<0.05	<0.002	122	<0.1	0.014	620	0	150	<0.025	<0.05	<0.025		10	<0.05	<0.005	300	3	<0.001	<0.05
		1/10/1996													182.8											
		4/3/1996													188.9											
		9/25/1996													199.6											
		1/15/1997													216											
		1/30/2010	<20	5.5		<0.0025	0.0062	<0.010	0.017	<20	<0.20	0.056	540	<2.0	390	<0.030	0.37	11	<0.005	18	1.3	<0.025	570	41	<0.00020	<0.040
PL-WQ-01	28 ft	9/10/2010	<20	1.6	<1	<0.001	<0.001	0.012	0.016	<20	0.13	0.064	570	<2	400	<0.006	0.35	1.9	<0.01	18	0.025	0.0054	630	44	<0.0002	0.015
PL-WQ-03	3 ft	9/10/2010	<20	1.7	<1	<0.001	<0.001	0.012	0.016	<20	0.13	0.063	580	<2	400	<0.006	0.34	2	<0.01	17	0.032	<0.005	640	45	<0.0002	0.015
PL-WQ-04	composite	9/10/2010	<20	1.6	<1	<0.001	<0.001	0.011	0.015	<20	0.13	0.061	560	<2	380	<0.006	0.33	1.9	<0.01	15	0.024	0.0056	610	43	<0.0002	0.015
PL-WQ-05	7 ft	1/20/2011	31	0.48	<1	<0.001	<0.001	0.01	0.016	31	<0.2	0.062	570	<2	380	<0.03	0.39	0.61	<0.01	15	<0.1	<0.025	640	42	<0.0002	<0.04
PL-WQ-06	17 ft	1/20/2011	31	0.51	<1	<0.001	<0.001	0.011	0.016	31	<0.2	0.062	570	<2	380	<0.03	0.38	0.59	<0.01	16	<0.1	<0.025	640	44	<0.0002	<0.04
PL-WQ-07	26 ft	1/20/2011	30	0.54	<1	<0.005	<0.005	0.012	0.016	30	<0.2	0.061	590	<2	400	<0.03	0.39	0.64	<0.01	16	<0.1	0.026	660	39	<0.0002	<0.04
PL-WQ-08	composite	1/20/2011	30	0.48	<1	<0.005	<0.005	0.01	0.015	30	<0.2	0.06	520	<2	380	<0.03	0.37	0.59	<0.01	16	<0.1	<0.025	590	44	<0.0002	<0.04
PL-WQ-09	1 ft	4/14/2011	41	0.13	<1	<0.001	<0.001	0.012	0.01	41	0.16	0.059	610	<2	420	<0.006	0.34	0.11	<0.01	17	<0.02	<0.005	680	44	<0.0002	0.025
PL-WQ-10	3 ft	4/14/2011	41	0.13	<1	<0.001	<0.001	0.012	0.01	41	0.16	0.057	600	<2	420	<0.006	0.33	0.11	<0.01	16	<0.02	<0.005	670	41	<0.0002	0.023
PL-WQ-11	16 ft	4/14/2011	41	0.14	<1	<0.001	<0.001	0.011	0.011	41	0.16	0.058	590	<2	400	<0.006	0.34	0.12	<0.01	16	<0.02	0.0055	660	41	<0.0002	0.024
PL-WQ-12	composite	4/14/2011	41	0.13	<1	<0.001	<0.001	0.012	0.01	41	0.16	0.059	600	<2	410	<0.006	0.34	0.12	<0.01	16	<0.02	<0.005	670	42	<0.0002	0.024
PL-WQ-13	2 ft	7/20/2011	48	0.029		<0.002	0.0073	0.014	0.0047	48	0.18	0.053	670	<2	470	<0.006	0.28	<0.006	<0.01	19	<0.02	<0.005	770	48	<0.0002	0.023
PL-WQ-14	11 ft	7/20/2011	48	0.021		<0.002	0.0077	0.014	0.0046	48	0.19	0.054	640	<2	460	<0.006	0.29	<0.006	0.011	18	<0.02	<0.005	780	46	<0.0002	0.024
PL-WQ-15	23.5 ft	7/20/2011	46	<0.02		<0.002	0.0066	0.013	0.0044	46	0.17	0.053	620	<2	430	<0.006	0.28	<0.006	<0.01	18	<0.02	<0.005	750	45	<0.0002	0.025
PL-WQ-16	composite	7/20/2011	47	<0.02		<0.005	0.0064	0.013	0.0043	47	0.18	0.053	640	<2	450	<0.006	0.28	<0.006	<0.01	19	<0.02	0.0051	770	46	<0.0002	0.025
PL-C2-WI	Sediment	9/9/2010		6100		<25	<25	2.9	3.9		<20	2	20000		890	<3	11	1400	<3.1	45	9300	4.1	610	380	<0.13	8.5

Metals analyzed using EPA Method 200.7/200.8/245.1/9012B and reported in mg/L

Appendix 8-E. Pit Lake Analytical Results

Sample Location	Depth	Collection Date	Nickel (mg/L)	Nitrate (As N)+Nitrite (As N) (mg/L)	Nitrate as N (NO3) (mg/L)	Nitrogen (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)
PL-WQ	NA	4/3/1989				<0.1				11			<0.1	165		2240			3546			0.4
		11/14/1990														2770			4064			
		2/11/1991			0.1				7.14	16.4	<0.001		0.03	223.6	3980	2437			2711			
		7/19/1991			0.03				7.76	20.3	<0.001		<0.02	248	6340	2920			4520			
		8/29/1991							7.61							2674.2			4384			
		11/26/1991							7.61							2540			4175			
		3/15/1992							4.88							2857			3819			
		5/25/1992							4.82							2665			3846			
		7/16/1992							4.36							2397.3			4229			
		10/8/1992							4.85							2706			4258			
		11/27/1992							6.26							2499.5			3900			
		12/15/1992							6.04							2902			4151			
		2/25/1993							6.29							2748			3951			
		9/28/1993							6.71							1566			4468			0.01
		3/17/1994							7.46							2670			3179			1.01
		9/22/1994							8.04							0			5124			
		12/12/1994			<5	<0.05			7.71	17	<0.005		<0.025	350	4720	2910		<0.005	4600			0.095
		12/19/1994			<5	<0.05			7.52	18	<0.005		<0.025	320	4690	2970		<0.005	4380			0.092
		1/29/1995							7.69							2906			4675			
		3/29/1995							7.53							2609.5			4891			
		6/27/1995														2923.8			5640			
		9/21/1995			<5	<0.05			8.31	21	<0.25		<0.025	430	5230	3170		0	5230			0.071
		1/10/1996							7.9							3452.1			5398			
		4/3/1996							7.95							3304.4			5378			
		9/25/1996							8.26							3290			6041			
		1/15/1997							8.05							3509			5772			
		1/30/2010	0.067	<2.0					6	25	0.031		<0.025	690	5700	5200		<0.0050	7770			6.4
PL-WQ-01	28 ft	9/10/2010	0.068	<1					6.67	26	0.022	6.6	<0.005	750	6600	6200	<10	<0.001	8400	0.12	<0.05	6.7
PL-WQ-03	3 ft	9/10/2010	0.067	<1					6.71	26	0.021	6.7	<0.005	760	6700	5600	<10	<0.005	8390	0.12	<0.05	6.8
PL-WQ-04	composite	9/10/2010	0.065	<1					6.7	26	0.023	6.5	<0.005	730	6700	6000	<10	<0.005	8340	0.11	<0.05	6.6
PL-WQ-05	7 ft	1/20/2011	0.069				<0.1	<0.1	7.17	29	0.025	6.1	<0.025	740	7900	5700	<10	<0.001	8170	0.11	<0.25	5.8
PL-WQ-06	17 ft	1/20/2011	0.066				<0.1	<0.1	7.19	29	0.025	6	<0.025	740	8000	5600	12	<0.005	8120	0.11	<0.25	5.7
PL-WQ-07	26 ft	1/20/2011	0.068				<0.1	<0.1	7.18	29	0.031	6.1	<0.025	760	8000	5900	<10	<0.005	8210	0.11	<0.25	6
PL-WQ-08	composite	1/20/2011	0.066				<0.1	<0.1	7.23	28	0.03	5.9	<0.025	680	8000	5500	14	<0.005	7780	0.11	<0.25	5.3
PL-WQ-09	1 ft	4/14/2011	0.061				<0.1	<0.1	7.62	32	0.019	5.5	<0.005	800	7800	5600	<10	<0.001	8590	0.11	<0.05	5.2
PL-WQ-10	3 ft	4/14/2011	0.058				<0.1	<0.1	7.68	32	0.019	5.8	<0.005	790	7800	5800	<10	<0.001	8700	0.12	<0.05	5
PL-WQ-11	16 ft	4/14/2011	0.059				<0.1	<0.1	7.69	32	0.02	5.7	<0.005	770	7800	5700	<10	<0.001	8600	0.12	<0.05	5.1
PL-WQ-12	composite	4/14/2011	0.06				0.1	<0.1	7.72	32	0.023	5.9	<0.005	780	7800	5700	<10	<0.001	8390	0.11	<0.05	5
PL-WQ-13	2 ft	7/20/2011	0.039				<0.1	<2	7.71	35	0.033	5.4	<0.025	870	8300	6400	<10	<0.002	9520	0.12	<0.05	2.4
PL-WQ-14	11 ft	7/20/2011	0.04				0.24	<2	7.83	35	0.033	5.4	<0.005	920	8300	6200	<10	<0.002	9680	0.12	<0.05	2.5
PL-WQ-15	23.5 ft	7/20/2011	0.038				<0.1	<2	7.83	34	0.034	5.2	<0.025	890	8100	6200	<10	<0.002	9350	0.12	<0.05	2.5
PL-WQ-16	composite	7/20/2011	0.039				<0.1	<2	7.86	34	0.035	5.3	<0.005	900	8200	6400	<10	<0.005	9410	0.12	<0.05	2.4
PL-C2-WI	Sediment	9/9/2010	<5				<1.2	<1.2	6.76	<500	<25		<2.5	460		26000		<25		<500	<25	240

Metals analyzed using EPA Method 200.7/200.8/245.1/9012B and reported in mg/L

Appendix 8-F

Pit Lake Sediment Analytical Results

Appendix 8-F. Pit Lake Sediment Analytical Results

Sample Location	Depth	Collection Date	Aluminum (mg/Kg)	Antimony (mg/Kg)	Arsenic (mg/Kg)	Barium (mg/Kg)	Beryllium (mg/Kg)	Boron (mg/Kg)	Cadmium (mg/Kg)	Calcium (mg/Kg)	Chloride (mg/Kg)	Chromium (mg/Kg)	Cobalt (mg/Kg)	Copper (mg/Kg)	Cyanide (mg/Kg)	Fluoride (mg/Kg)	Iron (mg/Kg)	Lead (mg/Kg)	Magnesium (mg/Kg)	Manganese (mg/Kg)	Mercury (mg/Kg)	Molybdenum (mg/Kg)	Nickel (mg/Kg)	Nitrogen, Nitrate (As N) (mg/Kg)	Nitrogen, Nitrite (As N) (mg/Kg)	pH	Potassium (mg/Kg)	Selenium (mg/Kg)	Silver (mg/Kg)	Sodium (mg/Kg)	Sulfate (mg/Kg)	Thallium (mg/Kg)	Uranium (mg/Kg)	Vanadium (mg/Kg)	Zinc (mg/Kg)
PL-C2-WI	Sediment	9/9/2010	6100	<25	<25	2.9	3.9	<20	2	20000	890	<3	11	1400	<3.1	45	9300	4.1	610	380	<0.13	8.5	<5	<1.2	<1.2	6.76	<500	<25	<2.5	460	26000	<25	<500	<25	240

Notes:
Blank indicates not analyzed.
Sediment samples were analyzed as soil and so units were reported in mg/Kg.
Metals analyzed using EPA Method 200.7/200.8/245.1/9012B and reported in mg/Kg.

Appendix 8-G

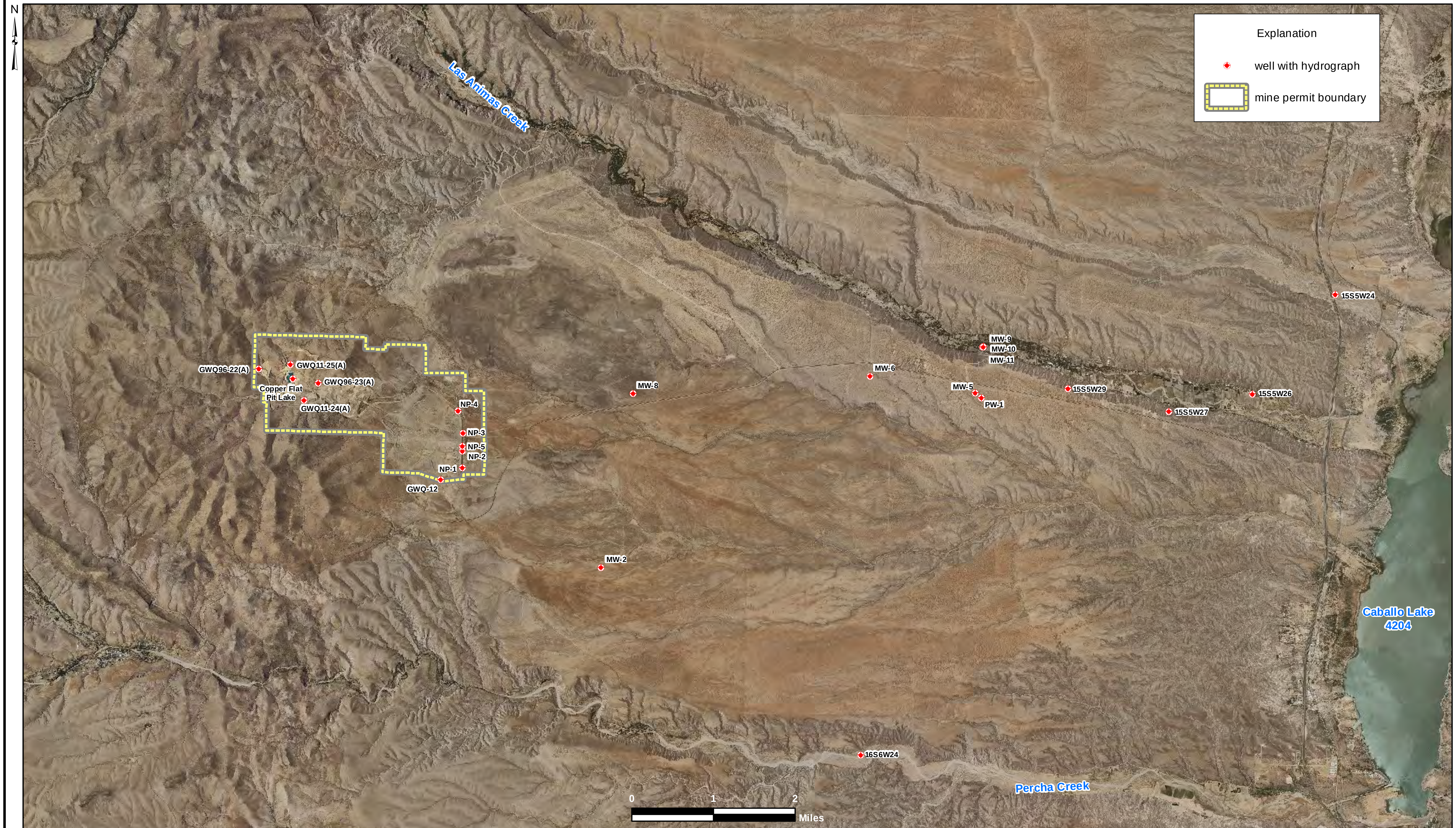
Water Level Data

Water Level Data

Historical and baseline water level data were evaluated for short-term and long-term trends. Short-term trends are based on multiple measurements over the last few years (2010 to current), and long-term trends are based on measurements collected between the 1970s to current. Historical water level data were compiled from the USGS database (and from measurements collected in support of previous mining operations and permits [Quintana Minerals, Gold Express, and Alta Gold]). Water level data collected for the Baseline Data Report were incorporated with the historical data. A summary of the wells selected for constructing hydrographs is presented as Table J1. Locations are shown on Figure JA.

Table J1. Summary of wells selected for constructing hydrographs

Name	Total Depth (ft bgl)	Measuring Point Elevation (ft amsl)	Aquifer	Number of Measurements	Period of Record
Copper Flat Pit Lake	40	5,440.00	Crystalline bedrock	9	Jun – Dec 2011
GWQ96-22(A)	244	5,596.17	Crystalline bedrock	9	Jan 2010 – Dec 2011
GWQ96-23(A)	100	5,489.84	Crystalline bedrock	11	Jan 2010 – Dec 2011
GWQ11-24(A)	146	5,517.37	Crystalline bedrock	6	Aug – Dec 2011
GWQ11-25(A)		5,533.60	Crystalline bedrock	6	Aug – Dec 2011
NP-1	106	5,188.75	Santa Fe Group	70	Oct 1981 – May 2011
NP-2	98	5,192.54	Santa Fe Group	74	Oct 1981 – May 2011
NP-3	79	5,199.73	Santa Fe Group	114	Oct 1981 – May 2011
NP-4	102	5,225.73	Santa Fe Group	60	Apr 1982 – May 2011
NP-5	44	5,198.81	Santa Fe Group	99	Nov 1981 – May 2011
GWQ-12	137	5,237.08	Santa Fe Group	35	May 1982 – Dec 2011
MW-2	1,500	5,007.39	Santa Fe Group	6	May 1975 – Jan 2009
MW-5	1,300	4,712.47	Santa Fe Group	10	Feb 1977 – Dec 2011
MW-6	1,000	4,768.33	Santa Fe Group	20	Jan 1976 – Dec 2011
MW-8	1,000	5,023.65	Santa Fe Group	5	Feb 1984 – Feb 2009
MW-9	252	4,454.32	Santa Fe Group	40	Sept 1994 – Dec 2011
MW-10	125	4,453.67	Santa Fe Group	31	Oct 1994 – Dec 2011
MW-11	65	4,454.00	Quaternary alluvium	27	Oct 1994 – Dec 2011
PW-1	960	4,707.67	Santa Fe Group	36	Dec 1975 – Dec 2011
15S5W24	60	4,279.00	Quaternary alluvium	166	May 1974 – May 2005
15S5W26	70	4,280.00	Quaternary alluvium	12	Feb 1972 – Feb 2009
15S5W27	30	4,315.00	Quaternary alluvium	6	Feb 1984 – Feb 2009
15S5W29	168	4,385.00	Santa Fe Group	13	May 1974 – Feb 2009
16S6W24	120	4,515.00	Quaternary alluvium	3	Jul 1974 – Jan 2004



Source: NAIP 2009 imagery, RGIS.

Figure A. Hydrograph location map.

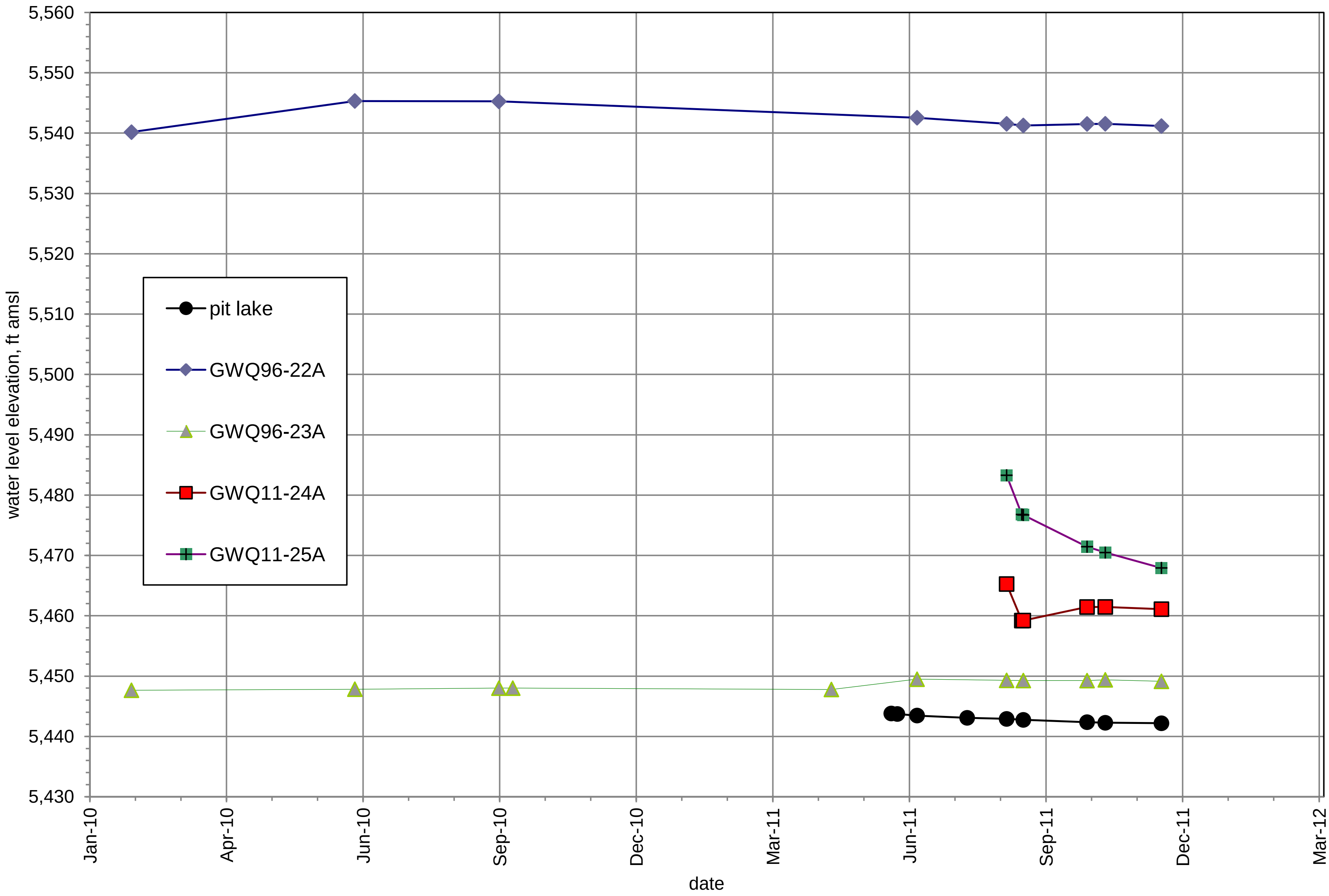


Figure B. Hydrograph of pit lake and monitoring wells surrounding pit lake, Copper Flat Mine area.

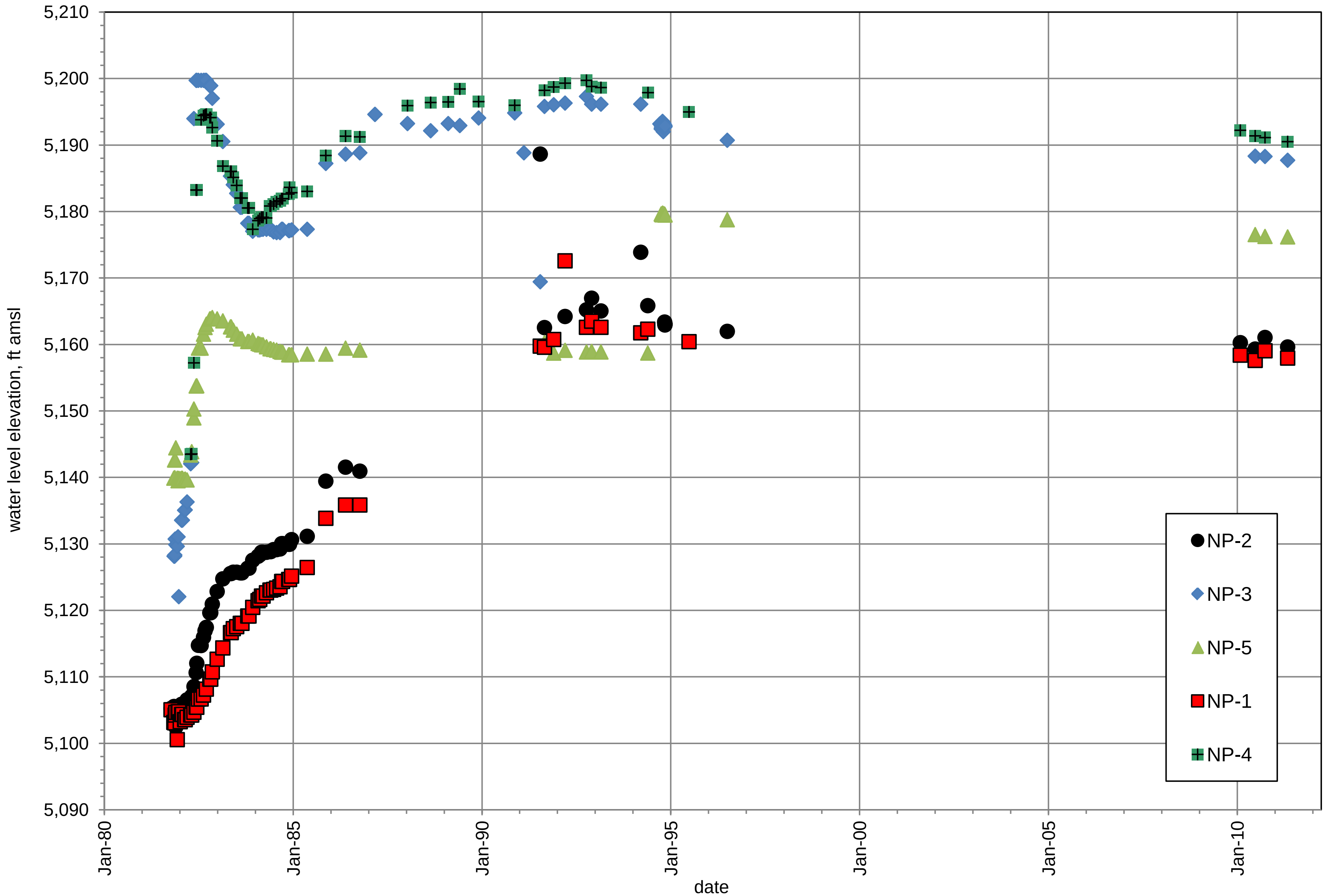


Figure C. Hydrograph of monitoring wells NP-1, NP-2, NP-3, NP-4, and NP-5, Copper Flat tailings impoundment area.

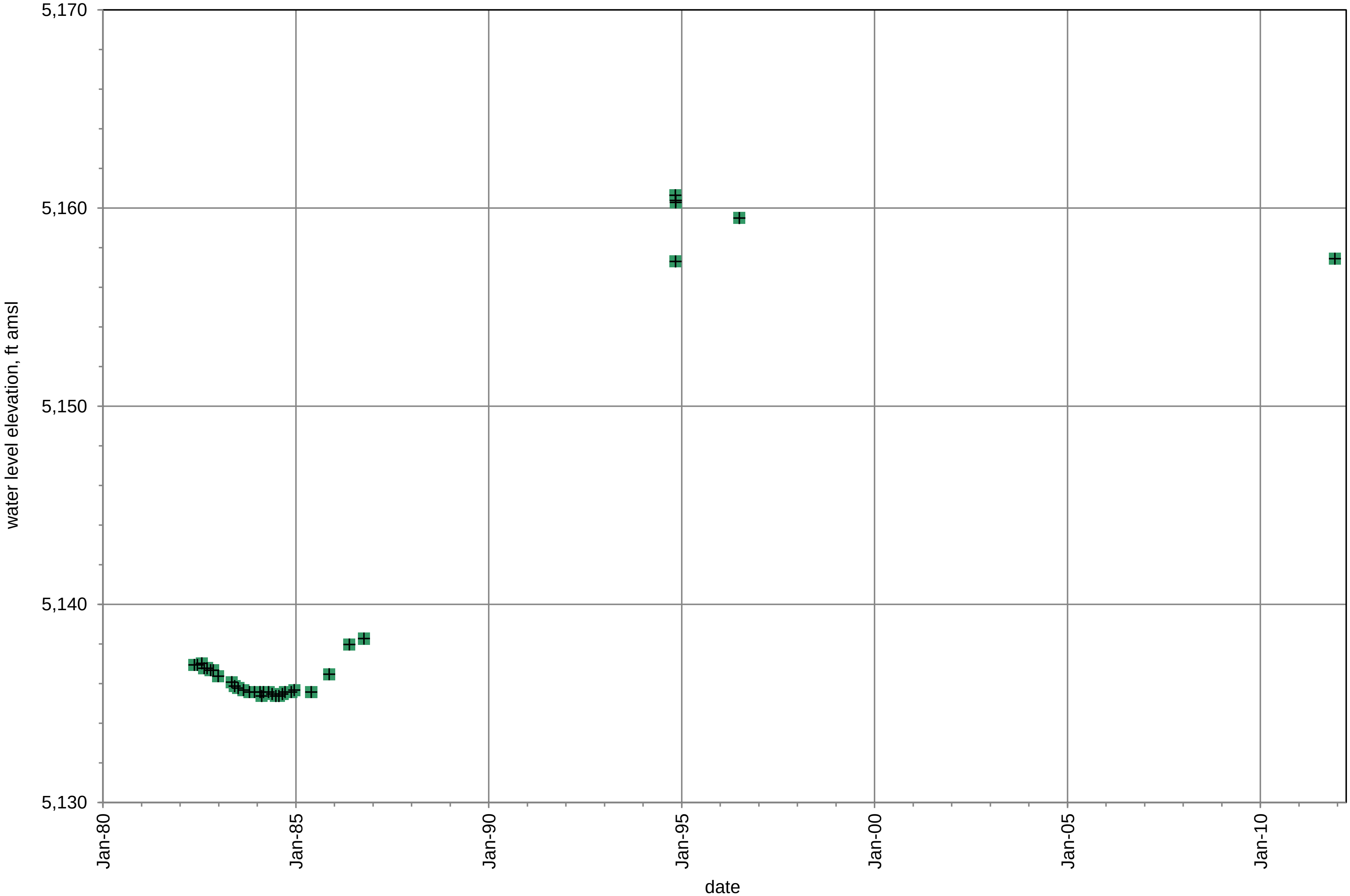


Figure D. Hydrograph of monitoring well GWQ-12, Copper Flat tailings impoundment area.

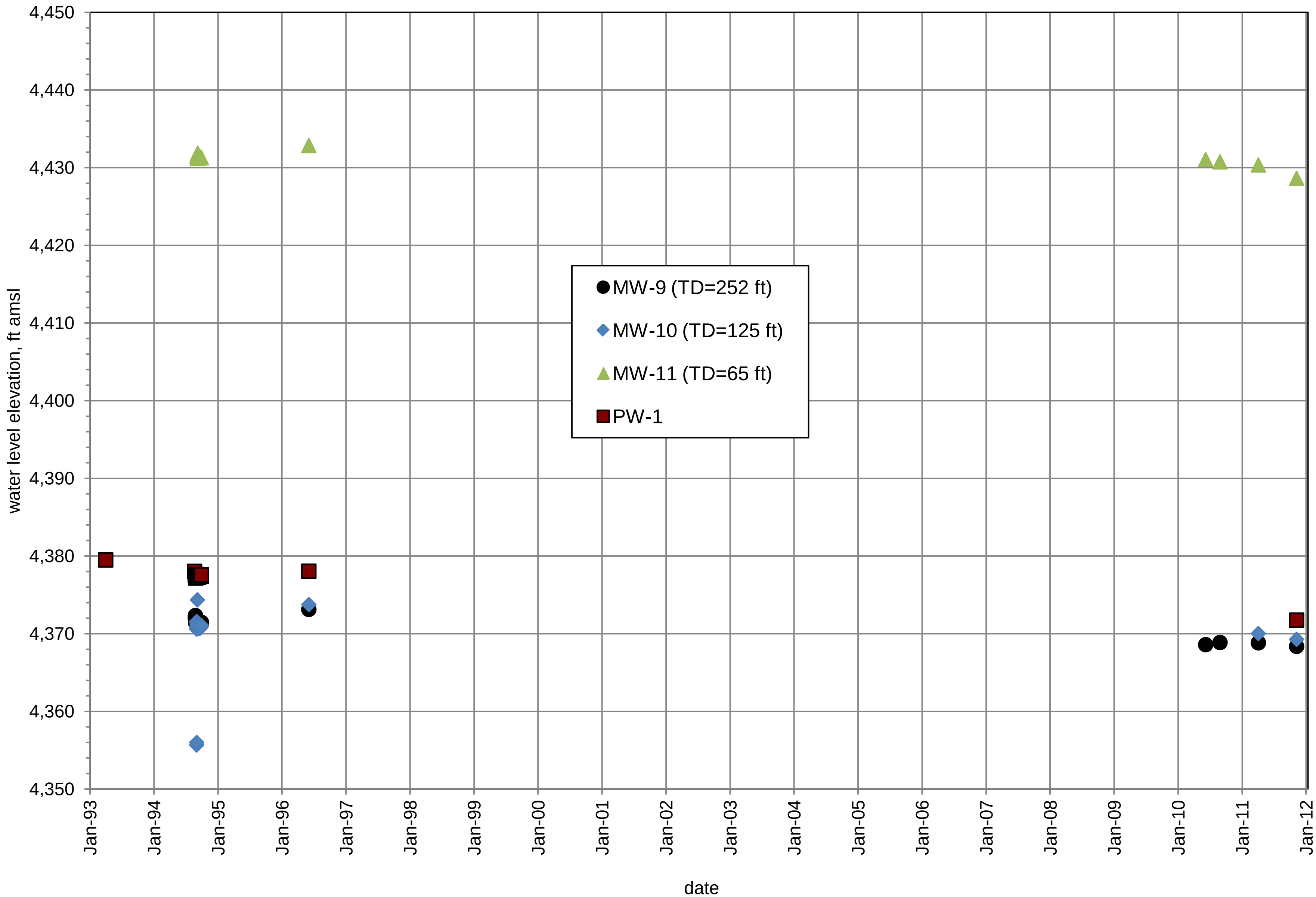


Figure E. Hydrograph of PW-1 and observation wells MW-9, MW-10, and MW-11.

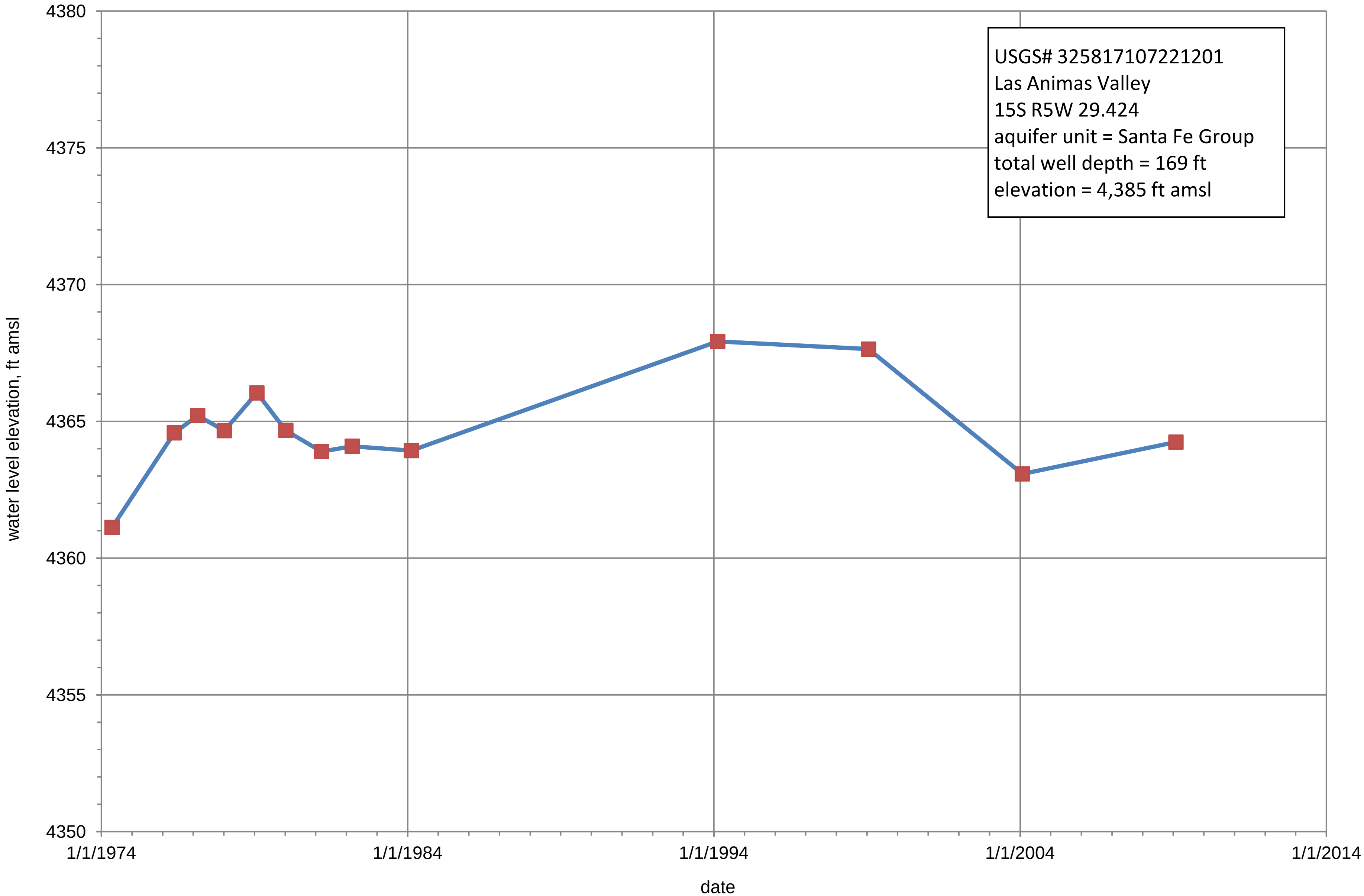


Figure F. Hydrograph of Well 15S5W29.

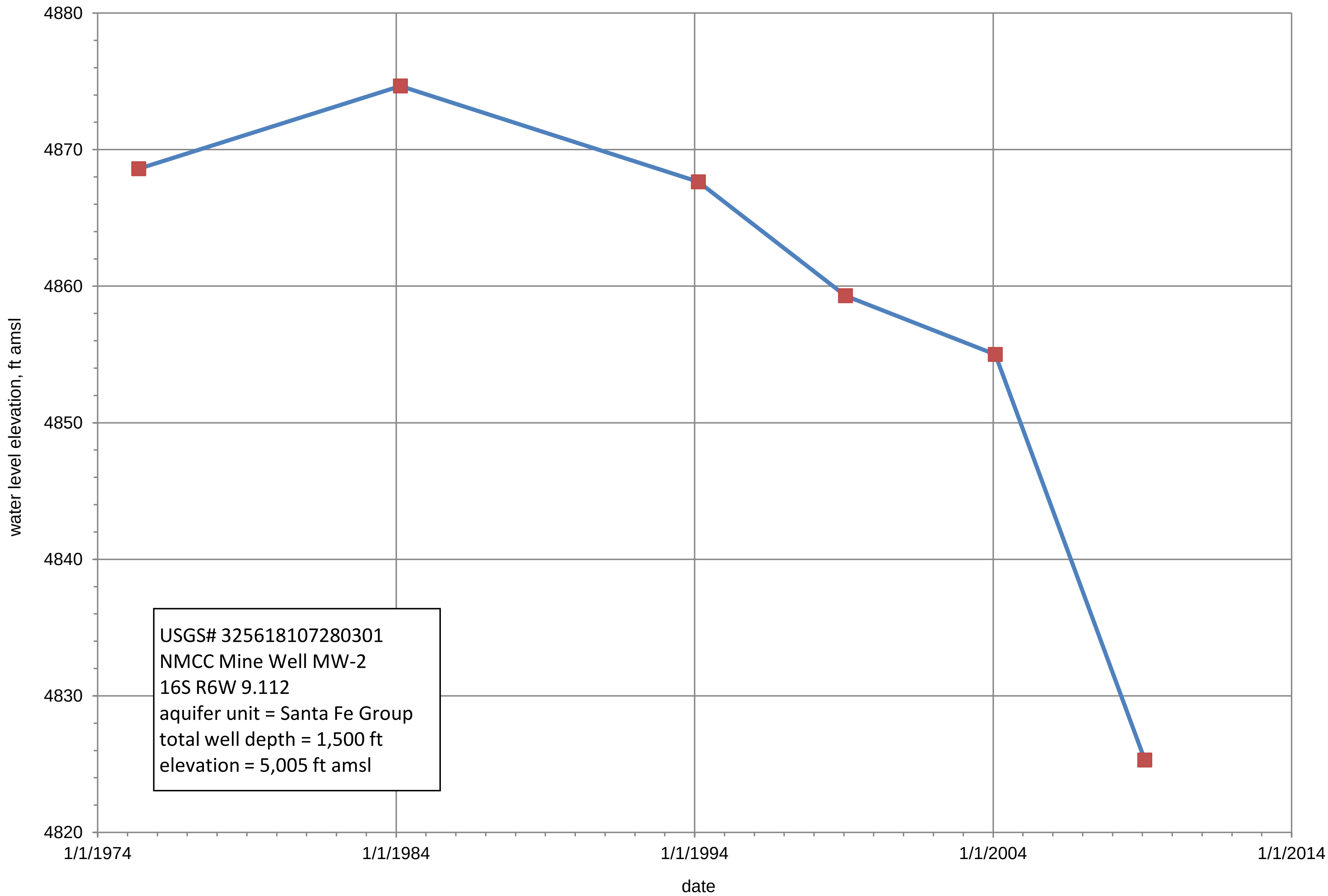


Figure G. Hydrograph of MW-2.

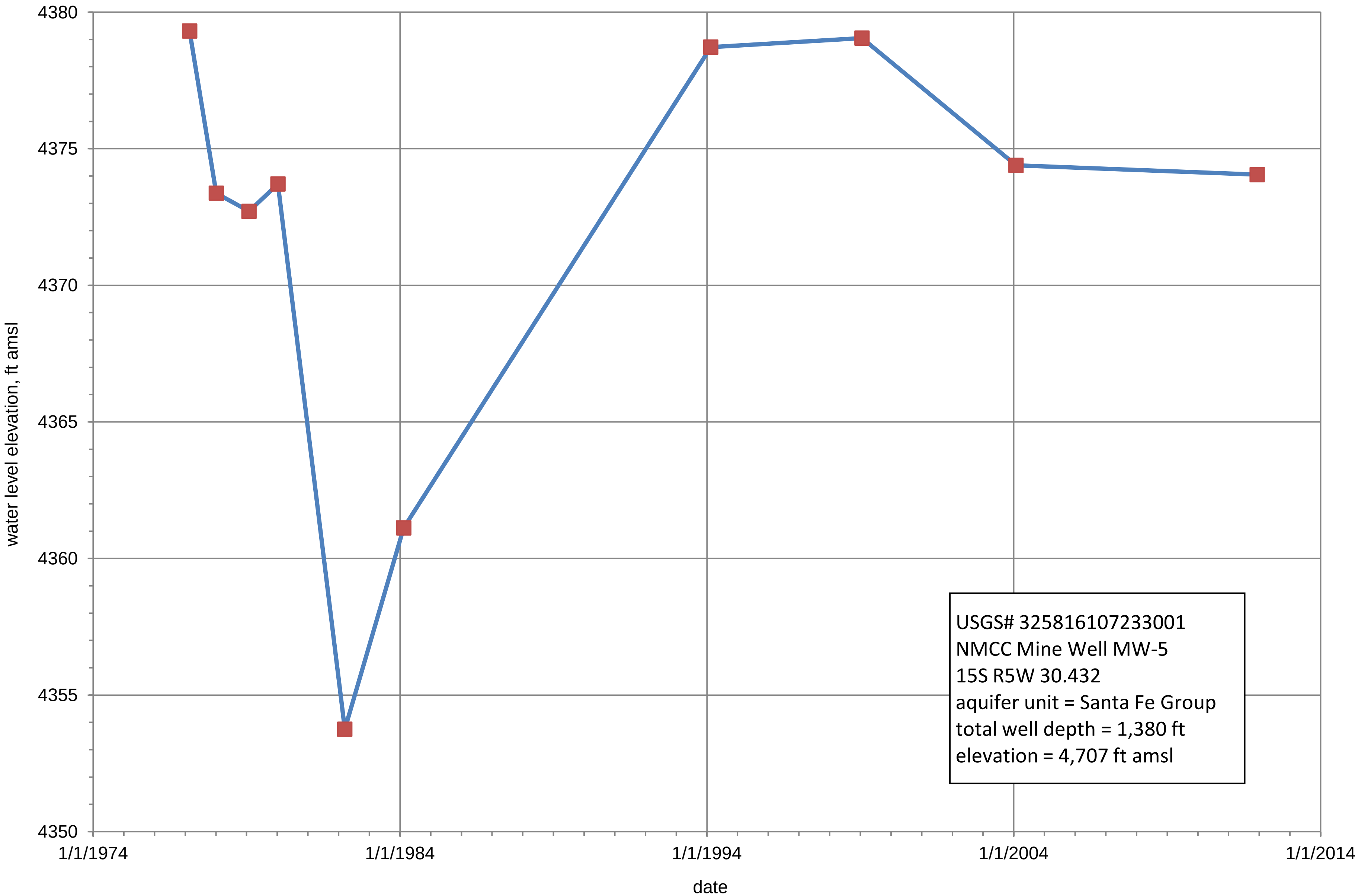


Figure H. Hydrograph of MW-5.

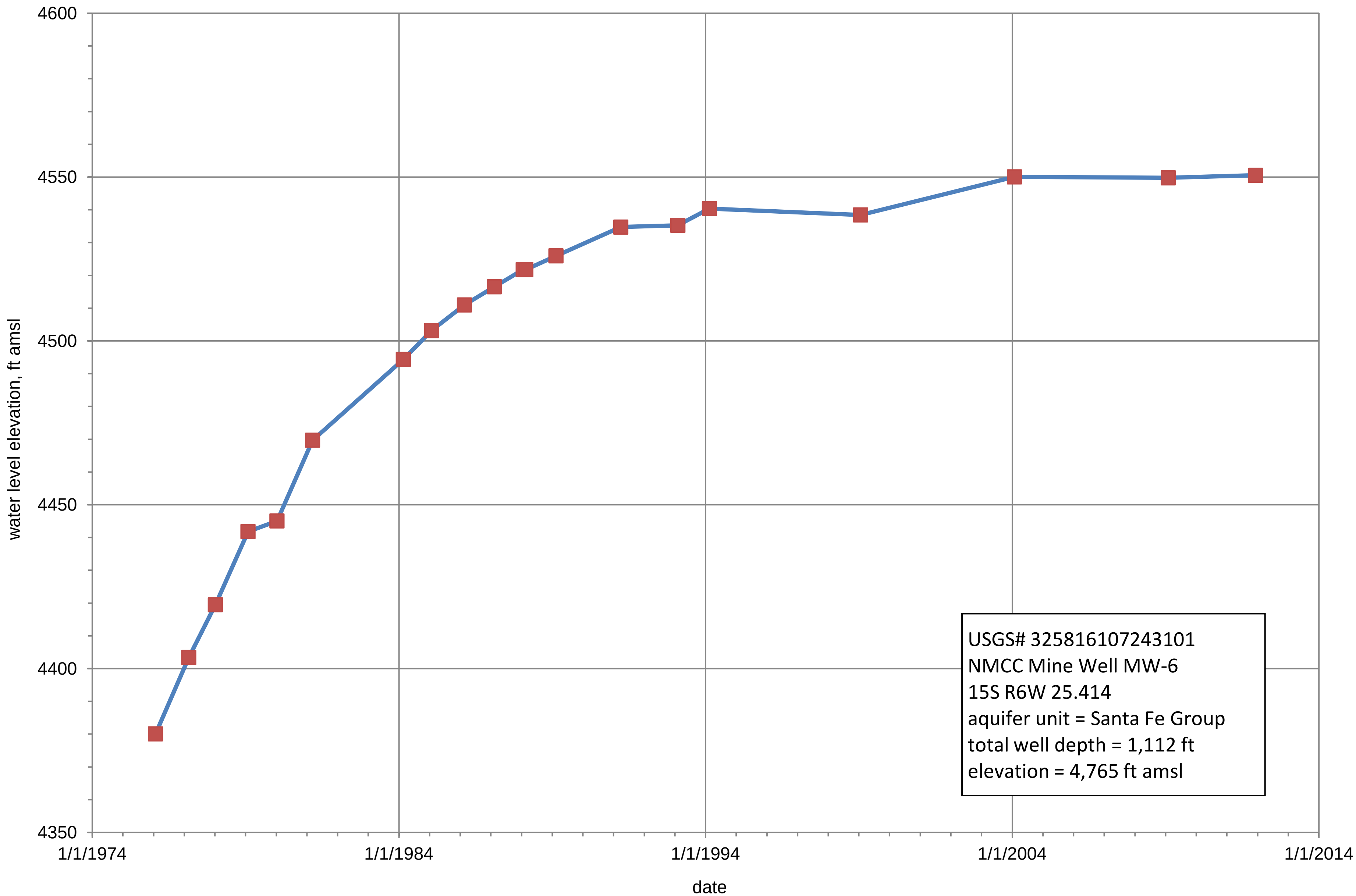


Figure I. Hydrograph of MW-6.

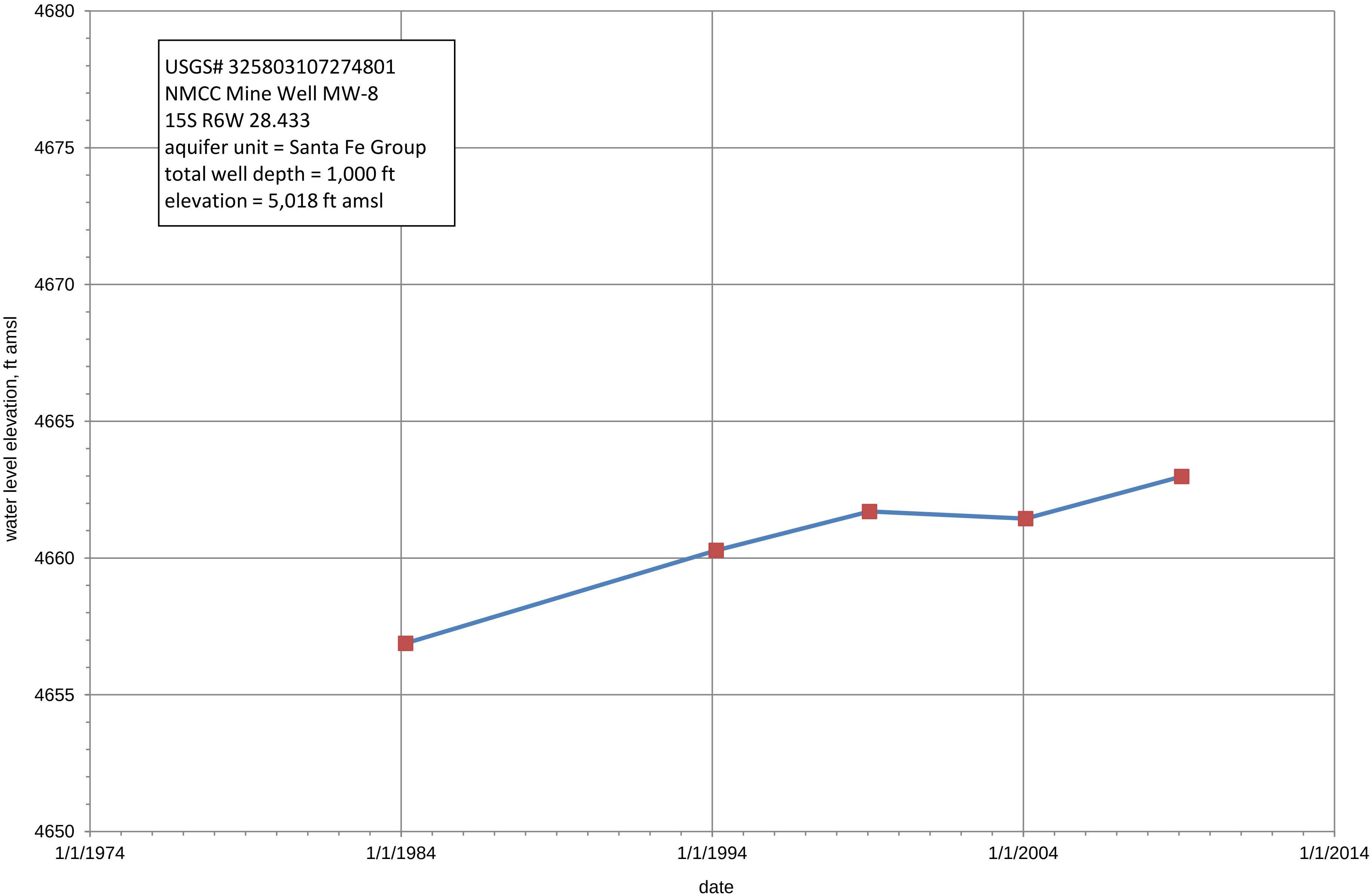


Figure J. Hydrograph of MW-8.

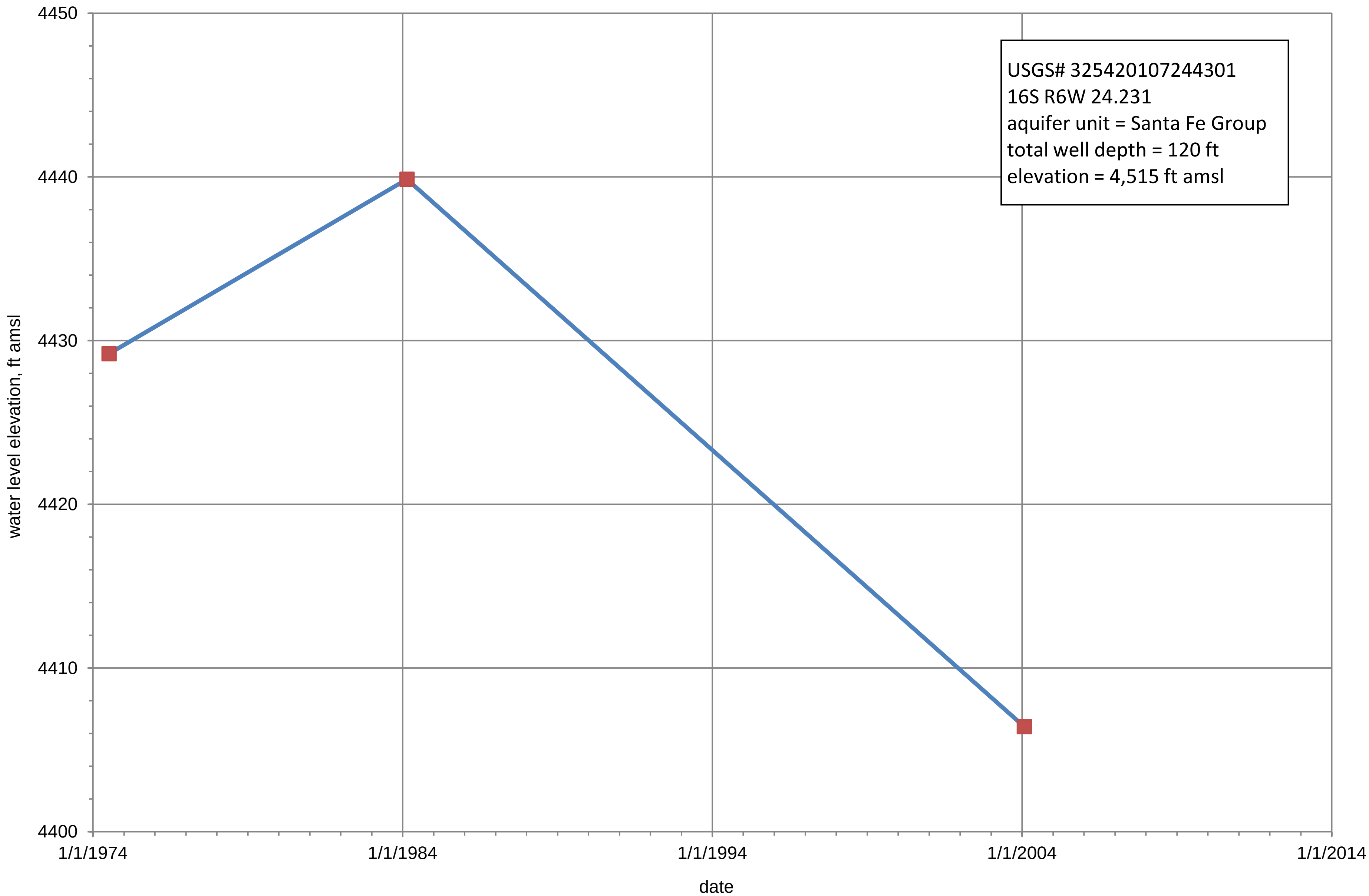


Figure K. Hydrograph of Well 16S6W24.

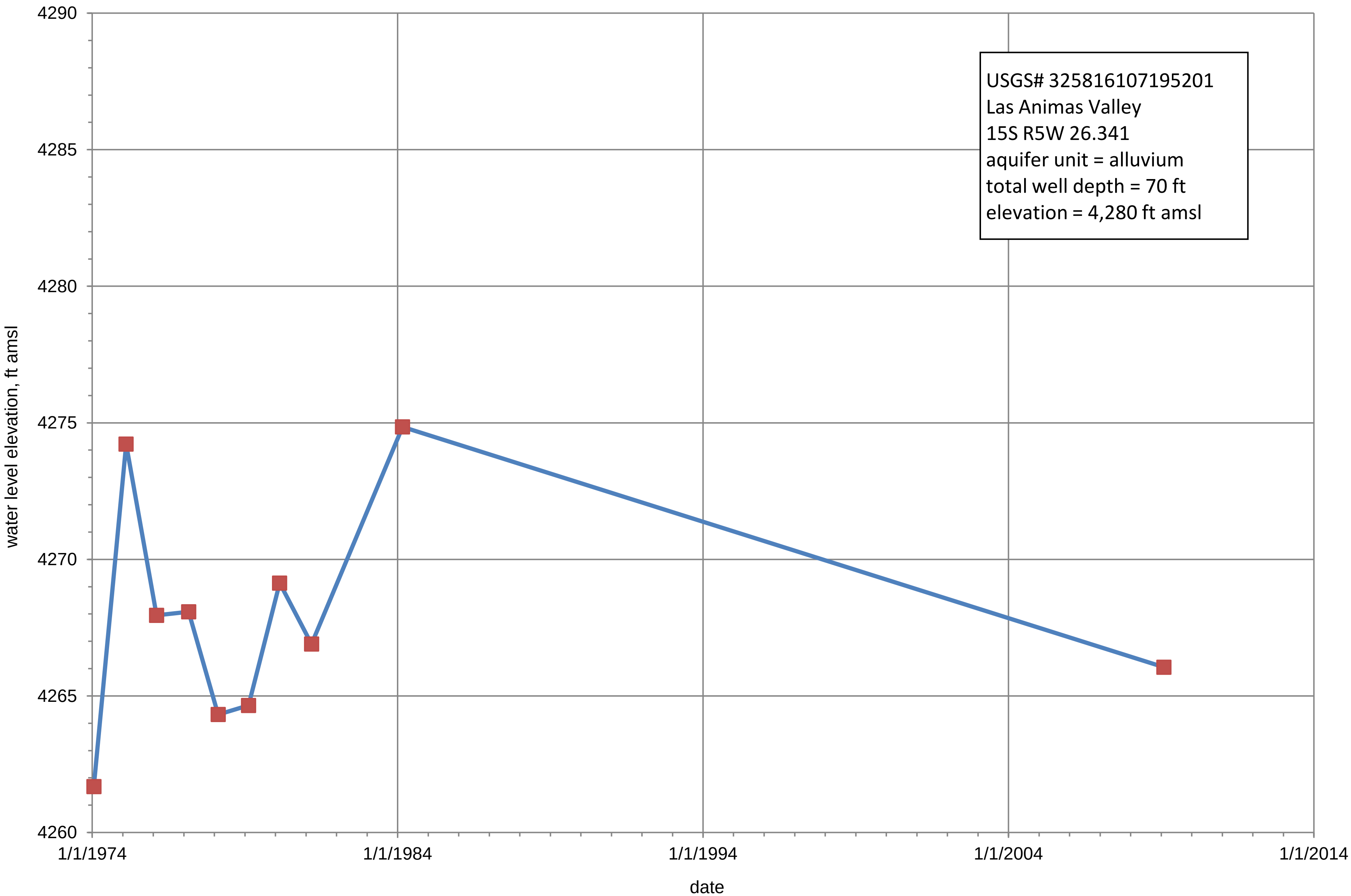


Figure L. Hydrograph of Well 15S5W26.

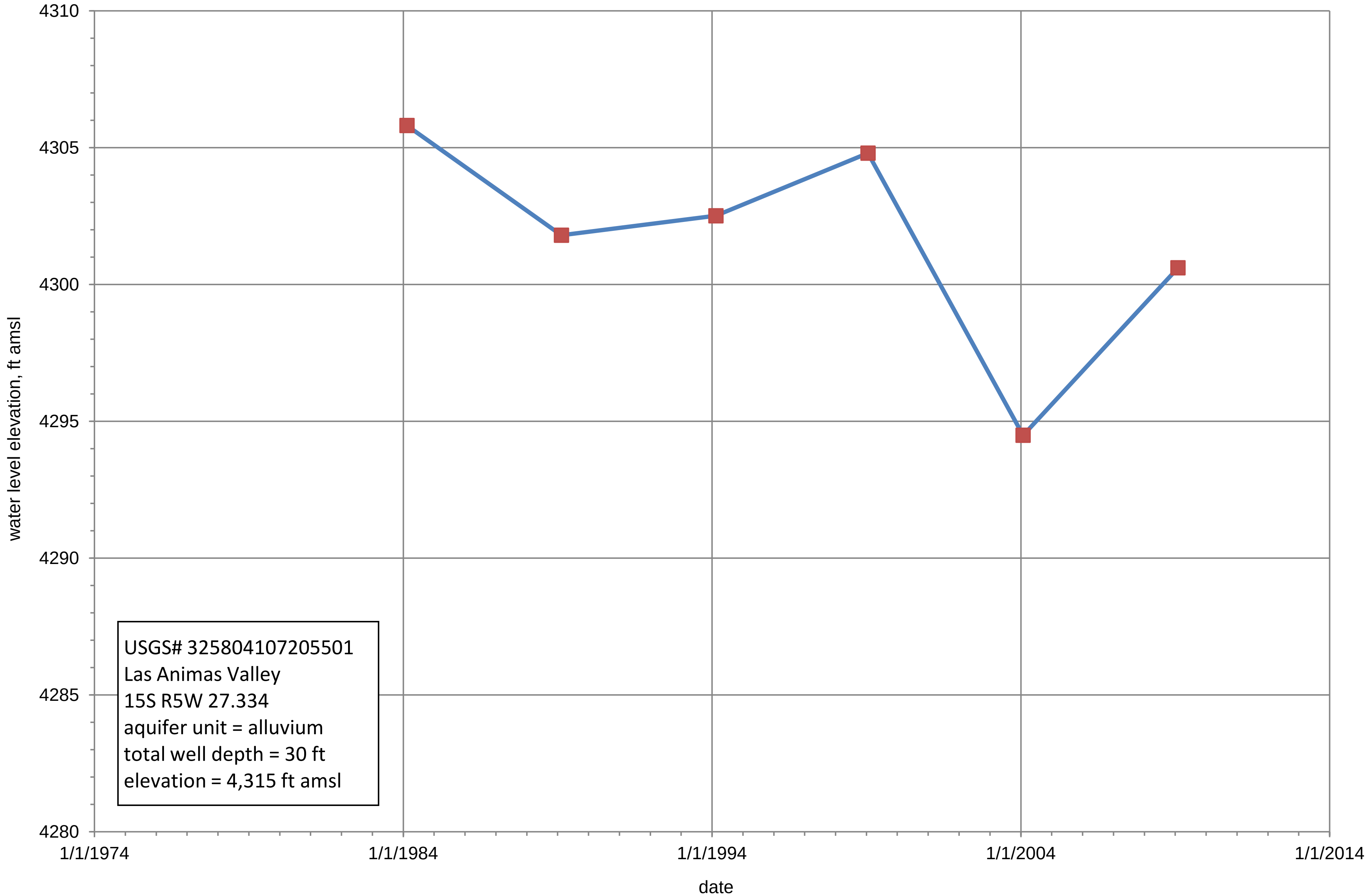


Figure M. Hydrograph of Well 15S5W27.

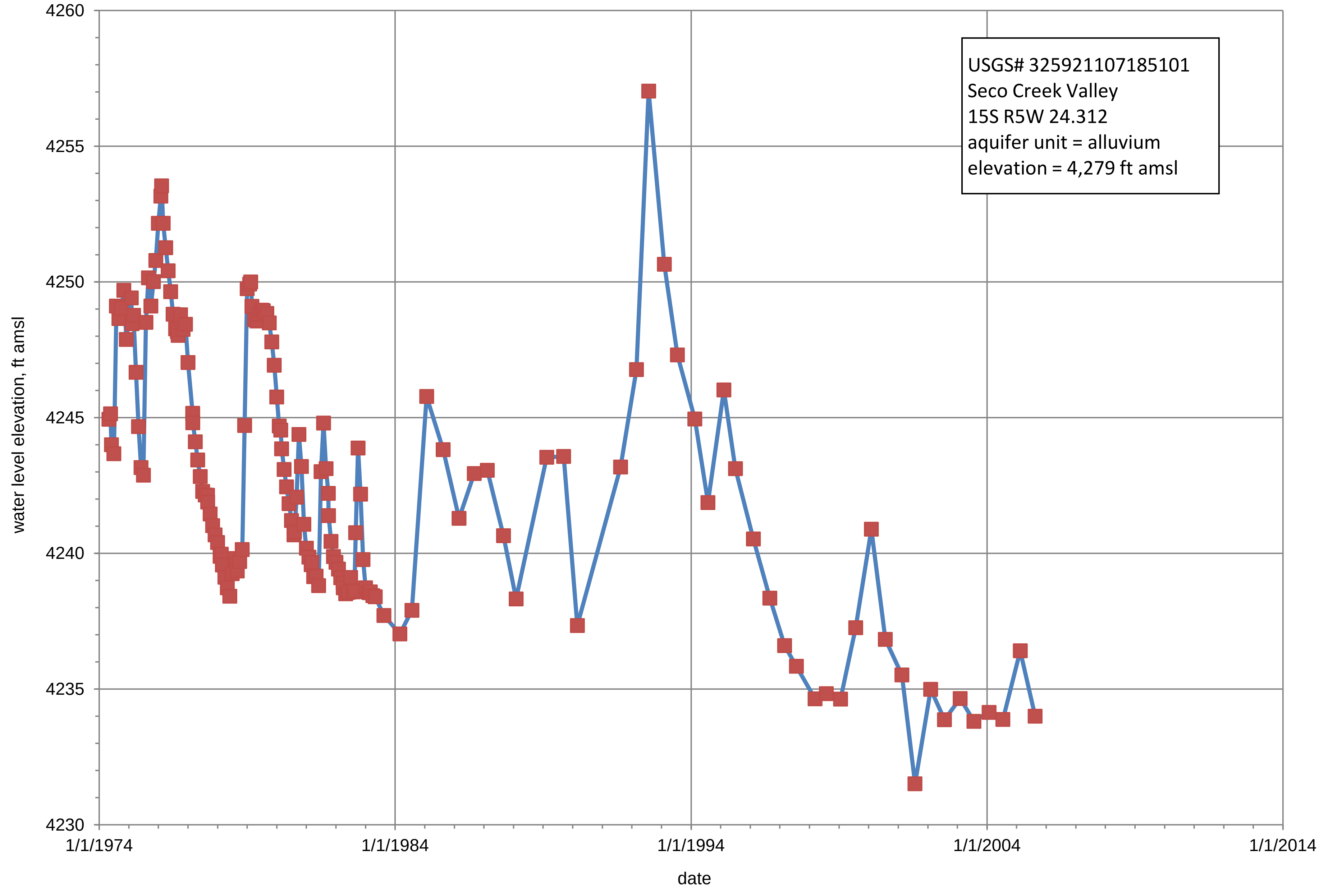


Figure N. Hydrograph of Well 15S5W24.

Appendix 8-H

List of Inventoried Wells

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TECHNICAL MEMORANDUM

To: Katie Lee, Project Scientist, New Mexico Copper Corporation THEMAC

From: Steven T. Finch, Jr., Principal Hydrogeologist-Geochemist

Date: September 6, 2011

Subject: Inventory of artesian wells in Las Animas Creek valley and vicinity, Sierra County, New Mexico

This memorandum is an update on the John Shomaker & Associates, Inc. (JSAI, 1995) inventory of artesian wells in Las Animas Creek valley and vicinity. Figure 1 is a regional map showing the locations of artesian wells in the inventory area, and Figure 2 is a map detailing artesian wells in the lower Las Animas Creek valley where density of wells is greatest. A list of inventoried wells is presented as Table 1. 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. New Mexico Office of the State Engineer (NMOSE) online WATERS database
4. NMOSE files
5. JSAI 1995 field survey
6. JSAI 2011 field survey

Well information from the six 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 right applications and permits. An attempt was made to match data from different sources to the correct well, and to reconcile apparent discrepancies.

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. Davie and Spiegel (1967) identified 27 wells in Las Animas Creek area and two artesian wells in the Oasis area. Currently there are over 61 artesian wells identified in the investigation area. Well depths range between 120 and 505 ft below land surface. Photographs of artesian wells located by JSAI in 1995 and JSAI in 2011 are attached as Appendix 1.

The artesian wells 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. A west-to-east cross-section down Las Animas Creek is presented as Figure 3. 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).

As shown on Figure 1, all of the known artesian wells are found east of the mapped north-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 (Fig. 3). 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 3:

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-south trending faults. The hydrograph presented as Figure 4 illustrates the vertical water level elevation difference between the alluvium and under lying 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-south trending faults shown on Figure 1. 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 (see Fig. 3).

The first artesian wells in the 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 in the early 1970s.

Flow from selected artesian wells has been measured by Murray (1959), Davie and Speigel (1967), JSAI (1995), and JSAI (2011). A summary of measured artesian flow rates is presented as Table 2.

Table 2. Summary of measured artesian flow rates

source	number of wells	year	total artesian flow (gpm)	comments
Murray (1959)	23	1946	460	Included Percha, Las Animas Creek, and Oasis areas
Davie and Spiegel (1967)	29	1966	1,186	Las Animas creek area only. Measured uncontrolled artesian flow = 141.65 gpm during March 1967
JSAI (1995)	12	1995	1,319	Survey limited to accessible wells with owner permission
JSAI (2011)	21	2011	222	Survey limited to accessible wells with owner permission

gpm - gallons per minute

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 therefore left open to flow continuously to the land surface. Since the area was declared by the State Engineer, valves to regulate artesian flow and metering have been conditions attached to many of the water right permits.

Over the last 50 years significant changes in flow rates have been observed in the few artesian wells that have time-series data. Attached as Figure 5 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 the artesian well upward leakage and open flow, however, appear to be mainly responsible for the long-term decline in artesian flow rates.

Attachments:

Table 1. List of artesian wells and associated data for Las Animas Creek valley, Oasis area, and Percha Creek valley, Sierra County, New Mexico.

Figure 1. Aerial photograph showing the locations of artesian wells in Las Animas Creek valley, Oasis area, and Percha Creek valley, Sierra County, New Mexico.

Figure 2. Aerial photograph showing the locations of artesian wells in Las Animas Creek valley, Sierra County, New Mexico.

Figure 3. West to east hydrogeologic cross-section C-C' along lower Las Animas Creek valley, Sierra County, New Mexico.

Figure 4. Graph showing historical water levels for observation wells MW-9, MW-10, and MW-11, Las Animas Creek valley.

Figure 5. Graph of measured artesian flow rates versus time for wells in Percha and Las Animas Creek valleys.

Appendix 1. Photographs of artesian wells located by JSAI in 1995 and JSAI in 2011.

References:

Davie, Jr., W., and Spiegel, Z., 1967, Las Animas Creek Hydrographic Survey Report, Geology and water resources of Las Animas Creek and vicinity Sierra County, New Mexico: New Mexico State Engineer Office, 44 p.

Hawley, J. W., and Kennedy, J. F., 2004, Creation of a digital hydrogeologic framework model of the Mesilla Basin and Southern Jornada del Muerto Basin: New Mexico Water Resources Research Institute Technical Completion Report No. 332, 105 p.

Murray, C. R., 1959, Ground-water conditions in the nonthermal artesian-water basin south of Hot springs, Sierra County, New Mexico: New Mexico Office of the State Engineer Technical Report No. 10, 33 p.

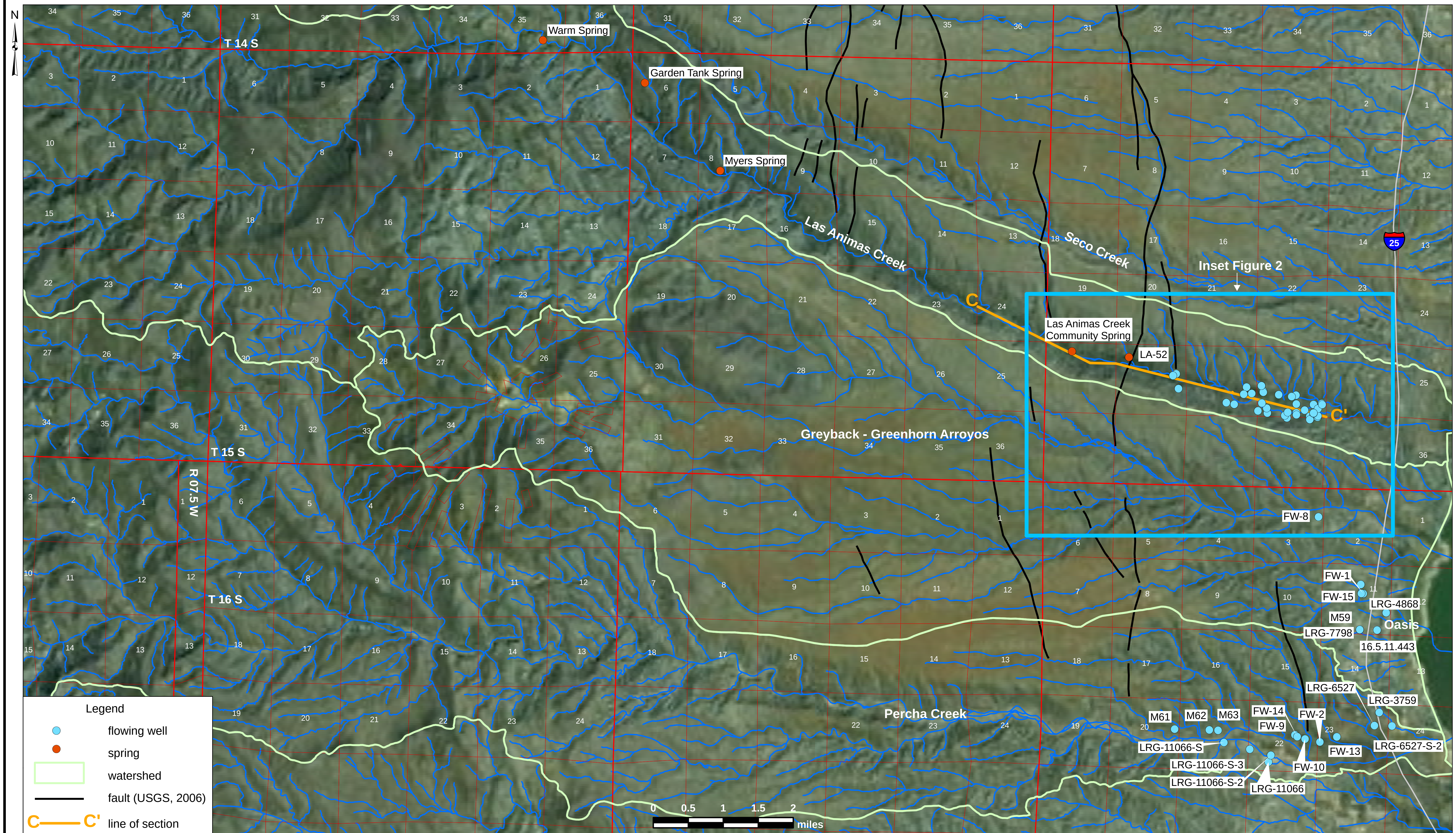
Seager, W. R., Clemons, R. E., Hawley, J. W., and Kelley, R. E., 1982, Geology of northwest part of Las Cruces 1x2 sheet (Scale 1:125,000), New Mexico: New Mexico Bureau of Mines & Mineral Resources Geologic Map 53.

Table 1. List of artesian wells and associated data for Las Animas Creek valley, Oasis area, and Percha Creek valley, Sierra County, New Mexico.

map location	reference location	alias	per-mitted use	per-mitted diversion (ac-ft/yr)	Northing UTM83	Easting UTM83	NMOSE File Number	year drilled	nominal casing diameter, in.	total depth (ft bgl)	land surface elevation (ft amsl)	measur-ing point elevation (ft amsl)	measur-ment date	depth to water level (neg = agl) (ft bgl)	water-level elevation (ft)	head pressure (psi)	artesian flow rate (gpm)	field pH	field conduc-tivity (µS/cm)	field temper-ature (°C)	owner	type	comments	q64	q16	q4	Sec	Tws	Rng	reference
FW-1	Oasis	16.5.11.233			3646146.0	282822.0	na															artesian	Flowing well	3	3	2	11	16S	5W	Davie and Spiegel (1967)
FW-1	Oasis				3646146.0	282822.0	na		8		4316	4317.0	4/19/1995	-1.0	4317.0		9.5		400	24.4	Scannells	artesian	Flowing well	3	3	2	11	16S	5W	JSAI (1995)
FW-1	Oasis				3646146.0	282822.0	na		8		4316	4316.3	6/30/2011	-0.3	4316.3		8	7.85	349	26.2	Middleton & Jack D.	artesian	Clear, no odor	3	3	2	11	16S	5W	JSAI (2011)
FW-2	Percha	M65			3642731.0	281825.0	LRG-8755	1947	18	226			1/1/1947				125		360		Dawson	artesian	flowed 125 gpm during 4 hr test	1	1	3	23	16S	5W	Murray (1959)
FW-2	Percha	LRG-8755			3642731.0	281825.0	LRG-8755	1947	18	250			11/28/1994				60				Dawson	artesian	original flow rate = 60 gpm	1	1	3	23	16S	5W	NMOSE Declaration
FW-2	Percha				3642731.0	281825.0	LRG-8755		16	180	4302	4304.5	4/19/1995	-2.5	4304.5		67.6		400	22.7	Dawson	artesian	Dawson irrigation well	1	1	3	23	16S	5W	JSAI (1995)
FW-2	Percha				3642731.0	281825.0	LRG-8755		16	180	4302	4302.0	6/29/2011	-2.3	4304.3		0				Dawson	artesian	Dawson irrigation well, valve closed	1	1	3	23	16S	5W	JSAI (2011)
FW-3	Las Animas	15.5.28.432			3650501.0	279856.0	LA-103	1965	8	325	4350		1/22/1966				200				C.A. Gilsoul	artesian	flowing irrigation well	2	3	4	28	15S	5W	Davie and Spiegel (1967)
FW-3	Las Animas				3650501.0	279856.0	LA-103		12		4357	4357.0	4/19/1995	0	4357.0		65		450	20.5	El Paso Utilities	artesian								JSAI (1995)
FW-3	Las Animas				3650501.0	279856.0	LA-103		12		4357	4357.7	6/30/2011	0	4357.0		40	7.56	397	22.2	El Paso Utilities	artesian	Clear, no odor							JSAI (2011)
FW-3	Las Animas	LA-103	IRR	0.68	3650501.0	279856.0	LA-103														El Paso Utilities	artesian	Location estimated from PLSS.	2	3	4	28	15S	5W	NMOSE files
FW-4	Las Animas	15.5.28.421, W-5			3650898.0	280140.0	LA-105		8	435											W.B. Jones	artesian		1	2	4	28	15S	5W	Davie and Spiegel (1967)
FW-4	Las Animas				3650898.0	280140.0	LA-105		6	450	4327	4333.0	4/20/1995		4327.0	15	86		1100	23.3	Gram	artesian	Livestock well							JSAI (1995)
FW-4	Las Animas				3650898.0	280140.0	LA-105		6	450	4327	4333.5	6/30/2011	0	4327.0		60	7.47	1032	23.9	Savage	artesian	Clear, no odor. Livestock well							JSAI (2011)
FW-4	Las Animas	LA-105			3650898.0	280140.0	LA-105														W.B. Jones COW Savage	artesian		1	2	4	28	15S	5W	NMOSE files
FW-5	Las Animas	15.5.27.311a			3650804.0	280521.0	LA-105-S														W.B Jones	artesian		1	1	3	27	15S	5W	NMOSE files
FW-5	Las Animas				3650804.0	280521.0	LA-105-S		12	325	4325		4/20/1995	0	4325.0		1,000		375	15	Gram	artesian	Irrigation well	1	1	3	27	15S	5W	JSAI (1995)
FW-5	Las Animas				3650804.0	280521.0	LA-105-S														Savage	artesian	Irrigation well. Could not locate for 2011							JSAI (2011)
FW-5	Las Animas	LA-105-S			3650804.0	280521.0	LA-105-S														Savage	artesian		2	1	3	27	15S	5W	NMOSE files
FW-6	Las Animas	15.5.27.334a			3650298.0	280617.0	LA-36		5	185							25				Ray Harrison	artesian		4	3	3	27	15S	5W	Davie and Spiegel (1967)
FW-6	Las Animas				3650298.0	280617.0	LA-36		4		4320	4322.5	4/20/1995		4332.7	5.5			500	21.1	Dunlap, Royce & Kay	artesian								JSAI (1995)
FW-6	Las Animas				3650298.0	280617.0	LA-36														Dunlap	artesian	Could not locate for 2011							JSAI (2011)
FW-6	Las Animas	LA-36	IRR	2.38	3650298.0	280617.0	LA-36	1952		165											W. C. Dunlap	artesian				3	27	15S	5W	NMOSE files
FW-7	Las Animas	15.5.27.344a			3650188.0	281067.0	LA-24		6		4304						60				I. Emery	artesian		4	4	3	27	15S	5W	Davie and Spiegel (1967)
FW-7	Las Animas	LA-24			3650188.0	281067.0	LA-24		6	335	4293		1/1/1965				60				Neely	artesian	Location estimated from topo.	4	4	3	27	15S	5W	NMOSE files
FW-7	Las Animas				3650188.0	281067.0	LA-24		6	335	4293	4297.0	4/20/1995	-30	4323.0	13	60		400	21.1	Chavez	artesian	Residence well.							JSAI (1995)
FW-7	Las Animas				3650188.0	281067.0	LA-24		6	375	4293	4294.1	6/30/2011	-34.7	4327.7	15	60	7.64	346	21.9	Chavez	artesian	Residence well. Clear, no odor							JSAI (2011)
FW-8	Oasis	16.5.3.244			3647909.0	281793.0	na		10				11/1/1966				25-50				John Gordon	artesian	stock well	4	4	2	3	16S	5W	Davie and Spiegel (1967)
FW-8	Oasis				3647909.0	281793.0	na		6		4328	4330.0	4/20/1995	-2	4330.0		12.5		450	17.2	BLM	artesian		4	4	2	3	16S	5W	JSAI (1995)
FW-8	Oasis				3647909.0	281793.0	na		6		4328	4330.0	6/29/2011	-2	4330.0		10	7.67	325	25.1	BLM	artesian	Clear, no odor	4	4	2	3	16S	5W	JSAI (2011)
FW-9	Percha	LRG-8752			3642895.0	281250.0	LRG-8752	1937	6	121	4301		1/1/1937				10				Dawson	artesian								NMOSE Declaration
FW-9	Percha				3642895.0	281250.0	LRG-8752		6	121	4301	4301.0	4/21/1995								Dawson	artesian	No measurements							
FW-9	Percha				3642895.0	281250.0	LRG-8752		6	121	4301	4305.1	6/29/2011	-4.1	4305.1		2	7.53	386	25.5	Dawson	artesian	Clear, no odor							
FW-10	Percha	M64			3642799.0	281483.0	LRG-8754	1944	8	216			6/13/1946				38		385		Dawson	artesian	8 in casing with 6 in discharge	1	2	4	22	16S	5W	Murray (1959)
FW-10	Percha	LRG-8754			3642799.0	281483.0	LRG-8754	1940	8	180	4302		12/1/1994				6				Dawson	artesian	original flow rate = 40 gpm	1	2	4	22	16S	5W	NMOSE Declaration
FW-10	Percha				3642799.0	281483.0	LRG-8754		6		4302	4302.2	4/21/1995	-0.2	4302.2		9		400	22.7	Dawson	artesian	irrigation well							JSAI (1995)
FW-10	Percha				3642799.0	281483.0	LRG-8754		6		4302	4302.2	6/29/2011	-0.2	4302.2		1.5	7.62	354	24.8	Dawson	artesian	Clear, no odor							JSAI (2011)
FW-11	Las Animas	M48			3650220.0	281593.0	LA-62	1938-1948	6	280	4276						55		800		Howard Young	artesian	Murray Field Number 48, well flows	3	4	4	27	15S	5W	Murray (1959)
FW-11	Las Animas	15.5.27.443			3650220.0	281593.0	LA-62			325											Howard Young	artesian	Well also used for commercial minnows	3	4	4	27	15S	5W	Davie and Spiegel (1967)
FW-11	Las Animas				3650220.0	281593.0	LA-62		6	320	4295		4/21/1995	0	4295.0		37		770	21.1	Bennett	artesian	Pond well.							JSAI (1995)
FW-11	Las Animas				3650220.0	281593.0	LA-62							0							Thompson	artesian	Pond well. Would not allow access, 2011.							JSAI (2011)
FW-11	Las Animas	LA-62	IRR	27.2	3650220.0	281593.0	LA-62	1938		320											Tyler and Linda Thompsom	artesian	Location estimated from PLSS.		4	4	27	15S	5W	NMOSE files
FW-12	Las Animas	15.5.27.434			3650223.0	281670.0	LA-42		6	298	4290		6/28/1958				135				Sofio S. Apodaca	artesian		4	3	4	27	15S	5W	Davie and Spiegel (1967)
FW-12	Las Animas	LA-42	IRR		3650223.0	281670.0	LA-42	1955	6	298											Sofio S. Apodaca	artesian	Hydrographic Survey well W-20, Sheet 1	3	4	4	27	15S	5W	NMOSE files
FW-12	Las Animas				3650223.0	281670.0	LA-42		6	320	4295		4/21/1995	0			25				Bennett	artesian	House well. Owner reported flow rate							JSAI (1995)
FW-12	Las Animas				3650223.0	281670.0	LA-42							0							Thompson	artesian	Would not allow access, 2011							JSAI (2011)
FW-13	Percha	LRG-6527-S			3642849.0	282214.0	LRG-6527-S	1974	12	170											George B. Ray	artesian		3	4	2	23	16S	5W	NMOSE Declaration
FW-13	Percha				3642849.0	282214.0	LRG-6527-S		12		4324	4324.2	6/29/2011	-0.2	4324.2		2	7.6	360	24.4	Grantham	artesian	Clear, free of sediment							JSAI (2011)
FW-14	Percha	LRG-8753			3642851.0	281304.0	LRG-8753	1938	6	147	4302		12/1/1994				8				Dawson	artesian								NMOSE Declaration
FW-14	Percha				3642851.0	281304.0	LRG-8753		6		4296	4299.0	6/29/2011	-3	4299.0		8	7.5	370	24.6	Dawson	artesian	House well. Clear, no odor.							JSAI (2011)
FW-15	Oasis				3646147.0	282778.0	na		6		4330	4330.6	6/29/2011	-0.6	4330.6		4	7.76	351	26.5	White	artesian	Clear, no odor							JSAI (2011)
FW-16	Las Animas				3650519.0	281867.0	na		12		4290	4292.4	6/29/2011	-2.4	4292.4		2.5	7.6	1592	31.9	Goff/Diamond	artesian	High temp from black discharge line							JSAI (2011)
FW-17	Las Animas	LA-31			3650203.0	281774.0	LA-31	1925													Gladys Weathersbee	artesian	domestic supply	4	4	4	27	15S	5W	NMOSE Declaration
FW-17	Las Animas	15.5.27.444a			3650203.0	281774.0	LA-31														H. F. Davis	artesian		4	4	4	27	15S	5W	Davie and Spiegel (1967)
FW-17	Las Animas				3650203.0	281774.0	LA-31		6		4261	4262.3	6/29/2011	-1.3	4262.3		5	7.69	714	23.4	Kirby	artesian	Kirby-south well. Clear, no odor.							JSAI (2011)
FW-18	Las Animas	15.5.27.444			3650231.0	281780.0	LA-30		6	350	4266		12/7/1966	-14.3	4280.3		20				H. F. Davis	artesian	flowing irrigation well	4	4	4	27	15S	5W	Davie and Spiegel (1967)
FW-18	Las Animas	LA-30			3650231.0	281780.0	LA-30	1955	6	350											Gladys Weathersbee	artesian		4	4	4	27	15S	5W	NMOSE Declaration
FW-18	Las Animas				3650231.0	281780.0			6		4266	4268.4	6/29/2011	-2.4	4268.4		2.6	7.47	1343	21.3	Kirby	artesian	Kirby-north. Clear, no odor.							JSAI (2011)
FW-19	Las Animas	15.5.27.333			3650348.0	280400.0	LA-57		6				12/7/1966				7				John Gordon	artesian		3	3	3	27	15S	5W	Davie and Spiegel (1967)
FW-19	Las Animas	LA-57	IRR	2.72	3650348.0	280400.0	LA-57	1950	6	180			11/8/1965				10				Harvey Chatfield	artesian	Location estimated from PLSS.	3	3	3	27	15S	5W	NMOSE files
FW-19	Las Animas				3650348.0	280400.0	LA-57		6		4342	4343.6	6/30/2011	-1.6	4343.6		2.5	7.24	491	21.6	Chatfield	artesian	Clear, no odor							JSAI (2011)
FW-20	Las Animas	15.5.27.311			3650777.0	280524.0	LA-105-S-2		8								7				W.B. Jones	artesian		1	1	3	27	15S	5W	Davie and Spiegel (1967)
FW-20	Las Animas	LA-105-S-2			3650777.0	280524.0	LA-105-S-2														W.B. Jones	artesian		1	1	3	27	15S	5W	NMOSE files
FW-20	Las Animas				3650777.0	280524.0	LA-105-S-2		8		4323	4324.3	6/30/2011	-1.25	4324.3		8	7.33	1625	24.1	Savage	artesian	Clear, no odor							JSAI (2011)
FW-21	Las Animas	15.5.27.334, W-10			3650408.0	280602.0	LA-38	1965		348											T. R. Poe	artesian		3	3	4	27	15S	5W	Davie and Spiegel (1967)
FW-21	Las Animas				3650408.0	280602.0	LA-38		10		4331	4333.6	6/30/2011	-11.6	4342.6	5		7.73	384	23.1	Dunlap	artesian	Clear, no odor							JSAI (2011)
FW-21	Las Animas	LA-38	IRR	6.358	3650408.0	280602.0	LA-38	1959	10	348											T. R. Poe	artesian	Location estimated from PLSS.	2	3	3	27	15S	5W	NMOSE Declaration

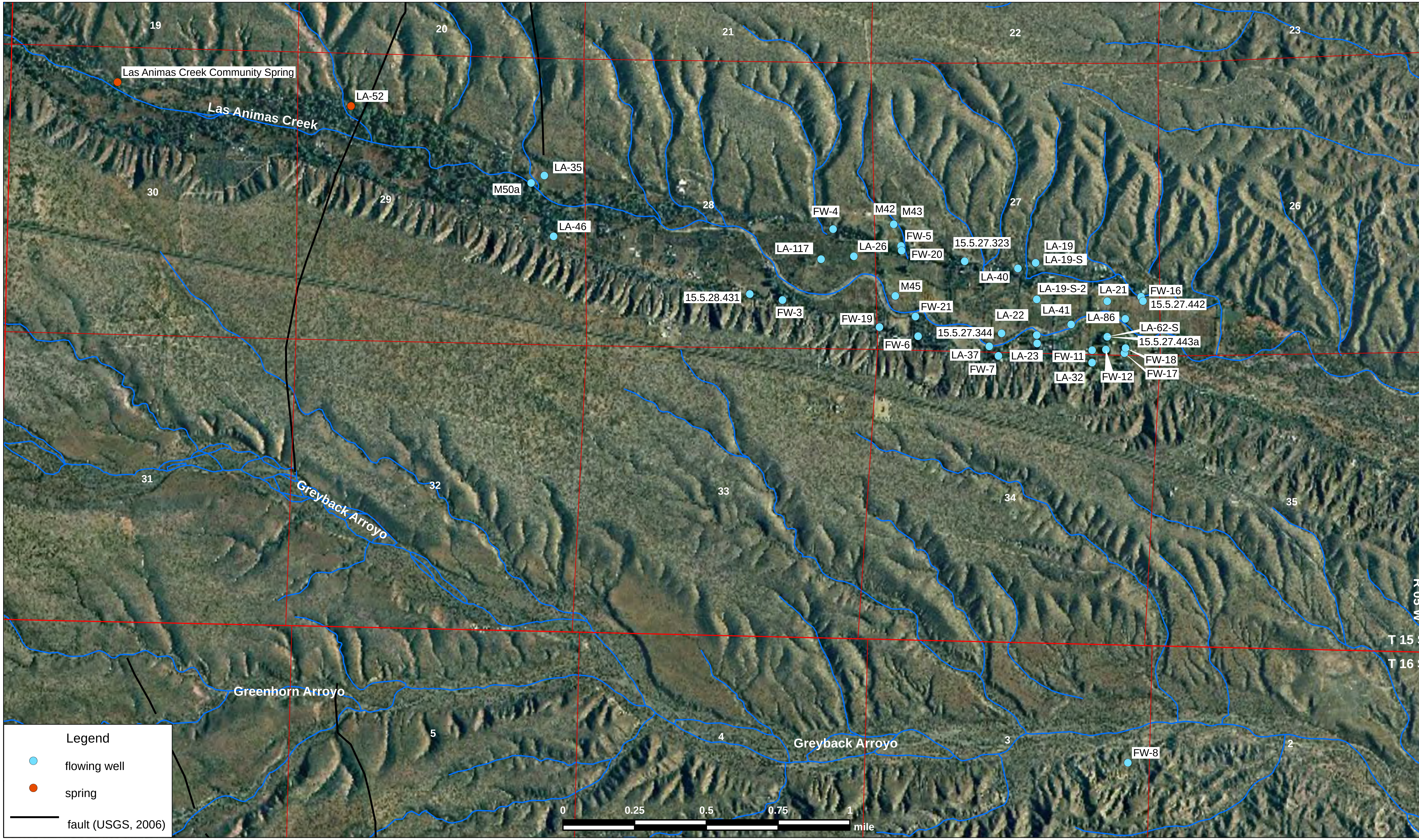
Table 1. List of artesian wells and associated data for Las Animas Creek valley, Oasis area, and Percha Creek valley, Sierra County, New Mexico.

map location	reference location	alias	per-mitted use	per-mitted diversion (ac-ft/yr)	Northing UTM83	Easting UTM83	NMOSE File Number	year drilled	nominal casing diameter, in.	total depth (ft bgl)	land surface elevation (ft amsl)	measur-ing point elevation (ft amsl)	measur-ment date	depth to water level (neg = agl) (ft bgl)	water-level elevation (ft)	head pressure (psi)	artesian flow rate (gpm)	field pH	field conduc-tivity (μS/cm)	field temper-ature (°C)	owner	type	comments	q64	q16	q4	Sec	Tws	Rng	reference
LA-19	Las Animas	W-18	IRR	2.72	3650709.0	281276.0	LA-19	1944	10	292											O. Williams	artesian		1	3	4	27	15S	5W	NMOSE Declaration
LA-19	Las Animas	15.5.27.413a			3650709.0	281276.0	LA-19	1945	10	301	4305										O. Williams	artesian	reported artesian flow of 150 gpm	3	1	4	27	15S	5W	Davie and Spiegel (1967)
LA-19-S	Las Animas		IRR		3650709.0	281276.0	LA-19-S	1951	8	323											EVERGREEN NURSERIES	artesian	Location estimated from PLSS.	3	1	4	27	15S	5W	NMOSE files
LA-19-S	Las Animas	15.5.27.413			3650709.0	281276.0	LA-19-S	1952	8	323	4305		12/7/1966	-16.2	4321.2						O. Williams	artesian	reported artesian flow of 150 gpm	3	1	4	27	15S	5W	Davie and Spiegel (1967)
LA-19-S-2	Las Animas		IRR		3650504.0	281282.0	LA-19-S-2	2002	8	300											EVERGREEN NURSERIES	artesian	NMOSE File	1	3	4	27	15S	5W	NMOSE files
LA-21	Las Animas	15.5.27.441			3650494.0	281678.0	LA-21	1961	6	410	4295		1/22/1967				150				J.N. Burkes	artesian		1	4	4	27	15S	5W	Davie and Spiegel (1967)
LA-21	Las Animas		IRR	90	3650494.0	281678.0	LA-21	1960	6	410											J.N. Burkes	artesian	NMOSE File		4	4	27	15S	5W	NMOSE files
LA-22	Las Animas	M47			3650304.0	281282.0	LA-22	1942	4	238	4300		6/12/1946	-7	4307.0		6		607		J.S. Stone	artesian	Murray Field Number 47	3	3	4	27	15S	5W	Murray (1959)
LA-22	Las Animas	15.5.27.433			3650304.0	281282.0	LA-22		3												I. Emery	artesian	artesian flow approximately 1 gpm	3	3	4	27	15S	5W	Davie and Spiegel (1967)
LA-22	Las Animas		DOM		3650304.0	281282.0	LA-22	1938	4	140											I. Emery	artesian	Location estimated from PLSS.	3	3	4	27	15S	5W	NMOSE Declaration
LA-23	Las Animas		IRR	11.9	3650257.6	281284.6	LA-23	1945		330			8/23/1965				45				I. Emery	artesian	Location estimated from topo.	3	3	4	27	15S	5W	NMOSE Declaration
LA-26	Las Animas	15.5.28.413			3650745.5	280256.4	LA-26		6	193	4350		12/7/1966	-6.8	4356.8		10				P.L. Watson	artesian		3	1	4	28	15S	5W	Davie and Spiegel (1967)
LA-26	Las Animas	W-2	IRR	37.74	3650745.5	280256.4	LA-26	1954	6	193											Wesley Able	artesian	Location estimated from topo.	3	1	4	28	15S	5W	NMOSE files
LA-32	Las Animas	15.5.34.221			3650149.6	281592.4	LA-32		8	325	4296										L.V. Portwood	artesian	artesian flow approximately 30 gpm	1	2	2	34	15S	5W	Davie and Spiegel (1967)
LA-32	Las Animas		IRR	15.3	3650149.6	281592.4	LA-32	1960	7	400											L.V. Portwood	artesian	original flow of 35 gpm	1	2	2	34	15S	5W	NMOSE Declaration
LA-35	Las Animas	M50b			3651197.4	278520.9	LA-35		6	125	4375			-3	4378.0		3		404		Oscar Brannon	artesian	2 flowing wells at this location.	4	4	2	29	15S	5W	Murray (1959)
LA-35	Las Animas	15.5.29.244a			3651197.4	278520.9	LA-35		6					17							B. Cordell	artesian	not flowing	4	4	2	29	15S	5W	Davie and Spiegel (1967)
LA-35	Las Animas		DOM		3651197.4	278520.9	LA-35	1938		120							0				Aleta Blanche Cardell	artesian	formerly artesian not flow as of 1967		2	4	29	15S	5W	NMOSE Declaration
LA-37	Las Animas	15.5.27.333a			3650241.3	281016.1	LA-37	1960	8	370	4328										T.R. Poe	artesian		3	3	3	27	15S	5W	Davie and Spiegel (1967)
LA-37	Las Animas		IRR	6.358	3650241.3	281016.1	LA-37	1940		370											T.R. Poe	artesian	Location estimated from topo.	3	3	3	27	15S	5W	NMOSE files
LA-40	Las Animas	M44			3650676.9	281176.5	LA-40				4320		6/13/1946	-13	4333.0		43		1390		Ruben Chavez	artesian	Murray Field Number 44	4	2	3	27	15S	5W	Murray (1959)
LA-40	Las Animas	15.5.27.324			3650676.9	281176.5	LA-40	1963	8	475	4320		12/7/1966	-17.8	4337.8		100				Ruben Chavez	artesian		4	2	3	27	15S	5W	Davie and Spiegel (1967)
LA-40	Las Animas		IRR	1.36	3650676.9	281176.5	LA-40	1947		450											Matthew L Chavez	artesian	Location estimated from topo.	4	2	3	27	15S	5W	NMOSE files
LA-41	Las Animas	15.5.27.434a			3650362.8	281474.9	LA-41				4290										Sofio S. Apodaca	artesian	Well capped.	4	3	4	27	15S	5W	Davie and Spiegel (1967)
LA-41	Las Animas		DOM	3	3650362.8	281474.9	LA-41	1945		190											Sofio S. Apodaca	artesian	Location estimated from PLSS.		3	4	27	15S	5W	NMOSE Declaration
LA-46	Las Animas		IRR	9.18	3650856.7	278572.7	LA-46	1948	16	167											George B. Green	artesian	Location estimated from topo.	4	2	4	29	15S	5W	NMOSE Declaration
LA-56	Las Animas	15.5.34.122			3650108.0	28059.0	LA-56	1958	6	275	4318										John Gordon	artesian	artesian flow approximately 50 gpm	2	2	1	34	15S	5W	Davie and Spiegel (1967)
LA-56	Las Animas		IRR	2.72	3650108.0	28059.0	LA-56	1954	6	375											John Gordon	artesian		2	2	1	34	15S	5W	NMOSE files
LA-62-S	Las Animas		IRR	27.2	3650294.0	281678.0	LA-62-S	1938		320											Tyler and Linda Thompsom	artesian	Location estimated from PLSS.	3	4	4	27	15S	5W	NMOSE files
LA-86	Las Animas		DOM	3	3650395.0	281779.0	LA-86	1975		270											Richard Piatt	artesian	Location estimated from PLSS.		4	4	27	15S	5W	NMOSE files
LA-117	Las Animas		IRR	32.98	3650729.0	280073.0	LA-117	1996		175			1996	17							Raymie Russell	artesian	Location estimated from PLSS.	3	2	4	28	15S	5W	NMOSE files
LRG-4868	Oasis				3645702.0	283348.0	LRG-4868	1984	6	300			8/23/1984	0							J. Dale Creley	artesian		4	2	4	11	15S	5W	NMOSE files
LRG-7798	Oasis				3645313.0	282741.0	LRG-7798	1991	4	240			7/8/1991	0							Harold Pickens	artesian		3	3	4	11	15S	5W	NMOSE files
LRG-14660	Oasis				3646354.0	282763.0	LRG-14660	1953	13	280											Bradley Shattuck	artesian		2	3	2	11	15S	5W	NMOSE files
M42	Las Animas				3650924.0	280480.0	na				4312		6/13/1946	-10	4322.0		20		1490		Gabriel Miranda	artesian	3 flowing wells at this location.	1	1	3	27	15S	5W	Murray (1959)
M43	Las Animas				3650924.0	280480.0	na	1942	6	244	4307		6/13/1946				75		1530		John Gordon	artesian	2 flowing wells at this location.	1	1	3	27	15S	5W	Murray (1959)
15.5.27.323	Las Animas				3650717.0	280878.0	na	1950	18	400	4320						40-50				John Gordon	artesian		3	2	3	27	15S	5W	Davie and Spiegel (1967)
M45	Las Animas				3650523.0	280489.0	na	1947	8	142									381		W.E. Cone	artesian	well flows	1	3	3	27	15S	5W	Murray (1959)
15.5.27.344	Las Animas				3650313.0	281085.0	na		6												I. Emery	artesian	artesian flow approximately 120 gpm	4	4	3	27	15S	5W	Davie and Spiegel (1967)
15.5.27.442	Las Animas				3650494.0	281878.0	na	1955	6	375	4285						15				John Gordon	artesian		2	4	4	27	15S	5W	Davie and Spiegel (1967)
15.5.27.443a	Las Animas	LA-85			3650294.0	281678.0	LA-85			325	4285										Howard Young	artesian	Well also used commercially to raise minnows.	3	4	4	27	15S	5W	Davie and Spiegel (1967)
15.5.28.431	Las Animas				3650533.0	279673.0	na		8		4355		3/2/1967				26				Cliff Hammond	artesian		1	3	4	28	15S	5W	Davie and Spiegel (1967)
M50a	Las Animas				3651156.0	278446.0	na	1938	6	170	4390		6/13/1946	-10	4400.0		2		546		Robert Eaton	artesian	2 flowing wells at this location.	3	4	2	27	15S	5W	Murray (1959)
LRG-11066	Percha				3642266.0	280643.0	LRG-11066	1962	8	120				0							John Danfelser	artesian	reported as artesian well	3	4	3	22	16S	5W	NMOSE Declaration
LRG-11066-S	Percha				3642715.0	279618.0	LRG-11066-S	1968	12	168				0							John Danfelser	artesian	reported as artesian well	2	1	4	21	16S	5W	NMOSE Declaration
LRG-11066-S-2	Percha				3642419.0	280698.0	LRG-11066-S-2	1939	6	150				0							John Danfelser	artesian	reported as artesian well	1	4	3	22	16S	5W	NMOSE Declaration
LRG-11066-S-3	Percha				3642561.0	280212.0	LRG-11066-S-3	1962	12	160				0							John Danfelser	artesian	reported as artesian well	3	1	3	22	16S	5W	NMOSE Declaration
LRG-3759	Percha				3643406.0	283189.0	LRG-3759	1968	6	240											Ivan and Goldie LeFollette	artesian	well record reports artesian conditions		2	2	23	16S	5W	NMOSE Declaration
LRG-6527	Percha				3643105.0	283076.0	LRG-6527	1971	12	505											George B. Ray	artesian	flows into pond	1	4	2	23	16S	5W	NMOSE Declaration
LRG-6527-S-2	Percha				3643096.0	283482.0	LRG-6527-S-2	1974	12	220											George B. Ray	artesian	unequipped - NMOSE field check	3	4	2	23	16S	5W	NMOSE Declaration
M59	Oasis				3645313.0	282741.0	na	1944	6	232	4305		6/12/1946	-16	4321.0		8		338		C. A. Moore	artesian		3	3	4	11	16S	5W	Murray (1959)
16.5.11.443	Oasis				3645300.0	283139.0	na															artesian		3	4	4	11	16S	5W	Davie and Spiegel (1967)
M61	Percha				3643022.0	278484.0	na	1943		257	4387			0	4387.0				365		J. L. Holden	artesian	2 other flowing wells at same location	4	4	2	20	16S	5W	Murray (1959)
M62	Percha				3643003.0	279283.0	na	1942	6	154	4364		6/14/1946	-12	4376.0		16		343		H. S. Moore	artesian		4	4	1	21	16S	5W	Murray (1959)
M63	Percha				3642995.0	279482.0	na	1944	6	130	4360										H. S. Moore	artesian	flowing irrigation well	3	3	2	21	16S	5W	



Source: ESRI i-cubed Nationwide Select Imagery, 2009.

Figure 1. Aerial photograph showing the locations of artesian wells in Las Animas Creek valley, Oasis area, and Percha Creek valley, Sierra County, New Mexico.



Source: ESRI i-cubed Nationwide Select Imagery, 2009.

Figure 2. Aerial photograph showing the locations of artesian wells in Las Animas Creek valley, Sierra County, New Mexico.

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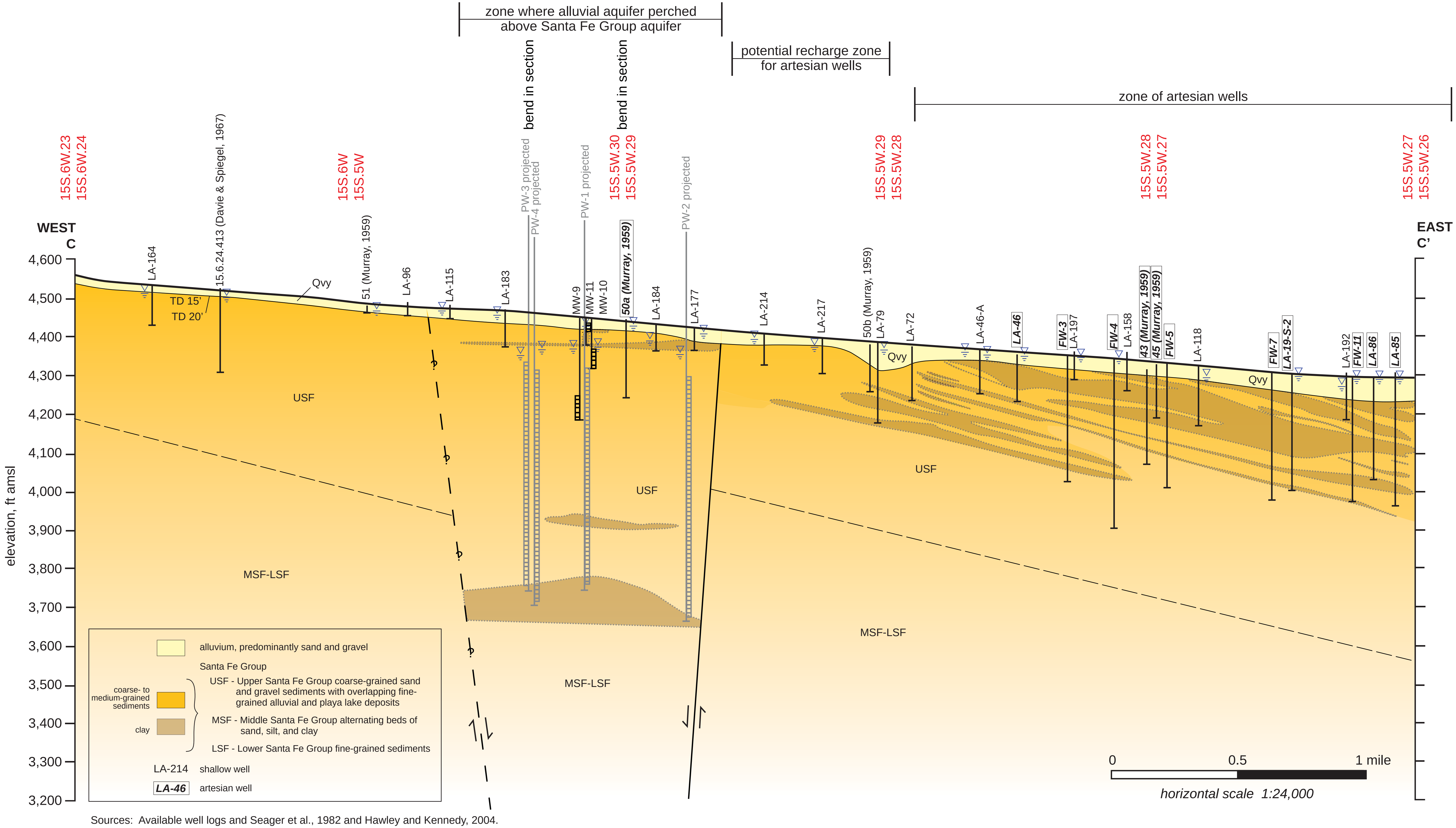

Figure 3. West to east hydrogeologic cross-section C-C' along Lower Animas Creek valley, Sierra County, New Mexico.

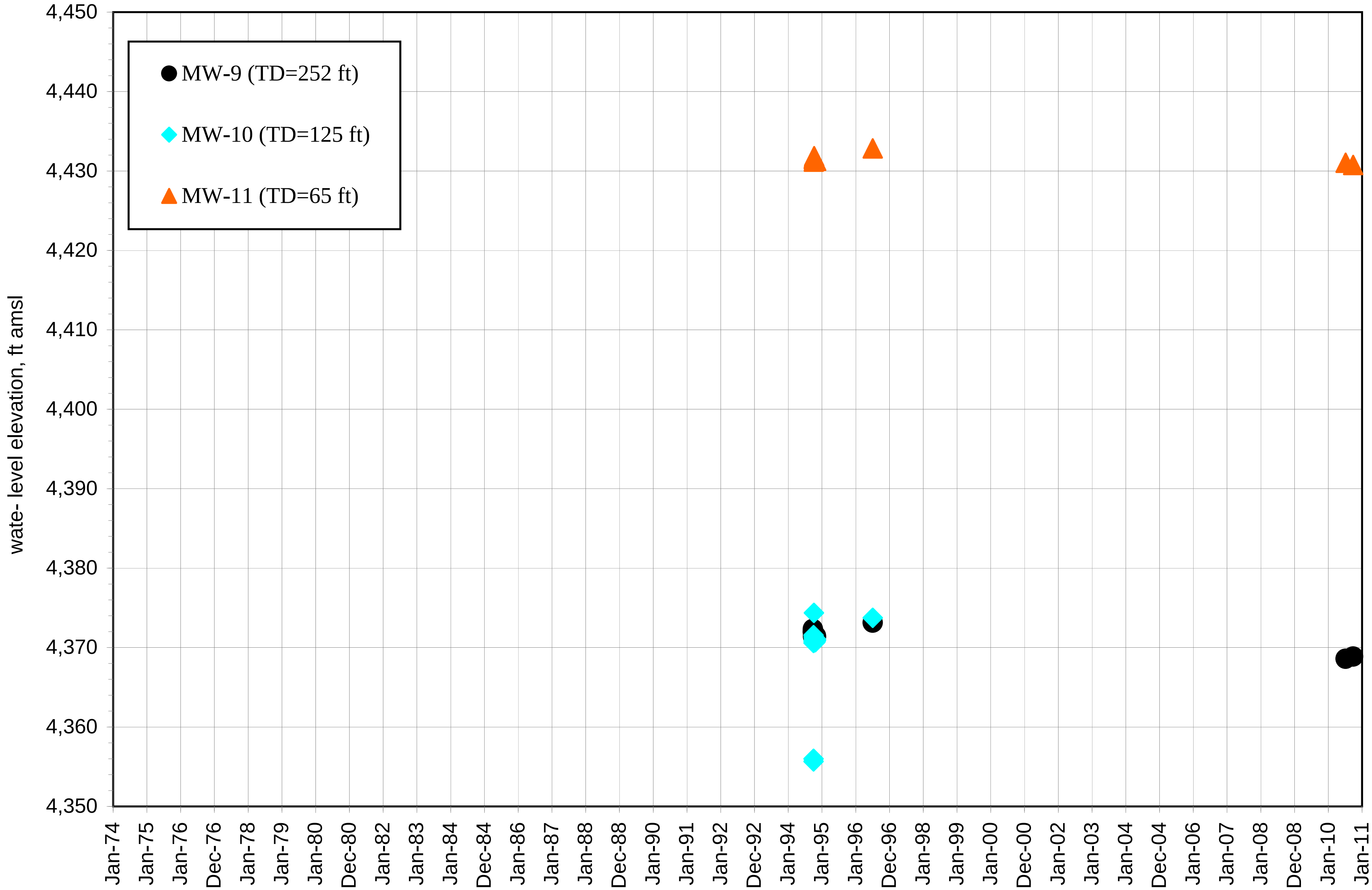

Figure 4. Graph showing historical water levels for observation wells MW-9, MW-10, and MW-11, Las Animas Creek valley.

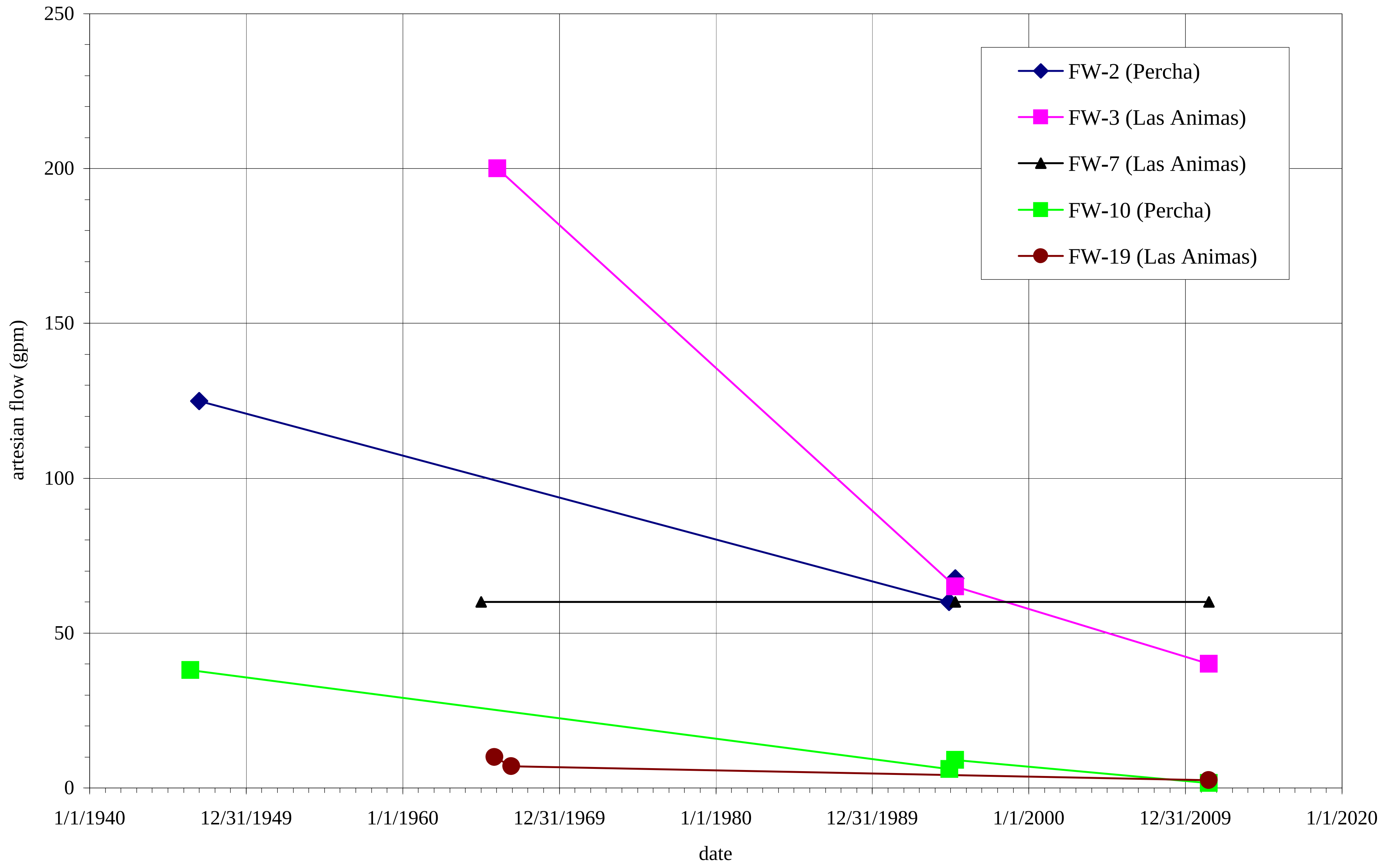

Figure 5. Graph of measured artesian flow rates versus time for wells in Percha and Las Animas Creeks valleys.

Appendix 1.

Photographs of artesian wells located by JSAI in 1995 and JSAI in 2011

Flowing Well 1 (1995)

Flowing Well 1 (2011)

Flowing Well 2 (1995)

Flowing Well 2 (2011)

Flowing Well 3 (1995)

Flowing Well 3 (2011)

Flowing Well 4 (1995)

Flowing Well 4 (2011)

Flowing Well 5 (1995)

Flowing Well 6 (1995)

Flowing Well 8 (1995)

Flowing Well 8 (2011)

Flowing Well 9 (1995)

Flowing Well 9 (2011)

Flowing Well 10 (1995)

Flowing Well 10 (2011)

Flowing Well 11 (1995)

Flowing Well 12 (1995)

Flowing Well 13 (2011)

Flowing Well 14 (2011)

Flowing Well 15 (2011)

Flowing Well 16 (2011)

Flowing Well 17 (2011)

Flowing Well 18 (2011)

Flowing Well 19 (2011)

Flowing Well 20 (2011)

Flowing Well 21 (2011)